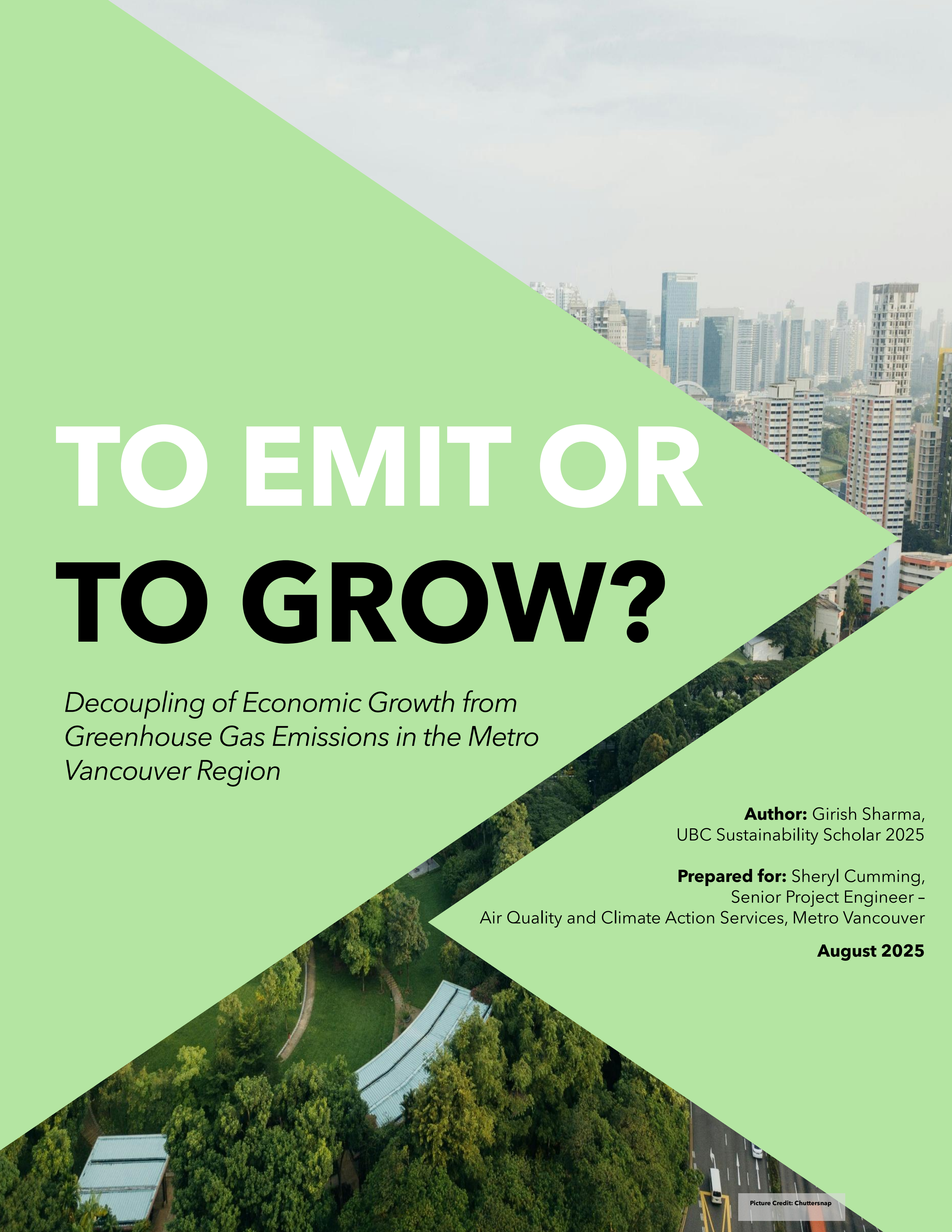
TO EMIT OR TO GROW?

Decoupling of Economic Growth from Greenhouse Gas Emissions in the Metro Vancouver Region

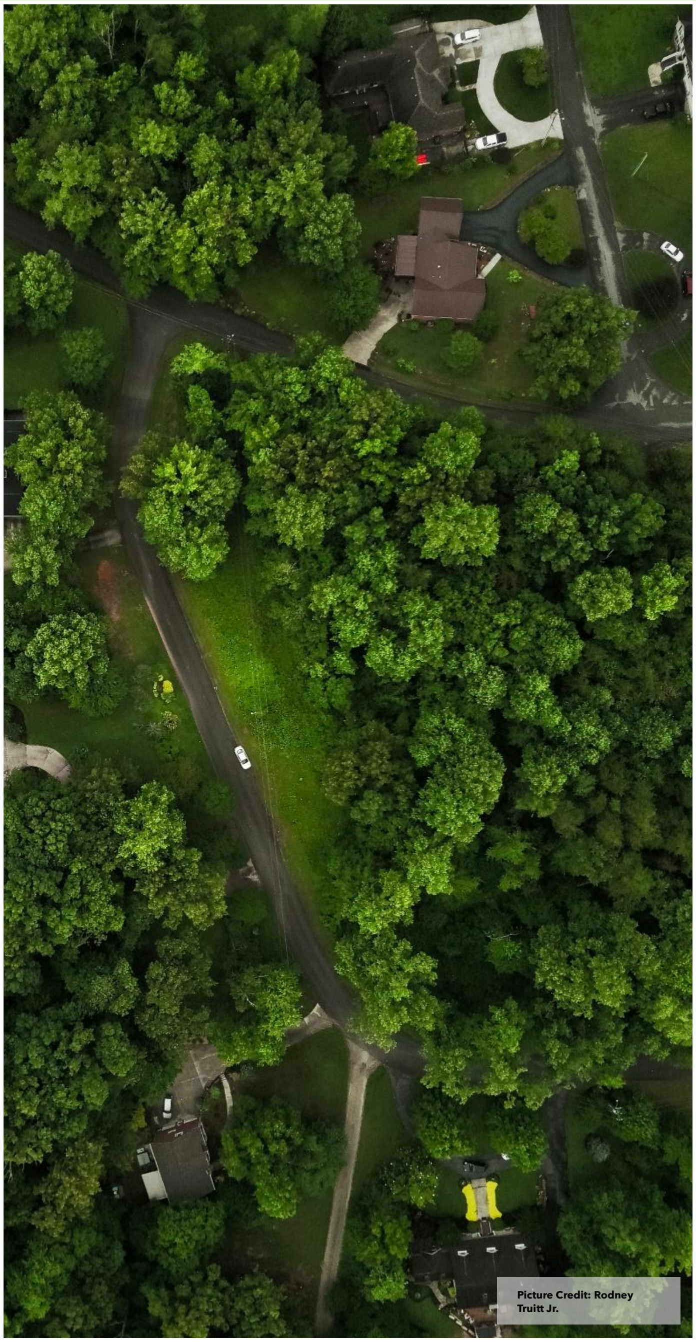
Author: Girish Sharma,
UBC Sustainability Scholar 2025

Prepared for: Sheryl Cumming,
Senior Project Engineer –
Air Quality and Climate Action Services, Metro Vancouver

August 2025



Picture Credit: Chuttersnap



DISCLAIMER

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability and climate action across the region.

This project was conducted under the mentorship of Metro Vancouver staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of Metro Vancouver or the University of British Columbia.

ACKNOWLEDGEMENT

I would like to thank my project mentor Ms. Sheryl Cumming – Senior Project Engineer, Air Quality and Climate Action Services at Metro Vancouver for her continuous support and guidance throughout the project. I also want to thank Mr. Jason Emmert – Program Manager, Regional Climate Action Policy and Ms. Lise Townsend – Division Manager, Air Quality and Climate Action Services for their extremely valuable comments and inputs.

I would also like to thank Ms. Karen Taylor and the UBC sustainability hub for providing students with the opportunity to work on multidisciplinary applied projects.

I acknowledge that the work for this project took place on the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam) people.

1. CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This study evaluates whether economic growth in Metro Vancouver's building and light-duty vehicle (LDV) sectors has been decoupled from greenhouse gas (GHG) emissions between 2010 and 2022. The analysis combines sector-level economic modeling with emissions inventory data, applying two complementary approaches—Tapio elasticity and Log Mean Divisia Index (LMDI)—to assess the strength and drivers of decoupling.

Key findings show a divergence in sectoral performance. The building sector's GDP expanded by 55% over the period, accompanied by a 14.6% rise in emissions. This represents ***weak decoupling***, where emissions continue to grow, albeit at a slower pace than economic output. In contrast, the LDV sector achieved ***strong decoupling***: GDP increased by 44% while emissions declined by 3.7%, with a structural shift toward electric vehicles, expanded transit and active mobility options, and improvements in vehicle efficiency over the years.

Labour market and fiscal effects underscore these dynamics. Despite rising output, jobs supported by building activity fell by nearly 8%, driven by fall in total jobs multiplier indicating productivity gains and technological efficiencies, while labour income rose by 26% and tax revenues more than doubled. The LDV sector maintained stable jobs support overall, with gains concentrated in service-oriented subsectors, alongside a 42% increase in labour income.

Decoupling metrics highlight the central role of efficiency improvements. Tapio results confirm strong decoupling for LDVs and weak decoupling for buildings, while LMDI decomposition shows that most emissions growth is attributable to economic activity, partly offset by declining emissions intensity. Notably, the building sector's adoption of the BC Energy Step Code exemplifies the potential for green investment multipliers: Step Code–related spending in 2022 is estimated to have generated up to 29% more GDP than traditional construction investment.

Policy implications are clear. Both sectors have demonstrated the technical capacity to reduce emissions, and the overall trend shows encouraging signs of decoupling when compared with the 2010 baseline. Year-on-year results further highlight opportunities to build on this momentum. Expert consultations indicate that businesses often comply only with minimum regulatory requirements, constrained by concerns over upfront costs and short payback horizons. To achieve the region's Clean Air Plan objectives, policy must therefore go beyond incremental measures—designing incentives that better align with business decision-making, and positioning sustainability not as a compliance cost but as a source of long-term efficiency and competitiveness.

Overall, the findings confirm that Metro Vancouver is on a credible and promising path toward decoupling economic growth from emissions. The LDV sector has already achieved strong decoupling, while the building sector continues to advance efficiency improvements that can curb operational emissions over time. What is crucial is to keep the momentum going and build on the progress achieved since 2010. Sustaining this trajectory will depend on embedding efficiency gains, accelerating the deployment of clean technologies, and ensuring that policy instruments convert technical potential into tangible emissions reductions.

1. INTRODUCTION

Urban regions are at once engines of economic growth and major contributors to greenhouse gas (GHG) emissions. As Metro Vancouver continues to expand economically, it faces the challenge of balancing economic growth with environmental responsibility. The question of whether growth can proceed without proportionate increases in emissions has become central to climate policy. Decoupling – the weakening or breaking of the link between economic activity and emissions – offers a framework for evaluating this balance and for informing strategies that aim to achieve both climate and economic goals.

This report sets out to examine whether Metro Vancouver's building and light-duty vehicle (LDV) sectors are progressing toward decoupling. These sectors are not only among the largest sources of emissions in the region but also closely tied to the everyday functioning of households and businesses. By assessing their economic contributions alongside emissions trends, the study seeks to clarify whether progress in sustainability is being matched by improvements in productivity and value creation.

The analysis is deliberately scoped to focus on buildings and LDVs, given their dual importance to economic output and emissions. Within each sector, economic activity is measured in terms of gross domestic product (GDP) and allied indicators such as employment, labour income, and tax revenues. These allied measures are considered for context but excluded from the decoupling metrics to prevent double counting. On the emissions side, the assessment draws from Metro Vancouver's inventory to capture sector-specific performance between 2010 and 2022.

Methodologically, the study combines multiple approaches. A systematic review of literature provides conceptual grounding and situates the analysis within wider research. Sector-specific economic activity is modelled using investment and output data, supplemented with Statistics Canada's Input–Output multipliers. Emissions trajectories are drawn from regional inventories and paired with economic measures to test for decoupling. Two complementary non-parametric methods are applied: Tapio elasticity, which captures the relative responsiveness of emissions to changes in GDP, and the Log Mean Divisia Index (LMDI), which decomposes emissions changes into their underlying drivers. Together, these methods provide a clear, evidence-based picture of how growth and emissions have interacted in Metro Vancouver over the past decade.

2. SYSTEMATIC LITERATURE REVIEW

To build a comprehensive evidence base, three sources were used to identify and screen relevant literature: grey literature identified via Google Search, academic publications from Semantic Scholar (via Elicit), and peer-reviewed articles from Scopus. Each source was treated as an independent search stream, but all were evaluated using the same research question and thematic focus.

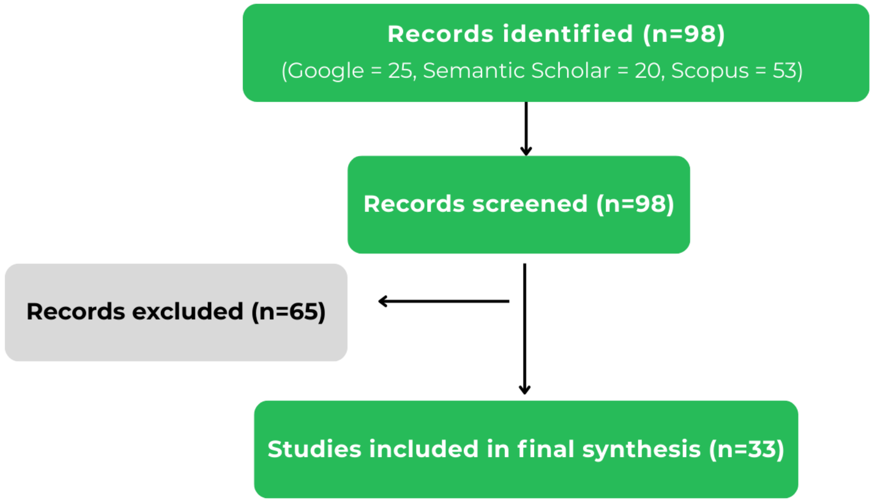


Figure 1 Literature Review Methodological Framework
Source: Author's Own

In the first stream, Google Search was employed to locate grey literature, policy reports, and technical publications through targeted keyword searches and Boolean logic. Of the 25 items reviewed, eleven were included in the synthesis – primarily high-quality conceptual documents and reports presenting grounded arguments. Eight items were excluded due to methodological limitations, such as the absence of quantitative analysis.

The second search stream utilized Semantic Scholar via Elicit, focusing on academic publications. A total of 20 papers were identified, of which nine were included. Ten were excluded for various reasons: six were nationally focused, primarily dealing with cross-country comparisons rather than urban sectors; three were policy-oriented but lacked empirical analysis of decoupling.

The third search stream used Scopus, querying a structured Boolean string incorporating terms such as decoupling, economic growth, GHG emissions, urban, buildings, and transport. This search yielded 53 articles, with 26 included in the synthesis. The 23 excluded papers were grouped into several categories, including national and cross-national comparisons, focus on heavy-duty vehicles, among others.

Following the three search streams, a final synthesis of 33 studies was included to ground the quantitative analysis and variable construction.[A]

2.1. Findings from Literature

The reviewed literature employed a diverse range of methodological approaches to measure decoupling. Tapio elasticity was the most frequently used framework, appearing in 24 studies – of which nine relied on it as the sole analytical metric. This method assesses the elasticity of GHG emissions relative to economic growth, classifying the relationship as strong decoupling, weak decoupling, coupling, or negative decoupling. Its widespread use stems from its intuitive interpretability and ease of application to both temporal and spatial datasets.

