TACOMA CLIMATE ACTION PLAN

SECTION 1, ENERGY AND EMISSIONS MODELING RESULTS

MODELING APPROACH

Modeling for Tacoma's Climate Action Plan was completed using population, building, transportation, and energy use data, analyzed in a model called CityInSight. This model calculates data on energy, emissions, and finances to allow for a deeper understanding of their relationships, and ultimately to help the City identify how it can best reach net zero greenhouse gas (GHG) emissions. Key features that help with this are that CityInSight allows for detailed analysis of the impacts of actions to reduce energy use and GHG emissions both year by year as well as through space (i.e. within different neighborhoods or traffic zones). To complement this modeling, Tacoma Power also regularly engages in more detailed energy modeling (at the hourly level), the results of which will be incorporated as a part of the goals of this Plan.

ACCOUNTING AND REPORTING PRINCIPLES

The City's GHG inventory and scenario modeling approach also correlate with the Global Protocol for Community-Scale GHG Emissions Inventories (GPC). The GPC provides a fair and true account of emissions via its principles:

Relevance: The reported GHG emissions shall appropriately reflect emissions occurring as a result of activities and consumption within the City boundary. The inventory will also serve the decision-making needs of the City, taking into consideration relevant local, state, and national regulations. Relevance applies when selecting data sources and determining and prioritizing data collection improvements.

Completeness: All emissions sources within the inventory (City of Tacoma) boundary shall be accounted for. Any exclusions of sources shall be justified and explained.

Consistency: Emissions calculations shall be consistent in approach, boundary, and methodology.

Transparency: Activity data, emissions sources, emissions factors and accounting methodologies require adequate documentation and disclosure to enable verification.

Accuracy: The calculation of GHG emissions should not systematically overstate or understate actual GHG emissions. Accuracy should be enough to give decision makers and the public reasonable assurance of the integrity of the reported information. Uncertainties in the quantification process should be reduced to the extent possible and practical.

MODELING APPROACH

The City went through a robust modeling exercise to develop a Net-Zero pathway that would allow us to meet our emissions target, the steps of which are illustrated in the figure below.

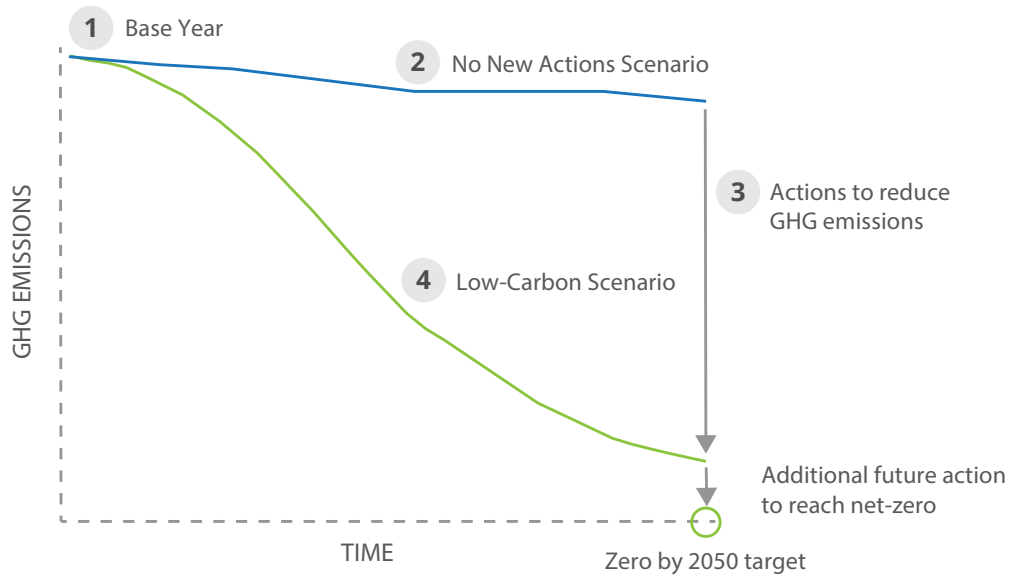

Figure 1. Modeling approach for Tacoma's Net-Zero pathway.

The four key steps to developing Tacoma's Net-Zero pathway were: (1) establishing a base year GHG inventory (2019 was used as it had the most recent and complete data), (2) modeling a No New Actions Scenario to show what emissions would occur while the City continues to grow and if its current plans are carried out, (3) undertaking research and engagement with the public and City staff on actions to reduce Tacoma's emissions, and (4) modeling these actions in a Net-Zero Scenario.