Another widely utilized approach was Log-Mean Divisia Index (LMDI) decomposition, which appeared in 12 studies, often in combination with Tapio elasticity or the Environmental Kuznets Curve (EKC). LMDI enables the decomposition of emission changes into activity, structural, and intensity effects, offering deeper insights into the underlying drivers of decoupling. Additionally, five studies employed regression-based models – including panel regressions and spatial econometrics – to examine the significance of explanatory variables such as renewable energy investment, urban density, and environmental regulations.

A smaller subset of studies explored more advanced methodologies, including Geographical Detector Models, structural equation modeling, and machine learning techniques like random forests. These approaches were predominantly applied in Chinese urban contexts, where detailed spatial and administrative datasets were available. Most studies combined multiple methods—such as Tapio elasticity with regression models or LMDI with spatial analysis—to strengthen analytical rigor and robustness.

The transport sector was the most extensively studied, with 13 papers examining urban mobility, fuel consumption, and modal shifts. These studies frequently relied on emissions inventories and energy statistics at the city or provincial level to analyze decoupling trends within urban transport systems.

The building and construction sector was the subject of seven studies, which utilized remote sensing data, land-use conversion metrics, and construction GDP shares to estimate emissions and assess decoupling. These studies emphasized factors such as urban sprawl, land-use intensity, and the energy performance of buildings.

[A] A synthesis of the 33 studies included in the review is provided in Appendix

The remaining studies took an economy-wide or mixed-sector approach, aggregating emissions and GDP at the city level without distinguishing by sector. These analyses often served as baseline assessments and typically employed Tapio elasticity or LMDI to examine decoupling at a macro-urban scale.

The reviewed literature presents varied findings on the presence and strength of decoupling in urban regions. Of the 33 studies, nine provided evidence of absolute decoupling, where GHG emissions declined while economic output continued to grow. These cases were primarily observed in high-income or highly regulated cities with targeted low-carbon transport or construction policies. Relative decoupling was more common, appearing in 15 studies, where emissions continued to rise but at a slower rate than GDP growth. The remaining studies reported no evidence of decoupling or identified instances of negative decoupling, particularly in rapidly urbanizing or industrializing regions.

Tapio-based studies frequently found stronger decoupling patterns in cities with higher GDP per capita or long-standing environmental regulations. LMDI-based studies provided a more detailed breakdown, often highlighting that activity effects - such as urban expansion and vehicle-kilometers traveled - continued to drive emissions growth, while energy intensity improvements and structural shifts, such as transitions from manufacturing to services, partially mitigated these pressures. Regression-based analyses offered deeper insights into the significance of specific drivers, particularly in studies that examined institutional variables, infrastructure investments, and environmental governance indicators.

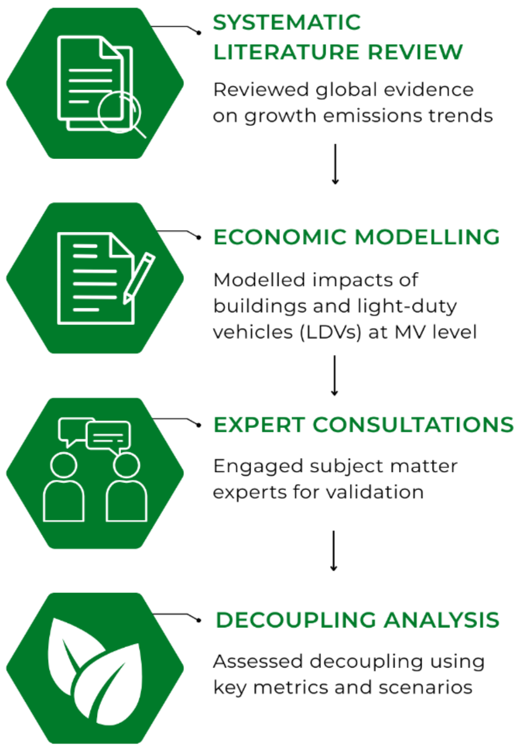
Several key drivers of decoupling emerged from the reviewed literature. Technological innovation – particularly advancements in vehicle efficiency and building energy performance – was frequently cited. Policy interventions, such as shifts in energy mix and modal transitions in transport systems, also played a significant role. Economic restructuring contributed as well, with studies linking decoupling to a transition from industry-heavy economies to service-oriented urban landscapes. Additionally, the availability and integration of renewable energy, especially in municipal grids, facilitated decoupling in certain cases.

Notably, this review found very few studies examining decoupling in Canadian urban contexts. Rather than a research limitation, **this presents a strategic opportunity for Metro Vancouver to establish a foundational evidence base for urban decoupling research in Canada**, generating insights that would inform policy decisions across the country's metropolitan regions.

3. METHODOLOGY

To comprehensively measure the decoupling of economic growth from GHG emissions, a four-step methodology was employed: i.) conducted systematic literature review (*presented in Section 2)*, ii.) modelled the economic impact of buildings and transportation, specifically light-duty vehicles (LDVs) at the MV level, iii.) conducted consultations with subject matter experts, iv.) performed decoupling analyses. The specific steps and metrics used in each of those methods are laid out below.

Buildings and LDVs were selected as the focus sectors for this analysis because they are among the largest sources of GHG emissions in the MV region and play a central role in both economic activity and daily life. Buildings are particularly significant given that most residents spend the majority of their time indoors, i.e., at home, at work, or in other enclosed spaces – making them sensitive to climate change impacts.[1] Rising temperatures and more frequent heatwaves increase demand for cooling, while worsening wildfire seasons heighten the need for air filtration, and colder winters sustain the demand for heating. Similarly, the LDV sector is central to regional mobility, with significant emissions and energy use stemming from both personal and commercial transportation. Considered together, the buildings and LDV sectors offer a valuable lens for examining the relationship between economic growth and emissions, while also



highlighting opportunities for targeted mitigation strategies.

3.1. Economic Modelling

To model the economic activity of the building and LDV sectors, two separate approaches specific to each sector were followed for the region (see *Figure 2* for the region's map).

3.1.1. Buildings

To calculate the economic activity of the buildings sector, investment in building construction was used as the base variable, serving as a proxy for the sector's gross economic output.[B] This variable essentially represents the spending value on building construction by households, enterprises, and governments – excluding the value of land.[2] This study used unadjusted current monthly estimates of building construction investment from 2010 to 2023, disaggregated by residential and non-residential buildings, and further broken down into new construction and repair/renovation for CMA Vancouver. To derive annual figures from the monthly estimates, the modelling included performing a simple linear summation.

Annual figures were then converted to 2017 constant dollar prices using the following approach for two intervals: 2010–2016 and 2017–2023.

- For 2017 onwards, the monthly Building Construction Price Index for CMA Vancouver (MV) and BC's residential and non-residential construction sectors were used, based on the composite MasterFormat division.[3] One of the primary reasons for extracting data for both BC and MV was the unavailability of MV-disaggregated Building Construction Price Index data before 2017 (see the point below).
  - For 2010–2016, BC Shelter Consumer Price Index as a proxy construction deflator was used,[4] with an assumption that MV's residential and non-residential building costs mirrored provincial trends. This assumption is reasonable given the observed alignment in building cost indices between MV and BC from 2017 to 2021 (see Table 1).

Picture Credit: Victor Dubugras

Table 1 BC and MV Building Construction Price Indices							
Particulars	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
BC Residential	100.00	107.66	112.86	116.10	127.20	144.98	156.31
MV Residential	100.00	107.63	112.83	116.04	127.15	144.87	156.49
BC Non-Residential	100.00	105.39	109.70	110.38	115.02	125.88	136.57
MV Non-Residential	100.00	105.37	109.72	110.40	115.05	125.90	136.88

Source: Statistics Canada[5]

Notes: All values have been converted to constant 2017 prices. To interpret the table, one should focus on the close alignment between BC and CMA Vancouver (MV)'s Building Construction Price Indices for both residential and non-residential sectors. The strong correlation observed between BC and MV from 2017 to 2023 provides credible justification for the assumption that MV's building construction price trends mirrored those of the province during the earlier period of 2010 to 2016. 2017 is a base year hence (=100).

The above calculated building construction investment amounts were thus used as a proxy for gross output. To estimate the economic activity of the building sector, the analysis was disaggregated by residential and non-residential building types. Statistics Canada's Input-Output multipliers specific to British Columbia were then applied to quantify sectoral contributions.

Specifically, the total multipliers for the following variables were used: i.) GDP at basic prices; ii.) Labour income, iii.) Taxes on products, iv.) Taxes on production; v.) Jobs created

These multipliers were applied separately for residential and non-residential building construction. The GDP at basic prices was calculated by multiplying the gross output (i.e., building construction investment) by the corresponding GDP multiplier. This resulting value was then used as the primary indicator of economic output for the building sector.

3.1.2. Transportation – Light Duty Vehicles

Light-duty vehicles (LDVs) are defined as transport vehicles with a gross vehicle weight rating (GVWR) less than or equal to 4,536 kilograms (10,000 pounds), corresponding to GVWR classes 1 and 2. This includes passenger cars, pickup trucks, multi-purpose vehicles, and vans.[6] For LDVs, a two-step methodology was employed: i.) Calculate the fuel demand in the MV region by different fuel types and LDV categories, ii.) Calculate the economic activity of the sector. Note that: (i.) is for descriptive analysis and formalizes the findings and has no bearing on (ii), which is formally used in the decoupling analysis.

Fuel Economy

For the estimation of fuel spend in the region, data from the City of Vancouver Transport Panel Survey on estimates for vehicle kilometres travelled per vehicle (VKT/vehicle) and per capita (VKT/capita) was used.[C] The survey also provides data on weekday trip purposes.

[C] It is important to recognize that the City of Vancouver is one of 21 municipalities within the MV region. As such, estimates of vehicle kilometres travelled (VKT) should be interpreted with caution and should not be conflated with figures representing the broader MV region. Fuel economy estimates are designed to establish a replicable analytical foundation that can be extended to other jurisdictions as relevant data becomes available. In the later stages of the analysis, an assumption is introduced: that VKT per vehicle in the City of Vancouver reflects the VKT per vehicle observed across the MV region. This assumption is considered reasonable and sufficiently flexible, given that vehicle registration data is available at the regional level. To estimate total kilometres travelled by registered vehicles, the number of registered vehicles is multiplied by the VKT per vehicle derived from City of Vancouver-level data. The lack of granular VKT-per-vehicle data at the municipal level constitutes a notable data gap and a key limitation of the current analysis.

Assuming that the proportional distribution of trip purposes remains consistent throughout the year, total annual vehicle kilometers traveled (VKT) were calculated across categories such as “return home,” “shopping,” and “to usual work.”

Vehicle registration data from Statistics Canada was used to identify the number of new LDVs registered in each year, disaggregated by fuel type $f \in$ {gasoline, diesel, battery electric} and vehicle class in $c \in$ {passenger, pickup, multi-purpose, van}.

Now, let $\mathrm{N}_{\mathrm{fct}}$ denote the number of new LDVs registered of fuel type f and class c in year t. Then, total annual distance travelled by that group is:

$$D_{fct} = \mathrm{VKT}_t \cdot N_{fct}$$

Multiplying annual distance with the average fuel efficiency gives fuel requirement in the region:

$$Q_{fct} = \frac{D_{fct} \cdot e_{fct}}{100}$$

where $\mathrm{e}_{\mathrm{fct}}$ is the average fuel consumption in L/100 km (gasoline, diesel) or kWh/100 km (electric), sourced from Natural Resources Canada's Fuel Consumption Guides (2017-2023)[7].

Since the guides classify vehicles by model and size (e.g., “Audi A3”, “Subcompact”), and registration data uses different categories, a concordance was built to streamline the analysis:

Picture Credit:
Confinedriley Pixels

Table 2 Vehicle Class Concordance	
Registration Category	Mapped Fuel Consumption Class
Passenger cars	Two-seater, MiniCompact, Subcompact, Compact, Mid-size, Full-size, Station wagon (Small, Mid-size)
Pickup trucks	Pickup truck (Small, Standard)
Multi-purpose vehicles	SUV (Small, Standard)
Vans[1]	Minivan, Special Purpose Vehicles, Van (Cargo, Passenger)

Source: Author's Own based on Fuel Consumption Guides

Note: 1. Special Purpose Vehicles (SPVs) are not identified as a separate category in the vehicle registration data. Based on chassis type and functional similarity, SPVs with GVWR < 8,500 lbs are concorded to the 'Vans' category. This includes ambulances, service vans, and similar vehicles typically derived from van platforms.

Fuel consumption is analyzed under three modes: city (stop-and-go), highway (rural/long-distance), and combined (55% city, 45% highway). Let $\mathrm{m} \in$ {city, highway, combined}. For each mode, nominal fuel expenditure is:

$$S_{fct}^{\text{nom},m} = Q_{fct}^{m} \cdot p_{ft}^{m}$$

Where $\mathrm{p}_{\mathrm{ft}}^{\mathrm{m}}$ is the price of fuel type f in year t and mode m. Residential electricity rates were used to estimate electricity costs. For gasoline and diesel, price data was sourced from the Fuel Consumption Guide.

To convert nominal spending into constant 2017 terms, fuel-specific deflators were derived using retail fuel price data for Vancouver CMA: $\delta_{ft} = \frac{\overline{p_{f,2017}}}{p_{ft}}$. Where $\overline{p_{f,2017}}$ is the average 2017 price, and p_{ft} is the observed price in year t. Monthly prices are averaged to produce annual deflators. For electricity, prices remained constant from 2017-2021, so $\delta_{\text{elec},t} = 1$ for $t \leq 2021$. For 2022, the price was deflated to 2017 levels:

$$\delta_{\text{elec},2022} = \frac{p_{\text{elec},2017}}{p_{\text{elec},2022}}$$

For "all fuels" type, a composite price deflator for each year and mode was derived by weighting each fuel type's deflator by its share of fuel quantity consumed:

$$\delta_{allfuel,t} = \sum_{f} \left(\frac{Q_{fct}^{m}}{\sum_{f'} Q_{f'ct}^{m}} \cdot \delta_{ft} \right)$$

Then, fuel spend (measure for demand) in real terms for each class and mode was calculated as:

$$S_{ct}^{\text{real},m} = \left(\sum_{f} S_{fct}^{\text{nom},m} \right) \cdot \delta_{ft}$$

The fuel expenditure referenced above corresponds to vehicles registered at the MV level. However, this entire expenditure is not directly attributable to the region itself. British Columbia imports approximately 70% of its gasoline, primarily from Alberta and the U.S. Pacific Northwest.[8] As a result, the fuel spend is discounted by 70% to estimate the portion of expenditure that can be reasonably attributed to the province of British Columbia.

Economic Activity

To estimate the economic activity or GDP of the light-duty vehicle (LDV) sector, four key industries were selected based on the North American Industry Classification System (NAICS), using 2017 chained prices for the period 2010–2014[9]

1. **Motor Vehicles and Parts Dealers:** This subsector includes establishments engaged in retailing motor vehicles, parts, and accessories, as well as providing related services.
2. **Automotive Repair and Maintenance:** This subsector encompasses businesses involved in the repair and maintenance of motor vehicles, including cars, trucks, vans, and trailers.
3. **LDV and Automobile Manufacturing:** This category captures establishments focused on the production of light-duty vehicles and their chassis.
4. **Motor Vehicles Parts Manufacturing:** This subsector includes establishments that manufacture motor vehicle components, including engines.

The total economic activity for the LDV sector is calculated as the linear summation of GDP contributions from these four subsectors.

3.2. Decoupling Analysis

For the analysis, two metrics are used to measure the decoupling of economic growth from GHG emissions i.) Tapio Elasticity ii.) Log Mean Divisia Index (LMDI).

3.2.1. Tapio Elasticity

This approach quantifies the elasticity between changes in carbon emissions and economic activity. By calculating the ratio of the percentage change in emissions to the percentage change in GDP, the model categorizes the degree of decoupling into distinct classifications: strong decoupling, weak decoupling, or negative decoupling. For a more intuitive interpretation of these categories, refer to the Results section. [10]

3.2.2. Log Mean Divisia Index

In addition to the elasticity analysis, the study employs the Logarithmic Mean Divisia Index (LMDI) method to decompose the total change in emissions into distinct contributing effects. [11] Notably, this study introduces significant modifications to the conventional decomposition approach. Rather than applying the method across all sectors at the national level – as is common in existing literature – the analysis focuses exclusively on the building and LDV sectors.

One of the key strengths of the LMDI method is its ability to achieve perfect decomposition without residuals, ensuring that all changes are fully accounted for. Moreover, LMDI accommodates zero and negative values, making it particularly well-suited to the characteristics of the dataset used in this study.

By applying LMDI, the analysis identifies the relative contributions of various factors to observed emissions trends. The below equations outline the specific components used in the decomposition.

The study uses the logarithmic mean to define weights for each sector i (either LDV or Buildings) for two time periods t and $t + n$:

$$w_i = \frac{X_{i,t+n} - X_{i,t}}{\ln X_{i,t+n} - \ln X_{i,t}} \qquad \text{(log-mean weight)}$$

Then, let:

- $S_{i,t}$, $S_{i,t+n}$ be the economic activity shares of each sector i in periods t and $t + n$
- $I_{i,t}$, $I_{i,t+n}$ be the emission intensities[D]
- $Y_{i,t}$, $Y_{i,t+1}$ be the total economic activity[E]

Then, the change in total emissions or energy use is decomposed into:

- Economic Activity Shares Effect: $\sum_i w_i \cdot \ln\left(\frac{S_{i,t+n}}{S_{i,t}}\right)$
- Emissions Intensity Effect: $\sum_i w_i \cdot \ln\left(\frac{I_{i,t+n}}{I_{i,t}}\right)$
- Total Economic Activity Effect: $\sum_i w_i \cdot \ln\left(\frac{Y_{i,t+n}}{Y_{i,t}}\right)$

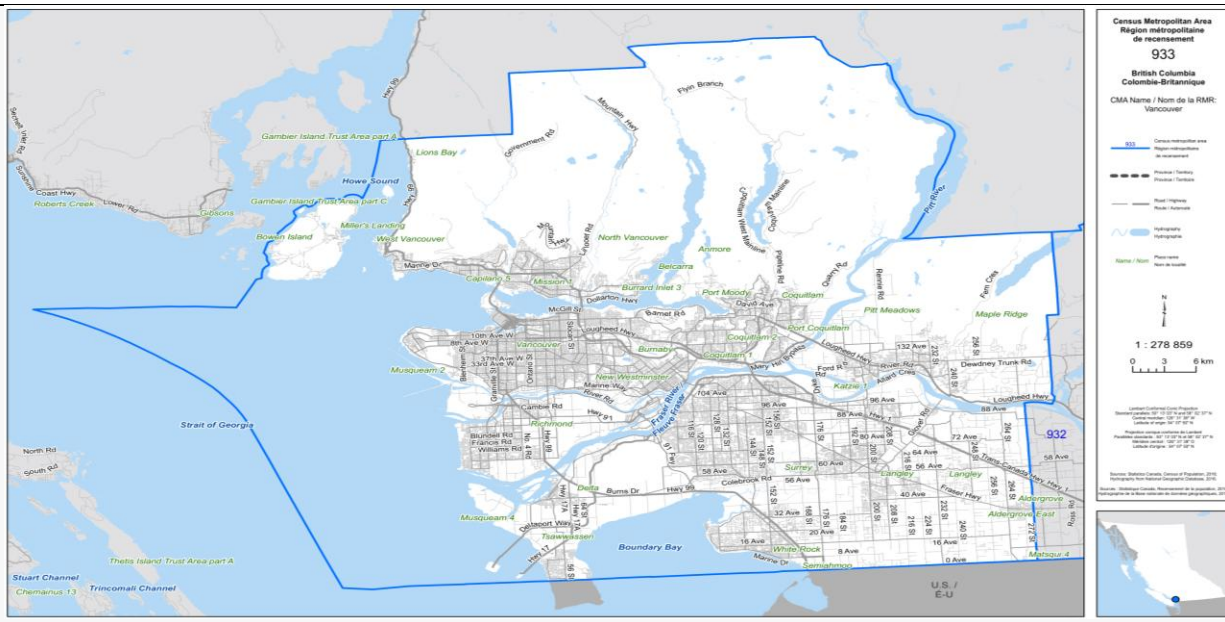


Figure 2 Census Metropolitan Area (CMA) - Vancouver

Source: Statistics Canada [12]

[D] Emissions intensity is defined as the total emissions released per unit of economic output, measured in metric tonnes of emissions per dollar of GDP.

[E] Here, the total economic activity refers to the combined economic output of the Buildings and LDV sectors. It should not be interpreted as the total economic activity of the region, which would include other sectors not considered in this study.

4. RESULTS

Picture Credit: EA Pexels

The Results section is structured into three primary subsections: (i) Buildings, (ii) Light-Duty Vehicles (LDV), and (iii) Decoupling Analysis. Subsections (i) and (ii) provide a sector-specific overview of economic activity, emissions profiles, carbon productivity, and other relevant indicators. Subsection (iii) examines the decoupling of greenhouse gas (GHG) emissions from economic activity through multiple analytical approaches, including year-on-year Tapio elasticity, Tapio elasticity using 2010 as the baseline year, and a decomposition of total emissions change into its underlying driving factors.

4.1. Buildings

4.1.1. Investment in Buildings Construction

Between 2010 and 2022, the total investment in building construction in the region increased by +54.6%, rising from $9.5 billion to $14.7 billion. Investments (or activity) peaked in 2019 at $16.9 billion, before falling sharply during the COVID-19 pandemic to $13.7 billion in 2021 – the lowest since 2016. By 2022, investments had partially recovered. Both residential and non-residential segments followed this trend, through residential segment exhibited greater volatility, falling to $9.8 billion in 2020 – lowest since 2015.

The breakdown by type shows that new construction consistently accounted for most of the investments in both subsectors (residential and non-residential). While construction may happen less frequently than repair and renovation, it is often associated with higher costs thus requiring more investments.

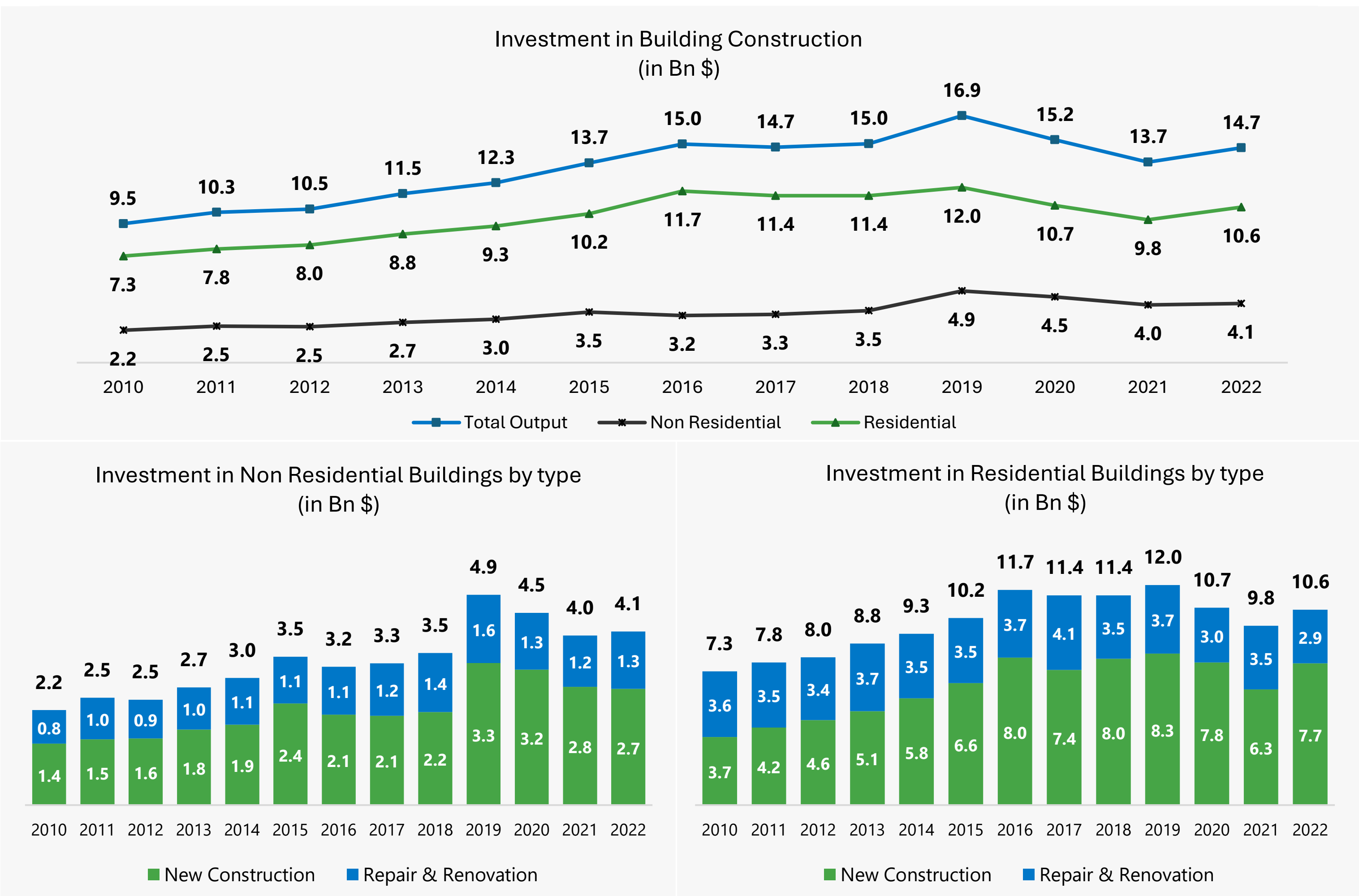


Figure 3 Investment in Building Construction by type

Source: Statistics Canada[13]

4.1.2. Economic Value-generated (GDP)

Using the investment in building construction data as a starting point, the sector's economic impact can be estimated through Statistics Canada's Input-Output multipliers. While investment figures capture total spending, including intermediate goods but excluding value of land, GDP at basic prices reflects sector's net value added – the new economic value created from these investments. Thus, often GDP is less than the gross output or investment amounts.

As shown in Figure 4, GDP trends closely mirror investments patterns illustrated in Figure 3, with both peaking in 2019 before experiencing a decline during the COVID-19 pandemic. The sector's GDP fell by 17.8% from $14.0 billion in 2019 to $11.5 billion in 2021, reflecting a slowdown in construction and renovation activity.

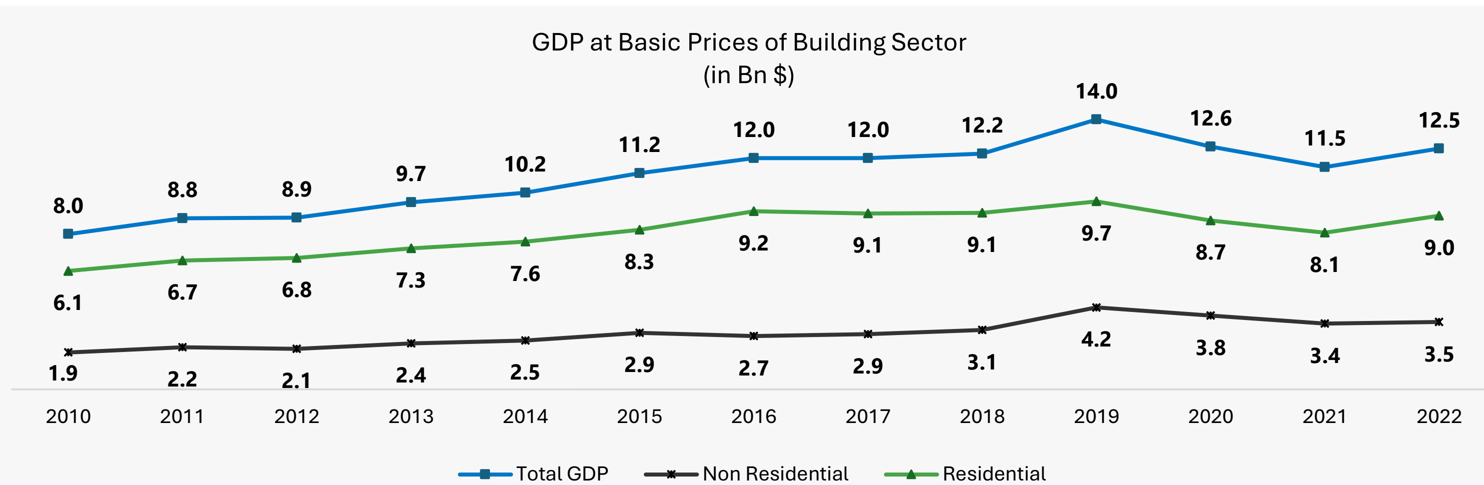


Figure 4 GDP of Buildings Sector

Source: Statistics Canada[14]

4.1.3. Allied Economic Impacts[F]

While GDP at basic prices remains the primary indicator of the building sector's economic value added, the sector also generates significant allied impacts – such as employment, labour income, and tax revenue. These impacts are not included in GDP calculations to avoid double counting, yet they offer valuable insight into how the sector influences the economy at a more granular level. For example, the number of jobs supported or the tax revenues generated for governments are often the most tangible and directly experienced outcomes of construction activity.

[F] The allied impacts presented in this section are derived using Statistics Canada's Input–Output multipliers and should be interpreted as model-based estimates rather than direct counts or measurements. These figures are intended to provide an indicative sense of the broader economic footprint of the building sector, rather than precise observed totals.

Full-time Equivalent Jobs (per million dollars of output)

Table 3 Jobs Supported by Building Investments (2010 vs. 2022)				
Year	Non-Residential Investment	Residential Investment	Total FTE Jobs	% Change (2010-2022)
2010	22,567	80,782	103,349	-
2022	27,991	67,187	95,178	-7.9% ↓

In 2022, investments in the non-residential building sector supported an estimated 27,991 full-time equivalent (FTE) jobs, while residential investment supported 67,187 FTE jobs. Combined, the sector supported 95,178 FTE jobs, representing a 7.9% decline from the 2010 total of 103,349 jobs.

At first glance, this may appear counterintuitive, since both total building investment (Figure 3) and sector GDP (Figure 4) have risen significantly over the same period. However, two factors explain this trend:

1. The FTE figures include jobs supported across the supply chain (direct, indirect, and induced), such as materials production and construction services, not just workers physically employed on building sites.
2. Technological advancements and process efficiencies have likely increased labour productivity since 2010, meaning fewer workers are required per million dollars of output.

Thus, the decline in jobs supported per unit of investment is not a negative signal per se; rather, it reflects broader productivity improvements and innovation within the sector's supply chains.

Table 4 Labour Income and Tax Revenue				
Year	Residential Labour Income ($ billions)	Non-Residential Labour Income ($ billions)	Total Labour Income ($ billions)	% Change (2010-2022)
2010	4.1	1.2	5.3	-
2022	4.7	2.0	6.7	26.4% ↑

In 2022, the building sector generated an estimated $6.7 billion in labour income, compared with $5.3 billion in 2010. Of this, residential construction contributed $4.7 billion and non-residential construction $2.0 billion.

When considered alongside the decline in FTE jobs over the same period (Table 3 above), this increase in labour income indicates that average earnings per worker have increased. Likely drivers include minimum wage increases and broader wage growth in construction and related industries.[G,15]

[G] Average minimum wage in British Columbia has gone up from $8.0 in 2010 to $15.7 in 2022.