BASE YEAR RESULTS

2019 ENERGY AND EMISSIONS

Below is a summary of Tacoma's energy use and emissions by sector in 2019, discussed in more detail in the New Action section. Different forms of energy have different GHG emission intensities. Our ultimate goal is emission reduction.

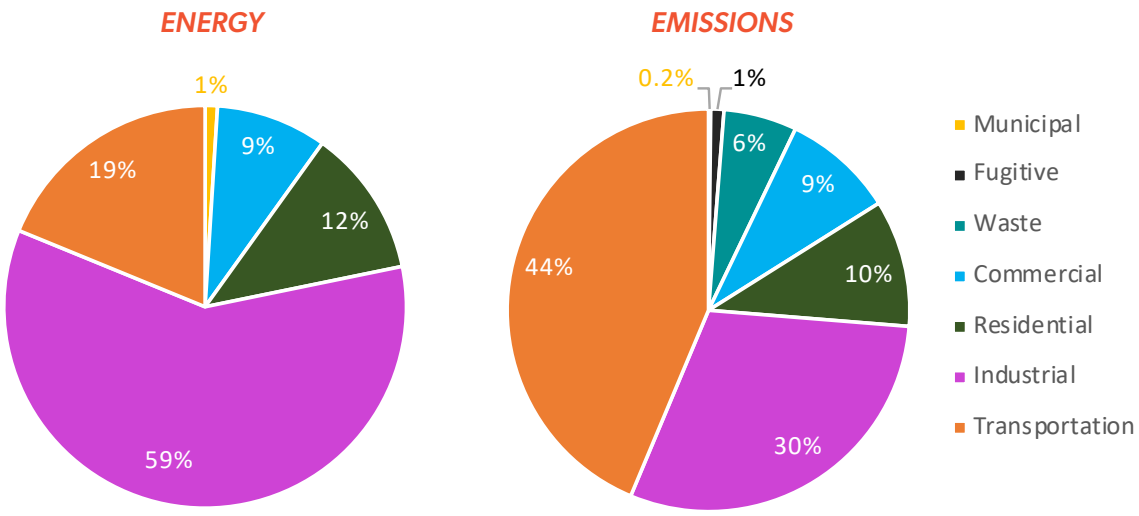

Figure 2. Energy and emissions by sector for Tacoma, 2019.

Tacoma's 2019 GHG emissions amounted to approximately 1.7 million metric tons of carbon dioxide equivalent emissions (MtCO2e), or 7.8 MtCO2e per person.

In 2019, industry accounted for 59% of Tacoma's energy use and 30% of its emissions. These included those from the refinery, gypsum plant, and the pulp and paper mill. The high (59%) proportion of industrial energy use compared to just 30% of emissions was primarily due to the use of wood at the pulp and paper mill, which was considered to be nearly carbon neutral.

Transportation accounted for 19% of Tacoma's energy use and 44% of its emissions, resulting from the use of gasoline and diesel for personal vehicles, commercial vehicles, city buses, and freight.

Commercial, residential, and municipal buildings together accounted for 21% of energy use and 19% of the city's emissions. The majority of this was from the use of natural gas and electricity to heat and cool buildings and water.

Six percent of Tacoma's emissions came from the decomposition of organic materials at its waste facilities, and 1% from leaks and losses in natural gas and oil systems (fugitive emissions).