Total tax revenue, calculated as the sum of taxes on products and on production, also increased substantially, from $812 million in 2010 to $2,152 million in 2022, reflecting both the increase in the sectoral output and rising unit values over time.

4.1.4. Emissions Overview

The building sector is the second-largest source of greenhouse gas emissions (GHGs) in the MV region, accounting for nearly 28% of the regional emissions in 2022.[16] This high share reflects well-documented factors identified in MV's regional priorities, most notably the persistent use of natural gas for space and water heating in both existing and new buildings.[17] While electricity is also used for heating, its share remains comparatively small, and its carbon intensity is much lower – natural gas produces roughly 16 times more GHG emissions per unit of energy than BC Hydro Electricity.

Emissions in the building sector have increased from 4.1 million tonnes CO_2e in 2010 to 4.7 million tonnes CO_2e in 2022, a 15% rise over the baseline. As shown in the Figure 5, the trend follows a U-shaped curve, with no reduction during the COVID-19 period. This is because these emissions are primarily operational – arising from activities such as heating – rather than from construction itself. While construction and renovation activity slowed during the pandemic (reflected in the investment and GDP trends), the operation of existing buildings continued largely unchanged, leaving operational emissions unaffected.[H]

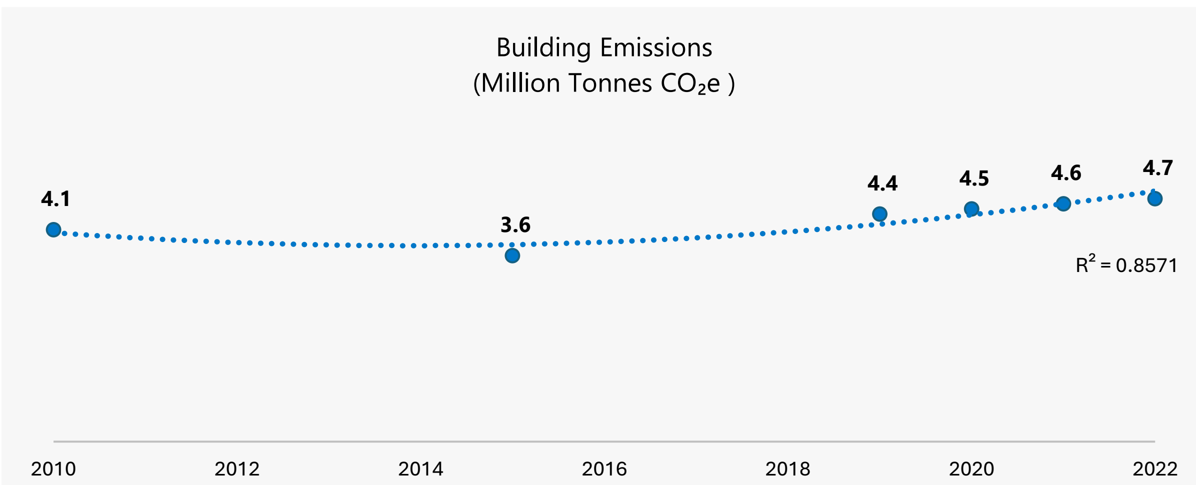


Figure 5 Buildings Emissions

Source: MV Emissions Inventory[18]

4.1.5. Greening the Economic Activity

Following the overview of emissions and economic activity in the preceding sections, I extend the analysis comparing economic activity vis-à-vis emissions using following three key metrices i.) carbon productivity and emissions intensity ii.) GDP premium from investing in clean energy.

[H] The emissions inventory used in this study does not account for embodied emissions - those generated outside the region during the production or activities associated with goods and services consumed within the region (e.g., building materials). Due to limited time-series data availability on consumption-based emissions, conducting a trend analysis remains challenging. This represents a key data gap and limitation of the study.

Carbon Productivity

This analysis examines how efficiently the building sector converts carbon emissions into economic value. Carbon productivity measures the GDP (in constant dollars) generated per tonne of CO_2e emitted.

In 2022, the sector produced $2.6 billion in economic activity for every million tonnes of carbon emitted, up 30% from $2.0 billion in 2010. This improvement suggests that, on average, the sector is generating more economic value per unit of emissions, indicating potential gains in energy efficiency and operational practices.

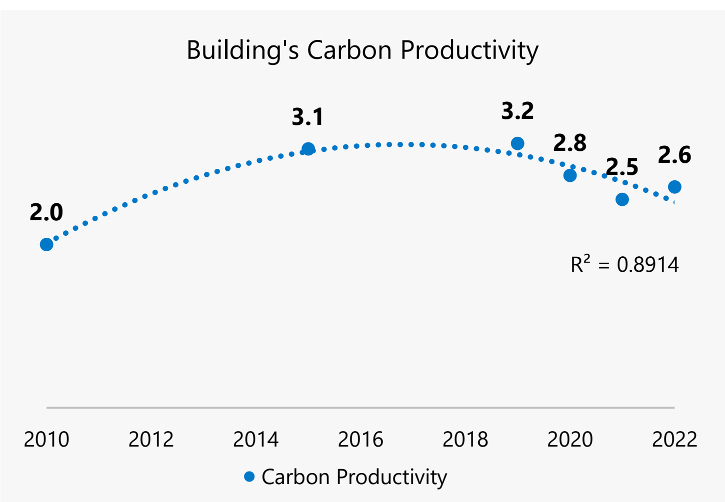
However, this metric should be interpreted with caution. A rise in carbon productivity does not automatically mean the sector is becoming more sustainable. It can also result from when GDP grows significantly while emissions rise in parallel - reflecting greater economic output but not necessarily reduced emissions and environmental impact. In the case of MV's building sector, overall emissions have increased since 2010, meaning the carbon productivity gains could partly be a result of stronger GDP growth rather than absolute decarbonization (we explore this idea further in decoupling analysis section).

Emissions Intensity

Emissions intensity is the inverse of carbon productivity, measuring the amount of GHG emissions generated per unit of economic output. As shown in Figure 6, emissions intensity of the building sector fell from 0.0005 tonnes per million dollars of GDP in 2010 to 0.0004 tonnes in 2022 – a 26% reduction.

Applying the emissions intensity effect formula outlined in Section 3.2, yields a value of –1.328 per million tonnes. Using a social cost of carbon of $270 per tonne, this reduction translates into an estimated $358 million in avoided climate-related damages to Canada over the period 2010–2022.

This improvement indicates that, relative to economic output, the sector has become less emissions intensive. However, as noted in the carbon productivity discussion, this does not necessarily imply absolute decarbonization, as total sector emissions have increased over the same period.



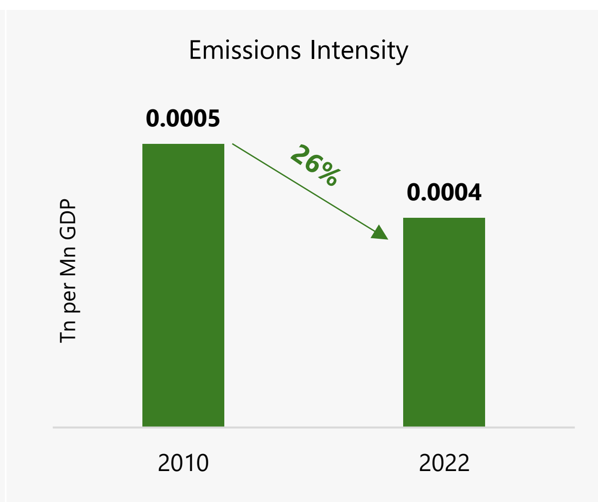


Figure 6 Building Sector Emission Efficiency

Green Investments

In 2017, the BC Energy Step Code (BC ESC) introduced performance requirements for improving the energy efficiency of new buildings, aiming to reduce both energy use and GHG emissions. Local governments can adopt the Step Code as part of the BC Building Code requirements, making compliance mandatory for new construction within their jurisdiction. The first province-wide "step up" occurred in May 2023, requiring most new buildings to be 20% more energy-efficient than the 2018 minimum standards.

While complying with the Step Code entails a capital cost, incremental cost analyses have found that all building types across all climate zones in BC can achieve Step Code targets for less than 4% of the cost. [19,I] Taking this as an upper bound, and assuming that 80% of new buildings in 2022 complied with the Step Code,[J] the implied cost premium is approximately $470 million. This amount is not an addition to the total $14.7 billion invested in building construction that year (*Figure 3*) but rather represents the portion of total investment directed toward improving energy efficiency.

Research by the International Monetary Fund (IMF) estimates that the green multiplier, i.e., the GDP generated per dollar of green investment ranges from 1.1 to 1.5.[20] Applying this to the $470 million cost premium, we compare two scenarios:

1. Status quo: if this $470 million were invested in traditional building construction, it would be expected to generate approximately $400 million in GDP (multiplier = 0.85).
2. Green investment: if the same amount is invested in Step Code - related improvements, GDP could range from $517 million (multiplier = 1.1) to $705 million (multiplier = 1.5).

Even under the most conservative assumption (multiplier = 1.1), green investments could deliver 29% more GDP impact than traditional construction investments, highlighting their potential to deliver both environmental and economic benefits.[21]

[I] The $14.7 billion total investment in 2022 is the observed amount and already reflects any additional costs from Step Code compliance. The 4% figure is therefore taken as a proportion of this observed total to estimate the share of spending attributable to green measures, rather than added on top of the total investment.

[J] Due to the absence of annually consolidated, region-wide statistics on Energy Step Code adoption in MV, the adoption value used in this analysis is constructed as an informed scenario. The estimate is not based on direct counts of permits or population under ESC-compliant bylaws. Instead, the assumed adoption rate is intended to reflect progression, consistent with the known direction of policy uptake.

Figure 7 GDP Impact from Green vs non-Green Investments

4.2. Transportation – Light-Duty Vehicles

4.2.1. Economic Value-generated (GDP)

Following the methodology in Section 3.1.2, GDP from LDV sector is estimated. As shown Figure 8, sector GDP increased from $1.6 billion in 2010 to $2.3 billion in 2019, before declining by 13% during the COVID-19 pandemic. By 2021, GDP had rebounded to pre-pandemic levels.

The sub-category breakdown shows that LDV sector's GDP is dominated by motor vehicle and parts dealers and automotive repair and maintenance – service-oriented components. These segments tend to be less sensitive to short-term shocks, which helps explain the sector's relative stability over time. Figure 8 shows that while dealership activity and repair services continued through most of the pandemic, the 2020 GDP drop likely reflects temporary constraints on operations and supply chains rather than a collapse in demand. Importantly, this GDP measure reflects value generated by the sector, not vehicle usage level or vehicles on the road, meaning fewer vehicles on the road during pandemic does not directly translate into proportionally lower GDP.

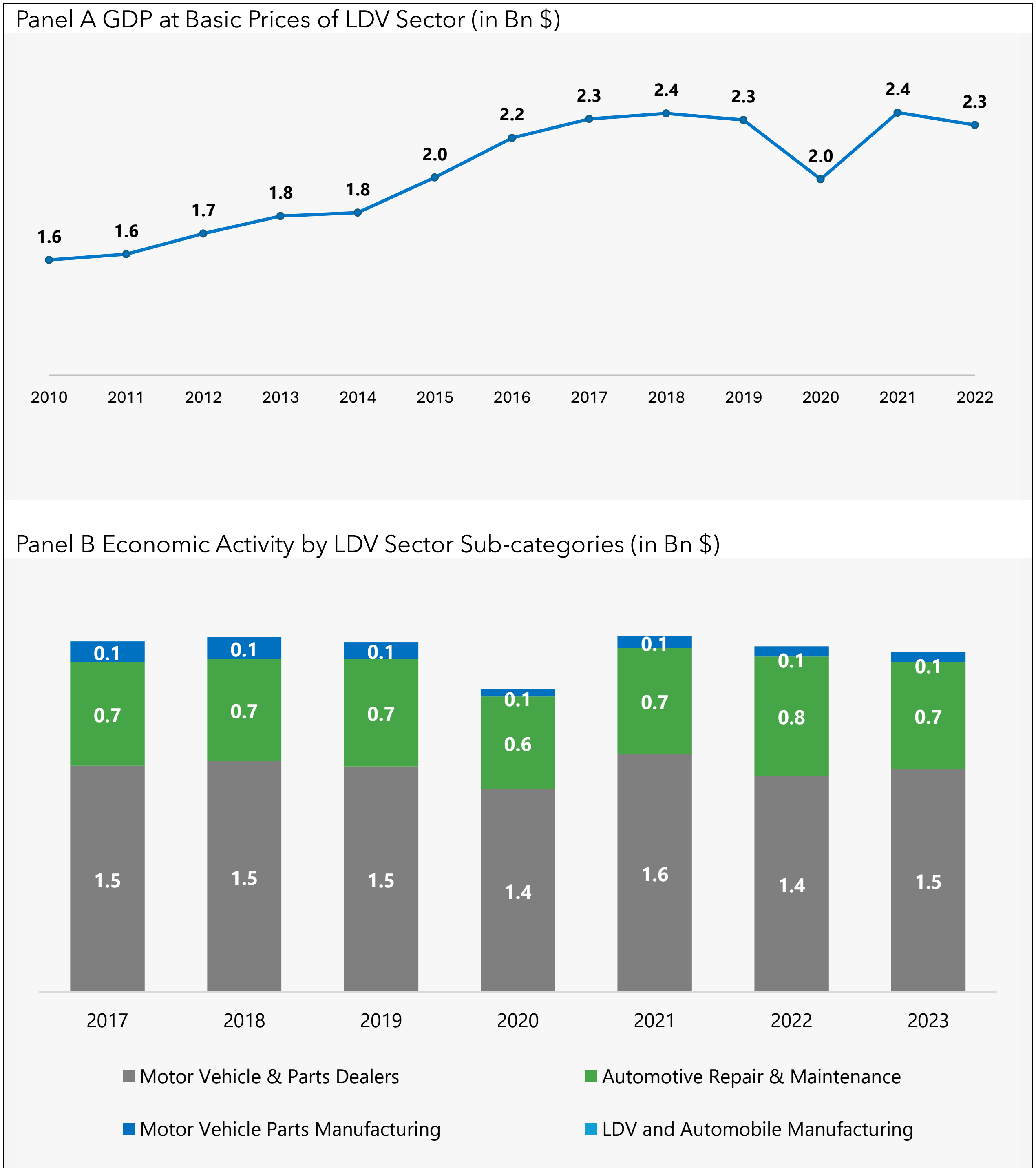


Figure 8 GDP of LDV Sector

4.2.2. Allied Economic Impacts[K]

Full-time Equivalent Jobs (per million dollars of output)

Table 5 FTE Jobs in the LDV Sector (2010 vs. 2022)

Sub-Sector	2010 FTE Jobs	2022 FTE Jobs	% Change (2010-2022)
Motor vehicle & parts dealers	14,618	15,749	+7.7% ↑
Automotive repair & maintenance	8,579	8,310	-3.1% ↓
LDV & automobile manufacturing	48	0	-100.0% ↓
Motor vehicle parts manufacturing	688	455	-33.9% ↓
Total LDV Sector	23,933	24,514	+2.6% ↑

In 2022, the LDV sector supported an estimated 24,514 FTE jobs, up slightly from 23,933 in 2010. The largest contributions came from motor vehicle and parts dealers (15,749 FTEs) and automotive repair and maintenance (8,310 FTEs), which together account for nearly all sectoral jobs reflecting the dominant contribution of these service-oriented subsectors in the LDV sector's GDP.

Employment in motor vehicle parts manufacturing declined (455 FTEs in 2022 vs. 688 in 2010), consistent with broader productivity gains and structural shifts in the supply chain. As with the building sector, such declines are not necessarily negative but instead reflect technological advancements, operational efficiency improvements, and rising labour productivity over time.

Labour Income and Tax Revenue

Table 6 Labour Income in the LDV Sector (2010 vs. 2022, $ Millions)

Sub-Sector	2010 Labour Income	2022 Labour Income	% Change (2010-2022)
Motor vehicle & parts dealers	748	1,131	+51.2% ↑
Automotive repair & maintenance	346	499	+44.2% ↑
LDV & automobile manufacturing	2	0	-100.0% ↓
Motor vehicle parts manufacturing	43	35	-18.6% ↓
Total LDV Sector	1,139	1,665	+41.6% ↑

[K] The allied impacts presented in this section are derived using Statistics Canada's Input–Output multipliers and should be interpreted as model-based estimates rather than direct counts or measurements. These figures are intended to provide an indicative sense of the broader economic footprint of the building sector, rather than precise observed totals.

In 2022, the LDV sector generated $1.6 billion in labour income, up from $1.1 billion in 2010. The majority came from motor vehicle and parts dealers ($1.1 billion) and automotive repair and maintenance ($499 million), together accounting for nearly all sectoral income. Labour income in parts manufacturing remained flat at about $35 million, mirroring the sector's decline in FTE jobs. Overall, the increase in income suggests rising average earnings per worker, driven by both wage growth in retail and repair subsectors and productivity improvements across the sector.

Total tax revenue in 2022 is estimated to be $215 million, a 29.6% increase from $166 million in 2010, highlighting the sector's modest fiscal contribution alongside relatively stable GDP performance.

Fuel Expenditure

Using the methodology outlined in Section 3.1.2 (Fuel Economy), fuel demand and expenditure in the region are estimated using two distinct approaches, with 2017 as the baseline year.

1. Static method: Measures fuel demand based solely on new vehicles registered in each year. Because this approach is not cumulative, the sharp drop in new vehicle registrations during the COVID-19 pandemic is reflected in a decline in fuel expenditure to $31 million in 2020.
2. Dynamic method: Measures fuel demand cumulatively, accounting for the fact that vehicles registered in prior years remain on the road in subsequent years. For example, vehicles registered in 2017 contribute to demand in later years, alongside newly registered vehicles. This produces a steadily rising trend, from $43 million in 2017 to $258 million in 2022.

While the dynamic method better reflects actual fuel demand, it is subject to vehicle "survivability" factors i.e., the typical lifespan after which vehicles exit the fleet. Given the short study period, vehicle retirements have minimal effect, though survivability is incorporated and Panel B in Figure 10 shows the estimated survivability of vehicle by age.

The estimates here are based on a composite fuel type; however, the model provided to the MV team can compute demand and expenditure by specific fuel categories, including gasoline, diesel, and battery electric. Importantly, not all fuel expenditure is attributable to MV or BC, as the province imports approximately 70% of its energy. Accordingly, only 30% of total fuel expenditure is presented as attributable to the region.[22]

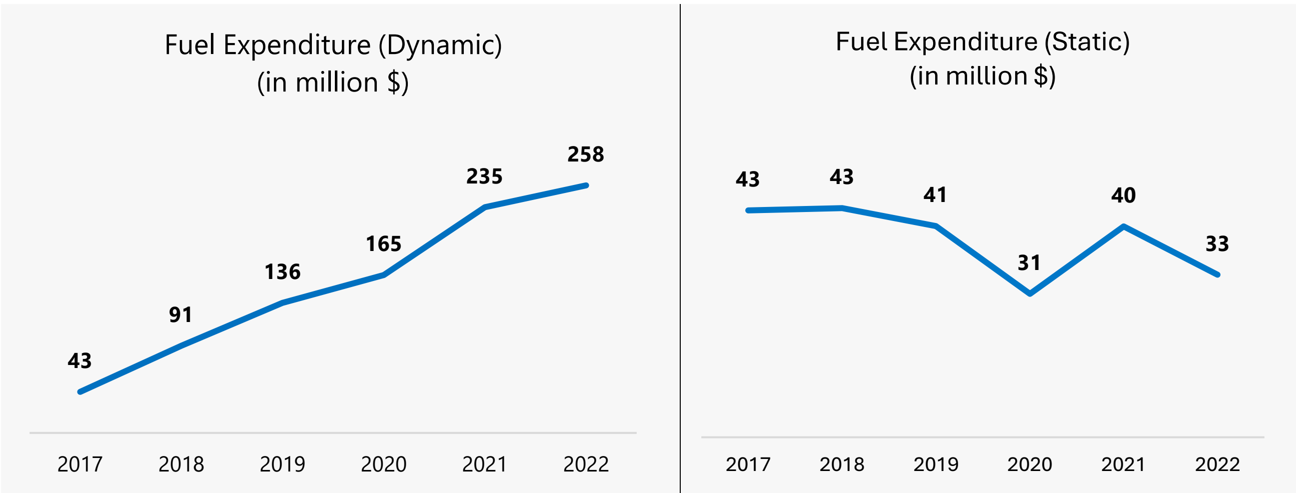


Figure 9 Fuel Expenditure in the region

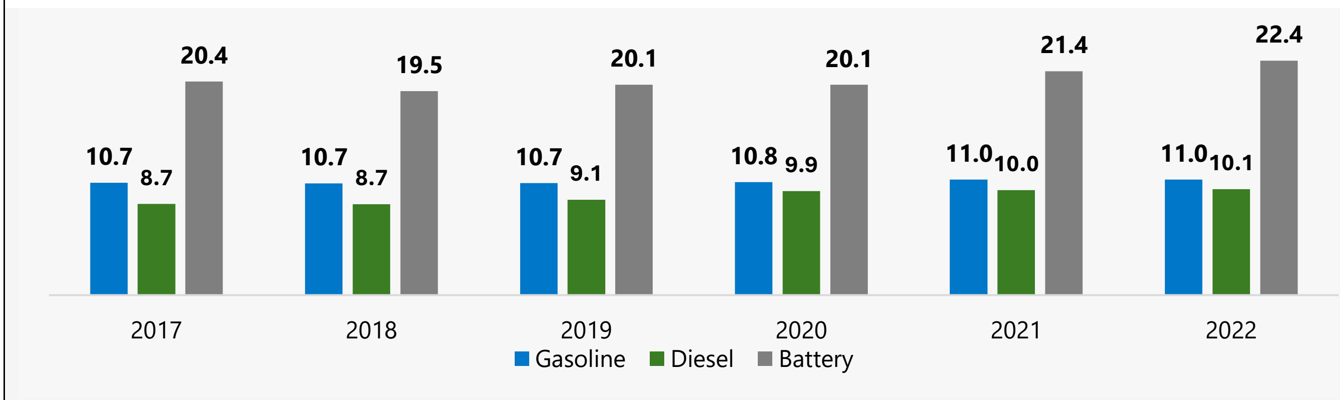
Fuel expenditure depends on several factors, including whether the vehicle is driven in city, highway, or combined conditions, and the type of LDV - passenger car, pickup truck, multi-purpose vehicle, or van. However, the most significant determinant is fuel type: gasoline, diesel, or battery electric. Each has a different efficiency, measured in litres (or kWh) required to drive 100 km.

The fuel expenditure model provided to the MV team can incorporate all permutations, thus allowing users to select a specific vehicle type, fuel type, and driving condition to generate tailored estimates. For this report, however, the focus is on *all vehicles* under a *combined* driving condition (city and highway), with fuel efficiency expressed as a composite weighted average.

Panel A of Figure 10 below shows that battery-electric vehicles are nearly twice as energy-efficient as gasoline and diesel vehicles. They also require less maintenance due to having fewer moving parts. This raises an intuitive question: if battery-electric vehicles are more road-efficient and require less maintenance, could reduced operating expenditure negatively affect regional GDP?

To address this, we return to the discussion in Section 4.1.5 (*Green Investments*). Evidence suggests that expenditure on clean energy or resource-efficient operations can have a greater GDP impact between 1.1 and 1.5 times that of traditional investment. This is due to factors such as long-term cost savings (e.g., lower energy use per km for battery-electric vehicles), innovation spillovers (R&D in clean technologies), and the labour-intensive nature of related industries (e.g., retrofitting buildings, installing solar panels, EV battery diagnostics), which often require specialized skills and boost productivity. In this sense, while EV adoption may reduce fuel expenditures, it can also redirect spending toward higher-multiplier sectors, resulting in a net positive economic effect.

Panel A Fuel Efficiency (L/kWh per 100 KM)



Panel B Estimated Survivability by Vehicle Age

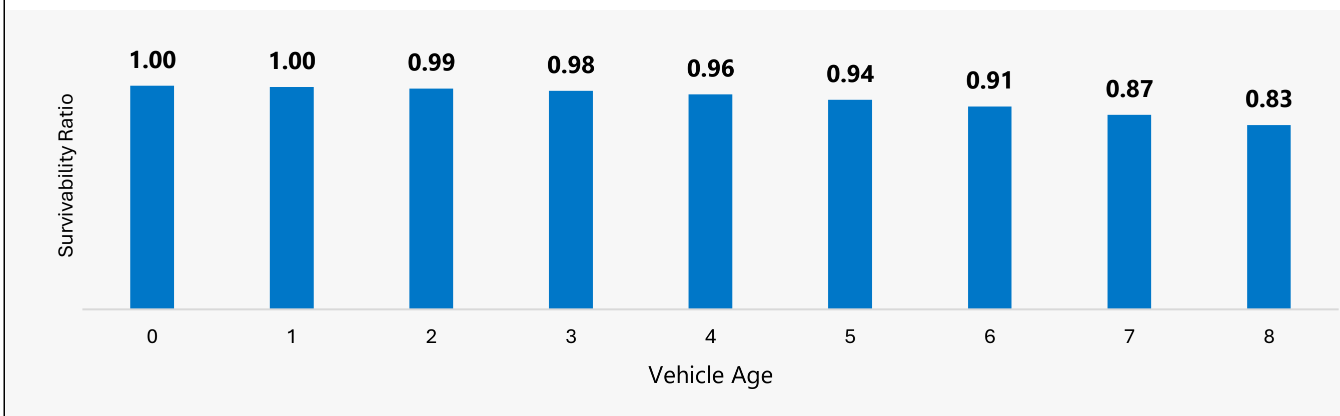


Figure 10 Fuel Efficiency and Estimated Survivability of LDV Vehicles by Vehicle Age

4.2.3. LDV Emissions Overview

The LDV sector is the largest single source of GHG emissions in the MV region, accounting for nearly 30% of total regional emissions in 2022,[23] with the highest share attributable to personal driving.[24] Sector-wide emissions have declined slightly since 2010, from 5.4 million tonnes CO_2e to 5.2 million tonnes CO_2e - a reduction of 3.7%.[25]

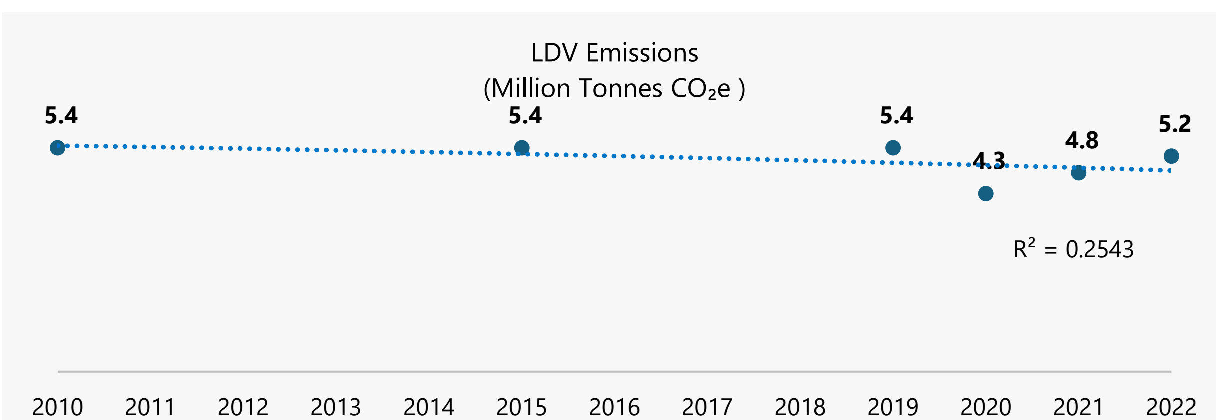


Figure 11 LDV Emissions

4.2.4. Greening the Economic Activity

Carbon Productivity

In 2022, the sector produced $444 million in economic activity for every million tonnes of carbon emitted, up 49% from $297 million in 2010. This improvement suggests that, on average, the sector is generating more economic value per unit of emissions, indicating potential gains in energy efficiency and operational practices with reasons attributable to discussed in the subsection on shift in mobility pattern and vehicle types on road.

Emissions Intensity

Emissions intensity is the inverse of carbon productivity, measuring the amount of GHG emissions generated per unit of economic output. For the LDV sector, emissions intensity fell from 0.0034 tonnes per million dollars of GDP in 2010 to 0.0023 tonnes in 2022 – a 33% reduction.

Applying the emissions intensity effect formula outlined in Section 3.2, yields a value of –2.133 per million tonnes. Using a social cost of carbon of $270 per tonne, this reduction translates into an estimated $576 million in avoided climate-related damages to Canada over the period 2010–2022.

This improvement indicates that, relative to economic output, the sector has become less emissions intensive. However, as noted in the carbon productivity and emission intensity discussion of the building sector, this does not necessarily imply absolute decarbonization.

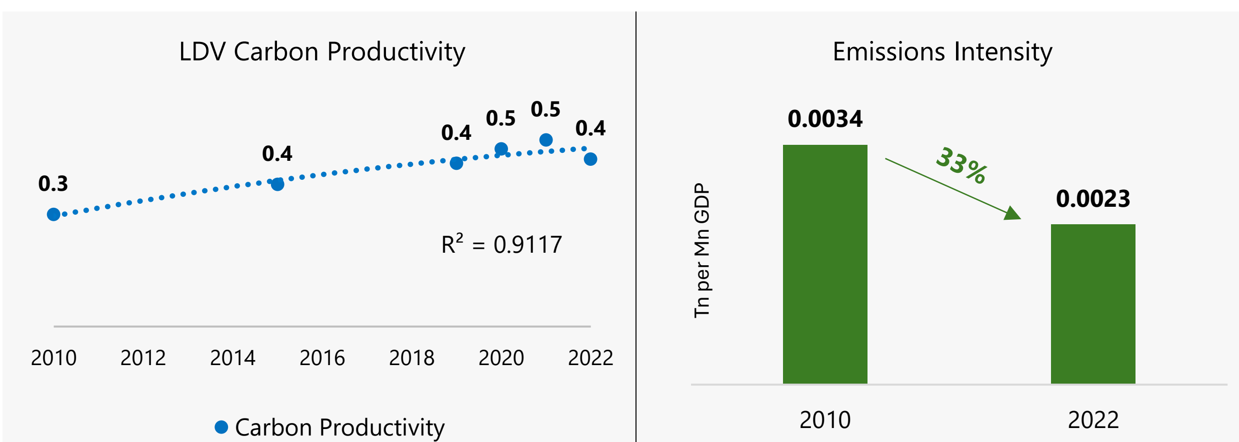


Figure 12 LDV Sector Emission Efficiency

Shift in Mobility Pattern and Vehicle types on Road

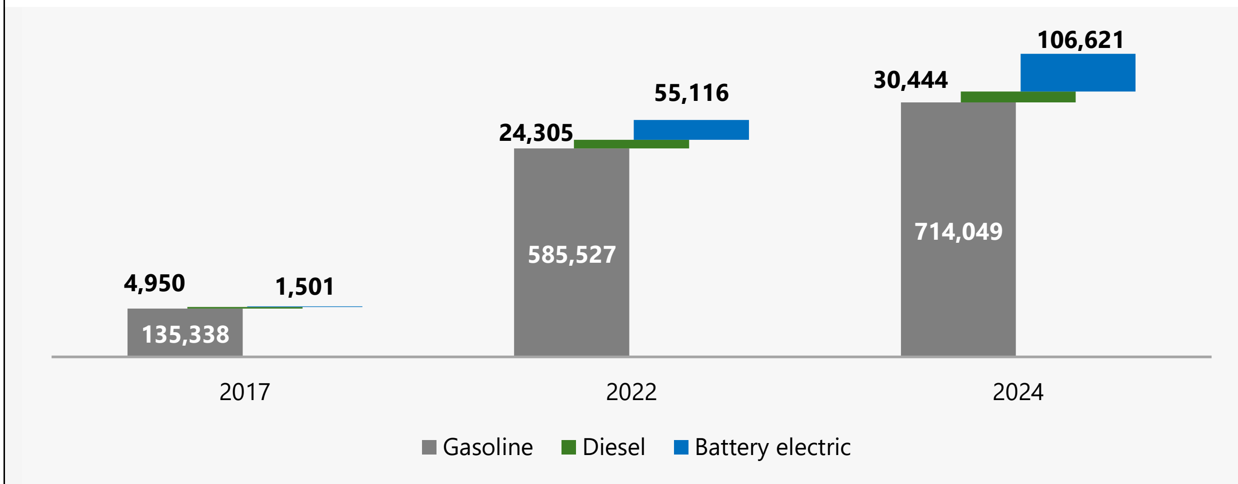
Several factors have contributed to the absolute decline in the emissions:

1. Increased EV adoption – Registered EVs in Metro Vancouver grew from 1,501 in 2017 to 106,621 projected on the roads by 2024 (Panel A Figure 13).

2. Gradual mode shift toward sustainable mobility – Between 2017 and 2023, the share of personal driving trips fell from 46% to 40%, while walking increased from 25% to 29%, along with small gains in cycling and transit use (Panel B Figure 13).
3. Policy interventions – Measures such as the federal LDV fuel economy standards, the SkyTrain Evergreen Extension, municipal EV-Ready bylaws, and the BC Zero-Emission Vehicle (ZEV) Act have all supported reductions in emissions intensity and encouraged the uptake of low- or zero-emission vehicles.[26]

While the overall reduction is modest, these structural shifts particularly in vehicle technology and travel behaviour suggest that the sector is moving toward lower-carbon operations and cleaner fuel. Importantly, as discussed in Section0 (Fuel Expenditure), increased EV adoption not only improves fuel efficiency and reduces emissions but can also redirect spending toward higher-multiplier, clean-technology sectors, generating broader economic benefits alongside environmental gains.

Panel A Vehicles on Road by Fuel Type with 2017 as baseline



Panel B Trip Mode Share

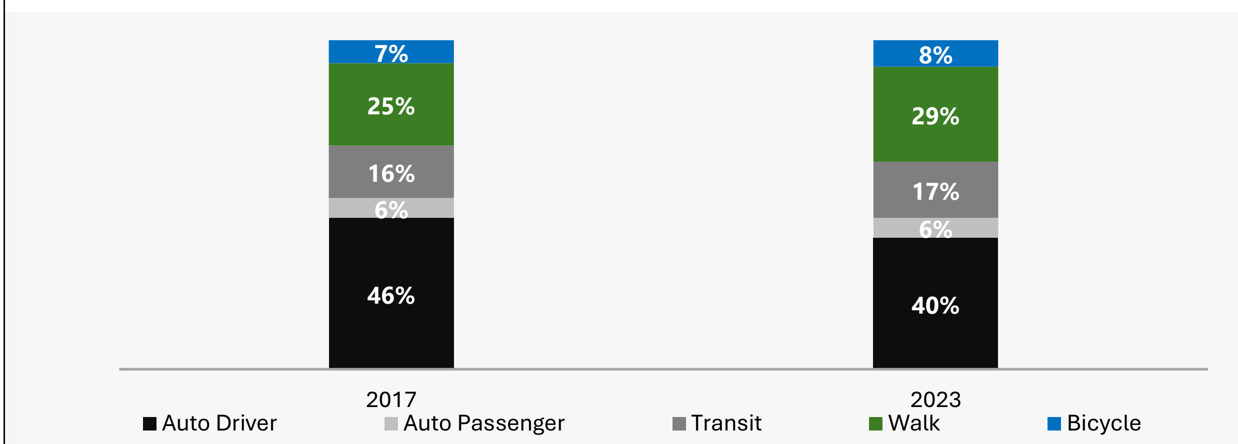


Figure 13 Dynamic Vehicle Registrations by Fuel-type and Trip Mode Share

4.3. Decoupling Analysis

4.3.1. Tapio Elasticity

Tapio elasticity measures the responsiveness of GHG emissions to changes in economic output, calculated as the percentage change in emissions divided by the percentage change in GDP over a given period. Its intuitive interpretation and straightforward calculation make it a widely used tool in policy analysis for assessing the extent of "decoupling" between economic growth and environmental impact.

In this report, Tapio elasticity is examined in three phases:

1. 2010–2022 – Comparing the earliest and latest available data points to assess long-term decoupling trends.

2. Year-on-year, 2019–2022 – Tracking decoupling progress through the COVID-19 period to identify years of strong, weak, or negative decoupling.

3. 2019–2022 vs. 2010 baseline – Assessing how each of the post-2019 years decoupled relative to 2010.

2010-2022

1. LDV sector: Between 2010 and 2022, GDP grew by 44%, while emissions fell by 3.7%, resulting in a Tapio elasticity of –0.084. This indicates ***strong decoupling,*** where economic activity increased alongside an absolute reduction in emissions - meaning the sector successfully grew its economic output while lowering its total emissions over the period.
2. Buildings sector: GDP increased by 55%, while emissions grew by 14.6%, resulting in a Tapio elasticity of 0.266. This reflects ***weak decoupling***, where emissions continued to rise but at a slower rate than economic output - indicating that the sector's emissions intensity has improved, though absolute emissions have not declined.

Year-on-year, 2019–2022

When plotting year-on-year changes in GDP and emissions across the eight Tapio decoupling categories, the COVID-19 period serves as a near "natural experiment."

1. 2020 – The LDV sector experienced ***recessive decoupling***: both GDP and emissions declined, but emissions fell by a greater percentage than GDP. This aligns with the sharp drop in on-road activity due to lockdowns and travel restrictions, while GDP contracted because of supply chain disruptions and reduced economic activity. The buildings sector, however, did not follow this pattern. While GDP fell, emissions still grew compared with 2019, reflecting the operational nature of building emissions (e.g., heating and cooling), which continued largely unaffected by the pandemic.

2. 2021 – For LDVs, the pandemic effects largely dissipated, with both GDP and emissions increasing relative to 2020, resulting in ***weak decoupling*** (emissions grew more slowly than GDP). The buildings sector remained less responsive, as discussed in Section 4.1.2, with economic activity still recovering slowly while operational emissions stayed elevated.

3. 2022 – LDV GDP fell compared with 2021, which had been boosted by immediate post-pandemic recovery, while emissions grew. This combination represents ***negative decoupling,*** where economic activity contracts but emissions rise.

2019–2022 vs. 2010 baseline

When comparing each year in the 2019–2022 period against 2010 as a baseline, the results are stable, hopeful and positive for both sectors as they demonstrate decoupling:

1. Buildings – All years show ***weak decoupling,*** with emissions higher than in 2010 but increasing at a slower rate than GDP.
2. LDVs – All years show ***strong decoupling***, with emissions consistently below 2010 levels and GDP higher, indicating sustained separation of economic growth from emissions.

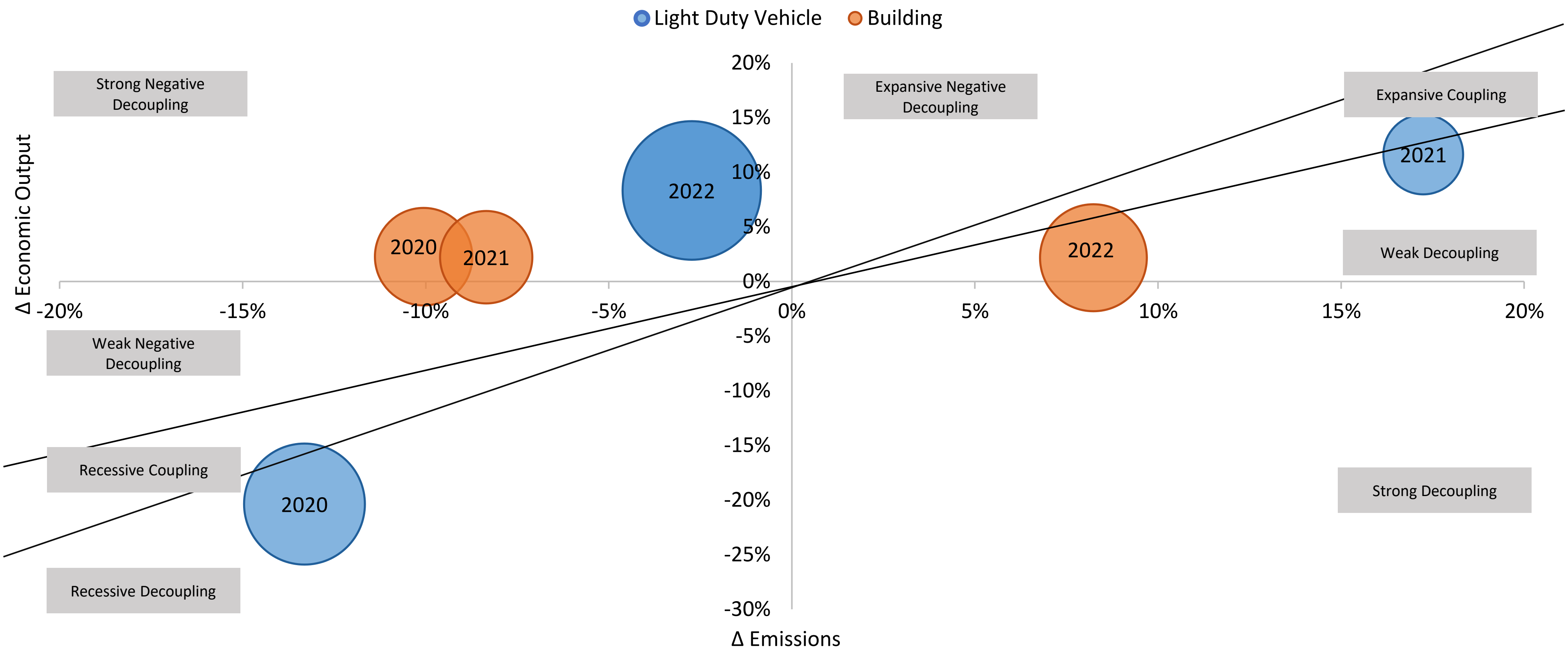


Figure 14 Tapio Elasticity Analysis Year-on-Year, 2019-2022

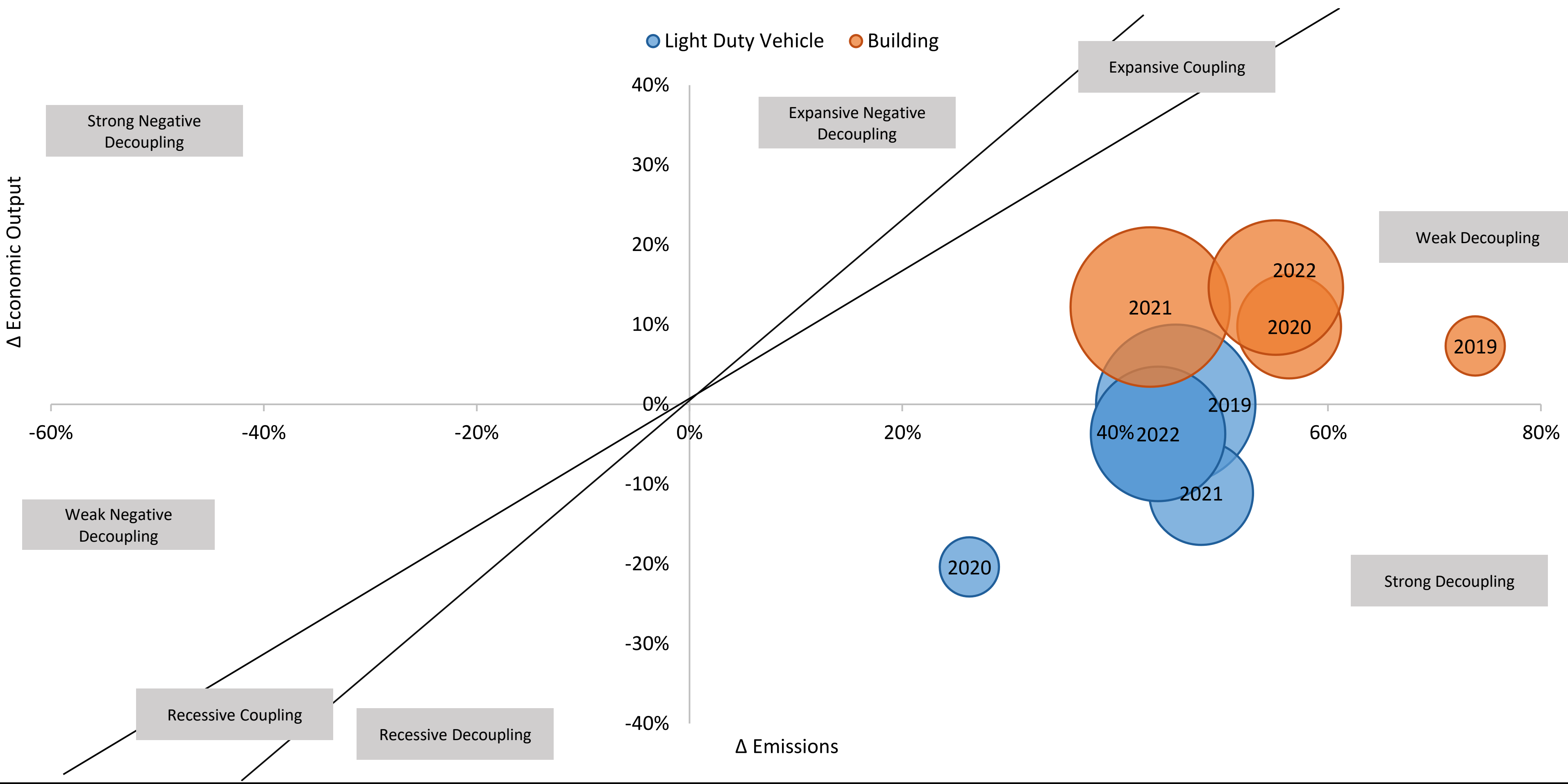


Figure 15 Tapio Elasticity Analysis Year-on-Year, 2019-2022 vs 2010 baseline

4.3.2. Log Mean Divisa Index

The Log Mean Divisia Index (LMDI) is an index decomposition technique that attributes change in emissions to underlying drivers such as emissions intensity, economic output, and changes in each sector's share of total economic activity. As outlined in Section 3.2 (Log Mean Divisia Index), this study focuses specifically on the building and LDV sectors, rather than the entire regional economy, to directly examine their role in decoupling. For modelling purposes, buildings are considered *emissions-efficient* relative to LDVs because their emissions intensity is lower. Under this assumption, an increase in the building sector's share of total GDP is treated as a positive outcome in the decomposition results (and negative % share in total economic activity effect).

The LMDI decomposition is carried out for four time periods:

1. **2010–2022** – Combined emissions from the two sectors increased by 0.4 Mt CO_2e, driven primarily by a 4.138 Mt CO_2e contribution from total economic activity growth. This was partially offset by a negative emissions intensity effect (–3.461 Mt CO_2e), indicating improved efficiency across both sectors, and a small negative share effect (–0.277 Mt CO_2e), reflecting a shift in GDP share toward the more emission efficient building sector. Overall, emissions rose, but most of this increase is attributable to economic growth, with emission efficiency gains nearly offsetting that rise.
2. **2010–2015** – Total emissions declined by 0.5 Mt CO_2e, with a substantial negative emissions intensity effect (–1.773 Mt CO_2e) indicating emissions efficiency improvements. The share effect was slightly positive (0.057 Mt CO_2e), indicating a marginal increase in LDV's share of GDP, which has higher emissions intensity than buildings.
3. **2015–2019** – This period saw the largest increase in emissions (+0.8 Mt CO_2e), largely from economic activity growth (+0.835 Mt CO_2e). The emissions intensity effect remained slightly negative (–0.084 Mt CO_2e), which is favourable, but the positive share effect (+0.050 Mt CO_2e) points to a rising GDP share for the less emission efficient LDV sector, adding upward pressure on emissions.
4. **2019–2022** – During the COVID-19 period, total economic activity contracted (–0.972 Mt CO_2e effect) while emissions still grew slightly (+0.1 Mt CO_2e). This was due to a positive emissions intensity effect (+0.680 Mt CO_2e), indicating efficiency losses, and a positive share effect (+0.392 Mt CO_2e) from a larger GDP share going to the less efficient LDV sector.

While year-to-year dynamics vary, the 12-year trend shows that most of the emissions growth is attributable to increases in total economic activity. Efficiency improvements captured in the negative emissions intensity effect have played a significant role in offsetting these increases, with modest additional gains from shifting GDP share toward the more efficient building sector.

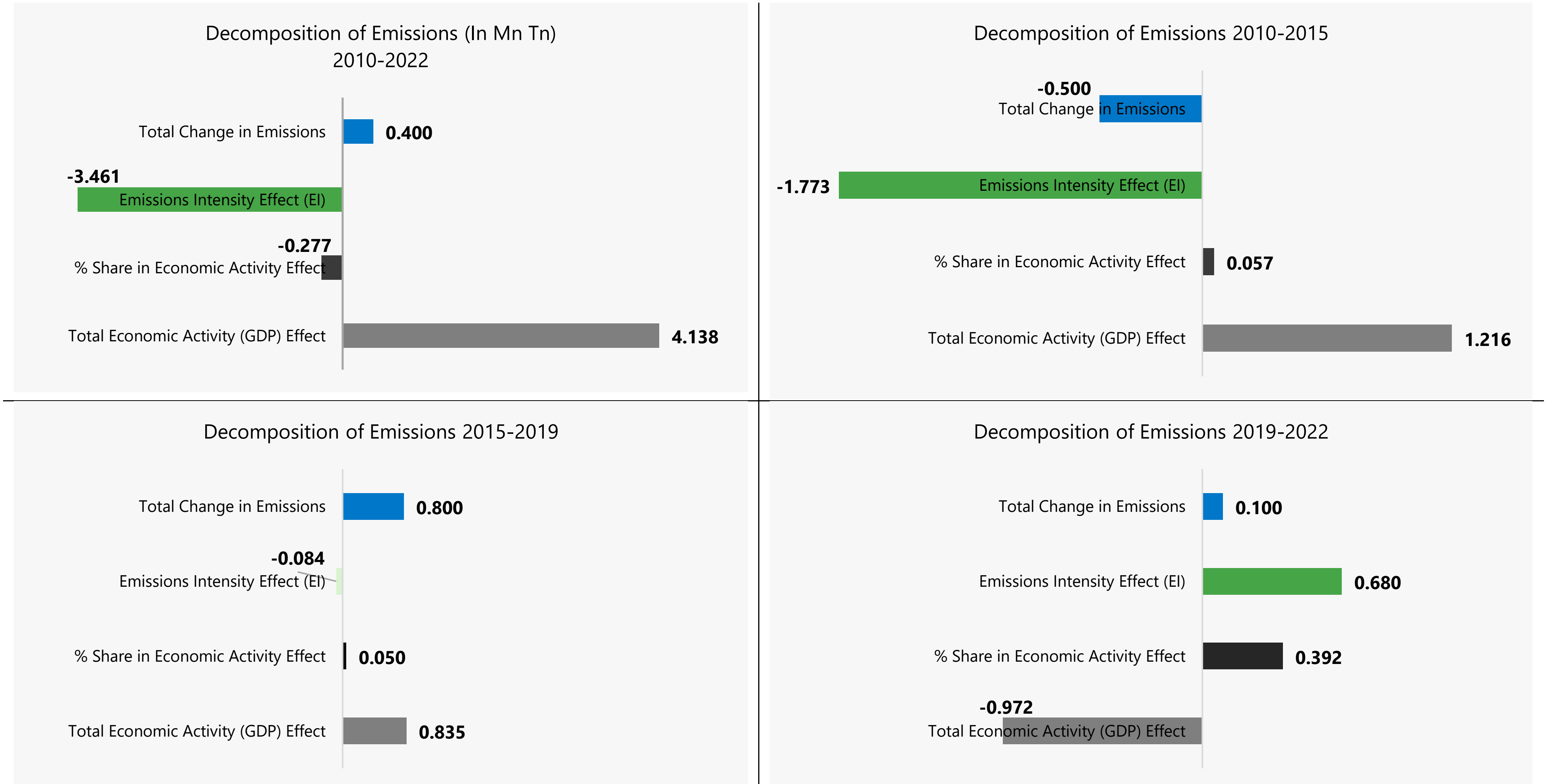
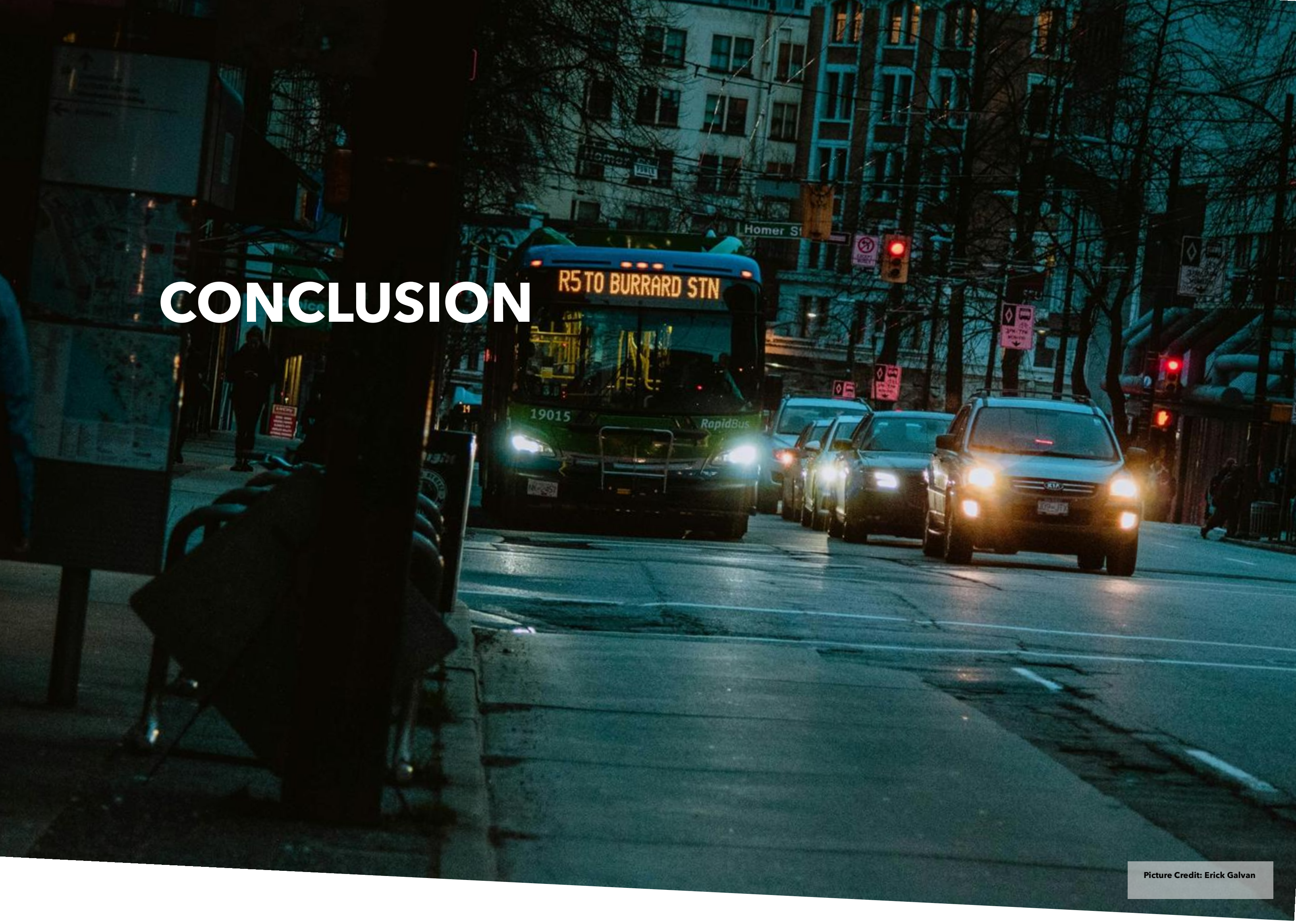


Figure 16 LMDI Decomposition over 2010-2022

CONCLUSION



Picture Credit: Erick Galvan

Between 2010 and 2022, economic output from both the building and transportation light-duty vehicle (LDV) sectors in the Metro Vancouver region grew substantially. GDP in the building sector rose by 55% and in the LDV sector by 44%. Over the same period, building sector emissions increased by 14.6%, while LDV emissions fell by 3.7%. This means the building sector achieved *weak decoupling*, i.e., GDP grew faster than emissions, while the LDV sector achieved *strong decoupling*, with economic growth alongside an absolute reduction in emissions.

For LDVs, emissions reductions have been driven by sustainable mobility shifts: a steep rise in electric vehicle registrations, greater uptake of walking and cycling, and telecommuting. In the building sector, operational emissions continue to rise with new construction, though measures such as the BC Energy Step Code represent progress. Our analysis shows that the estimated $470 million in Step Code–related investment in 2022 could generate up to 29% more GDP than traditional construction spending, reflecting higher green investment multipliers.

The LMDI decomposition confirms that most changes in emissions are explained by growth in economic activity, with improvements in emissions intensity providing a partial offset. This underscores the need for targeted measures that sustain efficiency gains while curbing activity-driven emissions growth.

Discussions with regional experts reveal that while MV businesses generally have the *ability* to adopt climate-positive practices, *willingness* is often lacking unless driven by regulation. Compliance tends to align with minimum standards, and cost remains a prohibitive factor, especially when paybacks exceed one or two quarters. Existing incentives – such as CleanBC tax credits or BC Hydro programs – are underutilized due to informational gaps and misalignment with business needs.

For the region to meet its Clean Air Plan objectives, stronger regulatory frameworks, better-targeted incentives, and reframing sustainability as a business efficiency strategy will be essential to translate technical and economic capacity into sustained emissions reductions.

6. APPENDIX

6.1. Synthesis of Systematic Literature Review

Title	Authors	Year	Country	Sector	Main Findings
Exploring the Dynamic Evolution and Drivers of the Coupled Coordination Relationship of Carbon Emission Efficiency and Economic Benefits in Construction Land Development	Zhang P.; Jin T.; Wang Y.; Guo H.	2025	China	Construction Land	- Spatial heterogeneity in decoupling, where the western region has not fully optimized industrial structure leading to heavy reliance on resource-intensive extraction - With the pace of urbanization between 2008-2013, the need to support infrastructure development increased and the intensity of land development increased significantly. In the process, the concept of low carbon planning, and green construction have not been fully implemented - Between 2013-2018, eastern and central China achieved relative decoupling due to policies promoting energy-saving, emission reduction, and green development measures
Driving factors and interactions of urban transportation carbon emissions: A case study of China	Wan J.; Wu X.; Li Y.; Li Z.; Deng K.; Zeng J.; Fan X.; Cao Y.	2025	China	Transportation	- Chief contributor to carbon emissions in transportation sector are gasoline, kerosene, diesel, fuel oil - they still dominate the market but their expansion rates have come down - City's large size, extensive public transport network, and significant private vehicle ownership, which offset the emissions reductions from increased public transit ridership
City-level transport decarbonization in China: A novel two-dimensional decoupling pathway analysis model	Zheng J.; Hu Y.	2025	China	Transportation	- The one-dimensional decoupling model cannot distinguish decoupling states among regions with varying economic development levels, thus need two dimensional - The decoupling pathways for Co2 emissions in the transport sector from the economic growth of Chinese cities showed an improved trend
Spatiotemporal Characteristics and Decoupling Effects of Urban Construction Land Expansion in Plateau Basins	Zeng Y.; Lobsang T.; Luo X.; Zhang Z.; Yang H.; Zhao X.	2025	China	Construction Land	- Weak decoupling remains prevalent. Many basins display unstable decoupling, relying heavily on land for economic growth - Policies changes boosting construction land expansions - Fluctuating decoupling state is driven by socioeconomic and policy factors
Analysis of Energy-Related-CO2-Emission Decoupling from Economic Expansion and CO2 Drivers: The Tianjin Experience in China	Yang F.; Lv Q.	2024	China	-	- Decoupling performance of Chinese cities has reduced - The decoupling index of CO2 throughout the study period shows three states, weak decoupling, expansive negative decoupling, and strong decoupling, and overall, the weak decoupling state is the most prevalent
Carbon emissions of urban rail transit in Chinese cities: A comprehensive analysis	Pu J.; Cai C.; Guo R.; Su J.; Lin R.; Liu J.; Peng K.; Huang C.; Huang X.	2024	China	Transportation	- ENI (Energy consumption per unit) passenger turnover serves as a leading indicator of increase in URT emissions - Emissions were highest in well-developed Type I cities (highest URT)
Towards Carbon Neutrality: Machine Learning Analysis of Vehicle Emissions in Canada	Guo X.; Kou R.; He X.	2024	Canada	Transportation	- Fuel consumption in the cities and on the highways had the greatest impact on the CO2 - Ethanol and diesel had significant effect on CO2 emissions
Economic growth and carbon emissions analysis based on tapio-ekc coupled integration and scenario	Hou L.; Wang Y.; Hu L.; Wang Y.; Li Y.; Zheng Y.	2024	China	Transportation	- most of the decoupling is more volatile in provinces with higher levels of economic development - Tapio decoupling shows most provinces show an inverted U-shaped state

simulation: a case study of China's transportation industry					
Urban expansion, economic development, and carbon emissions: Trends, patterns, and decoupling in mainland China's provincial capitals (1985–2020)	Zhao J.; Chen W.; Liu Z.; Liu W.; Li K.; Zhang B.; Zhang Y.; Yu L.; Sakai T.	2024	China	-	- Over 40 years the impervious land construction grew then gradually came down - National carbon emissions slowed down from 2015 onwards
A ZSG-DEA model with factor constraint cone-based decoupling analysis for household CO2 emissions: a case study on Sichuan province	Zhao R.; Liu J.; Long H.; Xiong X.; Wu D.	2023	China	Household Consumption	- Indirect emissions from the household accounted for the 60% of the emission while direct were notably from natural gas consumption with annual avg of 41% - Housing contributed to the maximum proportion of indirect CO2, see table 3 for what constitute in housing
Decoupling effect and driving factors of carbon footprint in megacity Wuhan, Central China	Pan G.; Li X.; Pan D.; Liu W.	2023	China	-	- From 2001-2020, Wuhan was in carbon surplus state and under pressure to reduce its emissions - Urban per capita residential building area is crucial in promoting Wuhan's CF
Impact from the evolution of private vehicle fleet composition on traffic related emissions in the small-medium automotive city	Tian X.; Huang G.; Song Z.; An C.; Chen Z.	2022	Canada	Transportation	- Quantity of SUVs have increased over the years - Emissions from SUVs and trucks rose by 374.0% and 69.3%, respectively, whereas emissions from four-door cars, two-door cars, station wagons, and vans all decreased
Spatiotemporal dynamics and driving forces of city-level CO2 emissions in China from 2000 to 2019	Li R.; Li L.; Wang Q.	2022	China	Transportation	- Income growth, private cars and cargo turnover play a nonlinear role in promoting carbon emissions - Results show that urbanization curbs carbon emissions from the transport sector, but this effect is lower than that of energy efficiency - Decoupling between income growth and CO2 in the Chinese transport sector are poor
Operational carbon transition in the megalopolises' commercial buildings	Gao S.; Zhang X.; Chen M.	2022	China	-	- Over two decades, carbon emissions intensity decreased and aggregated, and achieved an inflexion point as well - Economic development, industrialization, transportation, land urbanization, and the development of the electricity, gas, and water sector were the dominant socioeconomic factors contributing to the emissions - estimated using Random Forest model
Chinese cities exhibit varying degrees of decoupling of economic growth and CO2 emissions between 2005 and 2015	Ma M.; Feng W.; Huo J.; Xiang X.	2022	China	Buildings	- Operational carbon emissions from commercial buildings continued to rise at an annual level of 17.7%, with economic growth effects and energy use being the key drivers contributing to the rise - Megalopolises have been able to achieve decoupling
Decoupling analysis of traffic system carbon emission and coordination degree physical model	Shan Y.; Fang S.; Cai B.; Zhou Y.; Li D.; Feng K.; Hubacek K.	2021	China	-	- Improvement in the production and carbon efficiency is the most important factor - Decarbonizing the energy mix is the key factor as well
Material consumption and carbon emissions associated with the	Hao C.; Xin Y.	2021	China	Transportation	-China's urban traffic carbon emission shows improvement trend on the whole, although it shows varying degrees of fluctuation

infrastructure construction of 34 cities in northeast China					
Empirical study on carbon emission measurement and influencing factors of urban traffic based on "Population-Economy-Environment"	Liu C.; Wang X.; Lai F.; Huang Y.	2020	China	Transportation	-Energy consumption is negatively related to transportation carbon emissions and other factors are positively correlated
Decoupling sectoral economic output from carbon emissions on city level: A comparative study of Beijing and Shanghai, China	Wang Q.; Zhao M.; Li R.	2019	China	-	- Both cities observed strong decoupling, where economic output increased but CO2 emissions decreased - Different degrees of decoupling amongst different sectors
Determinants of decoupling economic output from carbon emission in the transport sector: A comparison study of four municipalities in China	Wang Q.; Wang S.; Li R.	2019	China	Transportation	-There were varying findings wrt decoupling across studied provinces - There were four decoupling state, expansive coupling, negative decoupling, weak decoupling, strong decoupling
Estimation of carbon emission and identification of driving factors in the Circum-Changsha-Zhuzhou-Xiangtan urban agglomeration of China	Deng Q.Z.; Tian Y.C.	2019	China	Agriculture, Industry, Transportation	-There is an inverted U shape curve between carbon emissions and per capita GDP - Human capital played a role in promoting growth and change of carbon emissions - Overall, observe a weak decoupling trend
Whether carbon intensity in the commercial building sector decouples from economic development in the service industry? Empirical evidence from the top five urban agglomerations in China	Ma M.; Cai W.; Cai W.; Dong L.	2019	China	Buildings	- The decoupling status was weak from 2001 to 2005 and then strong decoupling 2006 to 2015 - Decoupling status across the different urban agglomeration - commercial building sector
Decoupling analysis of CO2 emissions in transportation sector from economic growth during 1995-2015 for six cities in Hebei, China	Zhang L.; Kou C.; Zheng J.; Li Y.	2018	China	Transportation	-Heterogeneity in the decoupling/coupling status of the cities - Cities dominated by traditional industries emitted more CO2 in transportation sector than the industrial transformation cities
Empirical research on decoupling relationship between energy-related carbon emission and economic growth in Guangdong province	Wang W.; Kuang Y.; Huang N.; Zhao D.	2014	China	-	- Over the study period, the decoupling elasticity values rose from weak decoupling to expansive decoupling - Land economic output was the primary inhibiting factor, while energy intensity was the main promoting factor for decoupling

based on extended kaya identity					
A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part I: bibliometric and conceptual mapping	Dominik Wiedenhofer, Doris Virág et al.	2020	-	-	-This systematic review assesses the extent of decoupling economic growth from resource use and emissions, - Highlighting gaps in current research approaches and calling for more comprehensive analyses to address sustainability and climate crises.
Analysis of the Decoupling between Urban Economic Development and Transportation Carbon Emissions in China: Empirical Evidence from 284 Cities	Peng Zao, Jiannan Zhao, et al.	2024	China	Transportation	- Synthesis of evidence from 835 peer-reviewed articles. - Evaluation of empirical studies on decoupling related to energy, material resources, CO2, and GHG emissions. - Classification of policies into green growth, degrowth, and others.
Decomposition analysis of the decoupling process between economic growth and carbon emission in Beijing city, China: A sectoral perspective	Min Su, Shasha Wang, Rongrong Li, N. Guo	2020	China	-	The paper analyzes the decoupling between urban economic development and transportation carbon emissions in China, finding most cities are in a weak decoupling state.
Decoupling Analysis of Greenhouse Gas Emissions from Economic Growth: A Case Study of Tunisia	Mounir Dahmani, Mohamed Mabrouki, L. Ragni	2021	Tunisia	-	- Agriculture and industry have achieved strong decoupling, while transport and trade are detrimental to decoupling. - And weak decoupling is detected in construction and other industrial sectors. Meanwhile, transport sector is in expansive negative decoupling
Decoupling economic growth from building embodied carbon emissions in China: A nighttime light data-based innovation approach	Xiaoyun Du, Yangyang Yu, Boamah Fredrick Ahenkora, Yifan Pang	2023	China	Buildings	- Found an inverted U-shape relationship and that renewable energy consumption reduces emissions. - The findings validated an inverted U-shape relationship between GDP and GHG emissions. - The consumption of renewable energy contributes to the reduction of GHG emissions in the long run.
Do commercial building sector-derived carbon emissions decouple from the economic growth in Tertiary Industry? A case study of four municipalities in China.	Minda Ma, W. Cai	2018	China	Buildings	- The paper uses GDP and nighttime light data. - The long-term decoupling results of GDP and NTL are consistent
The methods and factors of decoupling energy usage and economic growth	Soumya Basu, Takaya Ogawa, Keiichi N. Ishihara	2022	-	-	- More significant decoupling effects observed in recent years can be attributed to significant improvements made in the energy efficiency work of China's commercial building sector

6.2. Building Sector Model – Snapshot

INPUT

Year	2022
Construction Type	Total (Both)
ESC Cost Premium Default 4% (Upper end conservative)	4%
ESC Premium Sensitivity (for ex. +-10%)	0%
ESC Adoption Level Sensitivity (for ex. +-10%)	0%

Girish Sharma:
The amount to be spent in order for building to comply with ESC requirements

Girish Sharma:
Based on the literature, the upper-end is 4%. However, if want to test the sensitivity (say 10% less than 4%, one could enter -10% here.

OUTPUT

In $ Mn	Non Residential	Non Residential Step Code	Residential	Residential Step Code
Gross Output (Investment	4,055	130	10,636	340
GDP at Basic Prices	3,479	111	8,973	287
Labour Income	2,074	66	4,719	151
Tax Revenue	568	18	1,584	51
FTE Jobs	27,991	896	67,187	2,150

Note: The figures above presents a snapshot from the Building Sector Model developed for this study. The full dynamic model has been shared with Metro Vancouver staff. Users can adjust input assumptions—such as cost premium, sensitivity levels, and adoption rates—and the model will automatically generate updated outputs for GDP, labour income, tax revenue, and FTE jobs. The values shown here reflect 2022 inputs and serve as an illustrative example of the model's functionality.

6.3. Light Duty Vehicle Model – Snapshot

INPUT

Year	2022
Fuel Economy Selections> (Available only from 2017 onwards)	
Analysis Type	Static
Travel Type	Combined
Fuel Type	All Fuel
Vehicle Type	Passenger cars
BC's Fuel Import Share	70%
BC to MV LDV Registrations	60%

I. OUTPUT

	2017	2018	2019	2020	2021	2022
Fuel Demand in the region	13.35	12.72	10.86	6.53	8.55	6.75

II. OUTPUT

2022	Motor Vehicle & Parts Dealers	Automotive Repair & Maintenance	LDV and Automobile Manufacturing	Motor Vehicle Parts Manufacturing	Total
Light Duty Vehicle GDP at Basic Prices	**1,443**	**796**	**-**	**68**	**2,307**
Labour Income	1,131	499	-	35	**1,665**
Tax Revenue	139	70	-	5	**215**
Jobs Created	15,749	8,310	-	455	**24,513**

Note: The outputs above are drawn from the Light Duty Vehicle (LDV) sector model developed for this study. The complete dynamic model has been shared with Metro Vancouver staff. Users can adjust input parameters such as analysis type, travel type, vehicle category, and regional fuel import shares, and the model will automatically recalculate fuel demand, GDP, labour income, tax revenue, and employment outcomes. The results presented here illustrate the 2022 scenario and demonstrate the model's ability to simulate alternative assumptions and policy settings.

7. REFERENCS

[1] Metro Vancouver. (2021, October). Climate 2050 roadmap: Buildings – A pathway to zero emissions and resilient buildings. Metro Vancouver. https://metrovancouver.org/services/air-quality-climate-action/Documents/climate-2050-buildings-roadmap.pdf

[2] Statistics Canada. (2025, May 26). *Investment in building construction (Survey 5014)*. Statistics Canada. https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5014

[3] Statistics Canada. (2024). Building construction price indexes, by type of building and division. Statistics Canada. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1810028901&pickMembers%5B0%5D=2.7&pickMembers%5B1%5D=3.1&cubeTimeFrame.startMonth=01&cubeTimeFrame.startYear=2017&cubeTimeFrame.endMonth=10&cubeTimeFrame.endYear=2024&referencePeriods=20170101%2C20241001

[4] Statistics Canada. (2025). Investment in building construction, by type of building and sector, monthly (x 1,000,000) [Table: 34-10-0175-01]. Statistics Canada. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1810000401&pickMembers%5B0%5D=1.26&cubeTimeFrame.startMonth=01&cubeTimeFrame.startYear=2000&cubeTimeFrame.endMonth=04&cubeTimeFrame.endYear=2025&referencePeriods=20000101%2C20250401

[5] Statistics Canada. (2024). Building construction price indexes, by type of building and division. Statistics Canada. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1810028901&pickMembers%5B0%5D=2.7&pickMembers%5B1%5D=3.1&cubeTimeFrame.startMonth=01&cubeTimeFrame.startYear=2017&cubeTimeFrame.endMonth=10&cubeTimeFrame.endYear=2024&referencePeriods=20170101%2C20241001

[6] Statistics Canada. (2022). Canadian workforce: Data tables – Labour force statistics. Statistics Canada.https://www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2022023-eng.htm

[7] Natural Resources Canada. (n.d.). Fuel consumption guide. Government of Canada. https://natural-resources.canada.ca/energy-efficiency/transportation-energy-efficiency/fuel-consumption-guide

[8] Government of British Columbia. (2023). Responsible oil and gas development: FPTA consultation paper. Government of British Columbia. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-gas-oil/responsible-oil-gas-development/fpta_consultation_paper_final.pdf

[9] Statistics Canada. (2022). North American Industry Classification System (NAICS) Canada 2022, sector 44-45: Retail trade. Statistics Canada. https://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getVD&TVD=1369825&CVD=1369826&CPV=44-45&CST=27012022&CLV=1&MLV=5

[10] Tapio, P. (2013). The causal relationship between transport and GDP: A literature analysis. https://www.demand.ac.uk/wp-content/uploads/2013/10/tapio.pdf

[11] Ang, B. 2015. LMDI decomposition approach: A guide for implementation. *Energy Policy*. https://www.sciencedirect.com/science/article/abs/pii/S0301421515300173

[12] Statistics Canada. (2016). 2016 Census: Vancouver (city), British Columbia: Reference maps. Statistics Canada. https://www12.statcan.gc.ca/census-recensement/geo/maps-cartes/pdf/S0503/2016S0503933.pdf

[13] Statistics Canada. (2025). Investment in building construction, Canada, monthly [Table: 34-10-0175-01]. Statistics Canada.https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3410017501

[14] Statistics Canada. (2025). Investment in building construction, Canada, monthly [Table: 34-10-0175-01]. Statistics Canada. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3410017501

[15] Life Sciences BC. (2022, June 1). https://lifesciencesbc.ca/industry/minimum-wage-increases-to-16-75-per-hour-on-june-1/

[16] Metro Vancouver. (n.d.). Emission inventories and forecasts.https://metrovancouver.org/services/air-quality-climate-action/emission-inventories-and-forecasts

[17] Metro Vancouver. (2021, October). Climate 2050 roadmap: Buildings – A pathway to zero emissions and resilient buildings. Metro Vancouver. https://metrovancouver.org/services/air-quality-climate-action/Documents/climate-2050-buildings-roadmap.pdf

[18] Metro Vancouver. (n.d.). Emission inventories and forecasts.https://metrovancouver.org/services/air-quality-climate-action/emission-inventories-and-forecasts

[19] BC Housing. (2017). BC Energy Step Code metrics. BC Housing. https://www.bchousing.org/publications/BC-Energy-Step-Code-2017-Metrics-Full.pdf

[20] Nicoletta Batini, Mario di Serio, Matteo Fragetta, and Giovanni Melina. "Building Back Better: How Big Are Green Spending Multipliers?", *IMF Working Papers* 2021, 087 (2021), accessed August 24, 2025, https://doi.org/10.5089/9781513574462.001

[21] Nicoletta Batini, Mario di Serio, Matteo Fragetta, and Giovanni Melina. "Building Back Better: How Big Are Green Spending Multipliers?", *IMF Working Papers* 2021, 087 (2021), accessed August 24, 2025, https://doi.org/10.5089/9781513574462.001

[22] Government of British Columbia. (2023). Responsible oil and gas development: FPTA consultation paper. Government of British Columbia. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-gas-oil/responsible-oil-gas-development/fpta_consultation_paper_final.pdf

[23] Metro Vancouver. (n.d.). Emission inventories and forecasts. https://metrovancouver.org/services/air-quality-climate-action/emission-inventories-and-forecasts

[24] Metro Vancouver. (2023). AQ trends & reports: Transportation.https://metrovancouver.org/services/air-quality-climate-action/Documents/aq-trends-reports-transportation.pdf

[25] Metro Vancouver. (n.d.). Emission inventories and forecasts.https://metrovancouver.org/services/air-quality-climate-action/emission-inventories-and-forecasts

[26] Metro Vancouver. (2023). AQ trends & reports: Transportation. https://metrovancouver.org/services/air-quality-climate-action/Documents/aq-trends-reports-transportation.pdf