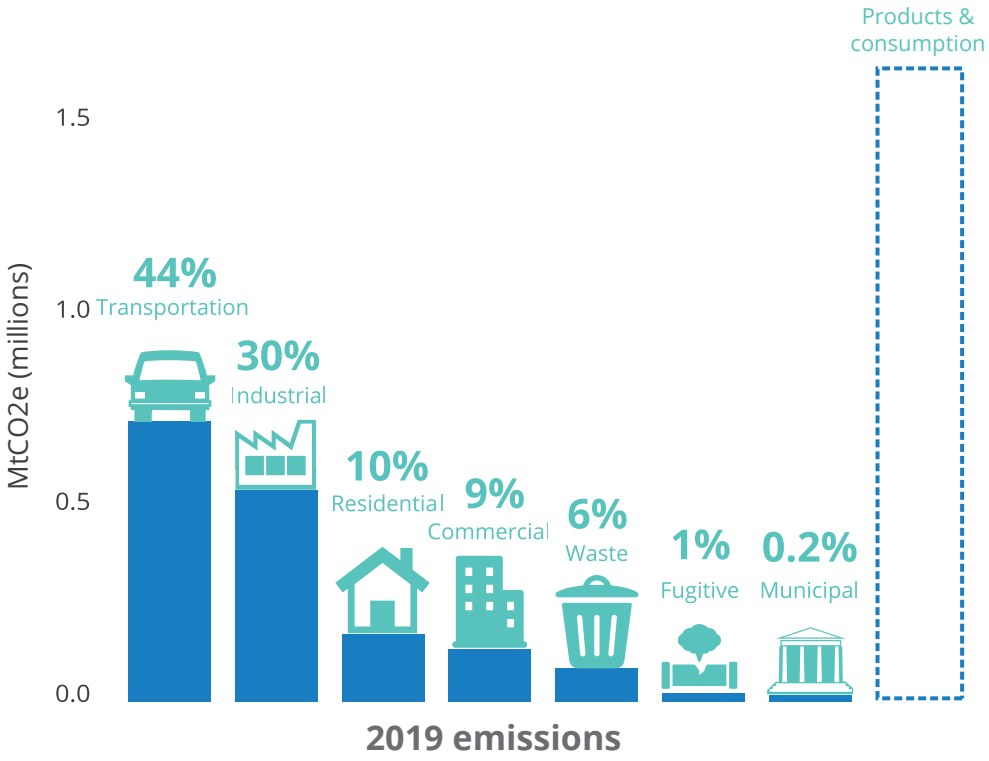

Figure 3. Emissions for Tacoma, 2019, including emissions from products and consumption.

The emissions discussed above are just those generated within Tacoma city limits. Figure 3 above shows that if we were to include emissions from the production and consumption of items from outside Tacoma, they would nearly double.

COMPARISON WITH PAST INVENTORIES

It is difficult to make an apples-to-apples comparison of past versus present GHG emissions inventories for Tacoma since the quality and availability of data has changed over time, as have

GHG accounting and reporting methodologies. It should be noted that the same is true when comparing inventories across jurisdictions, where data sources, accuracy, and calculation methodologies may differ. The figure below shows approximations of Tacoma's past (blue) emissions inventory results, adjusted to more closely match the methodology used for its recent 2019 (red) emissions inventory. With these adjustments, Tacoma has seen a modest decline of 25% between 1990 and 2019. From 2016 to 2019, on the other hand, emissions increased by 16% while population only increased by 3%.

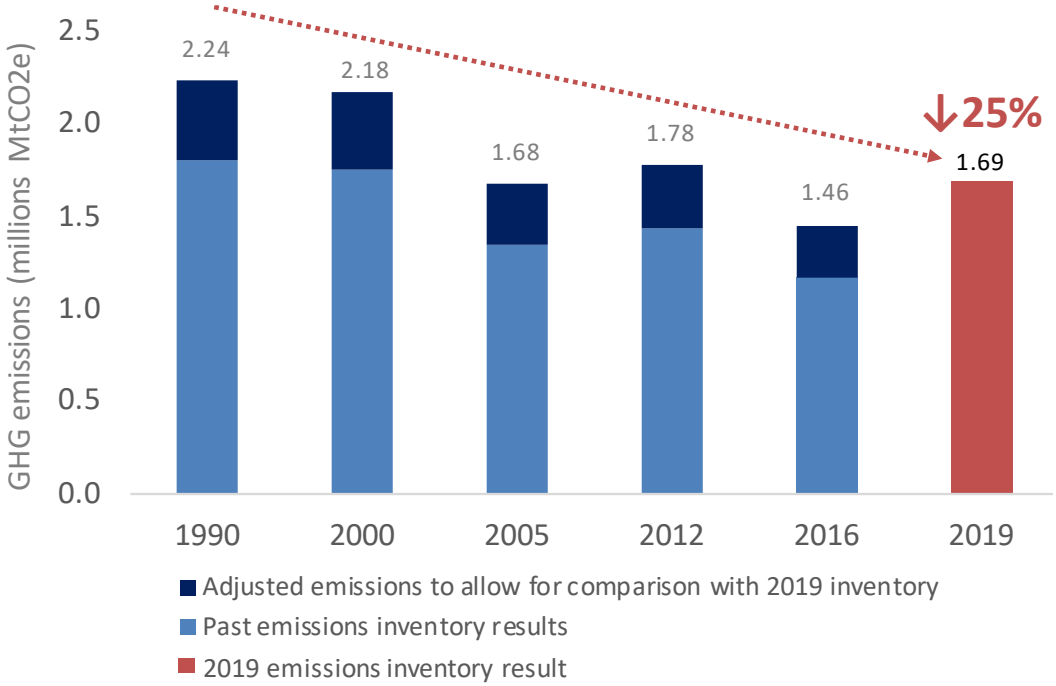

Figure 4. Past versus current GHG emissions in Tacoma.

NO NEW ACTIONS SCENARIO RESULTS

POPULATION AND DEMOGRAPHICS

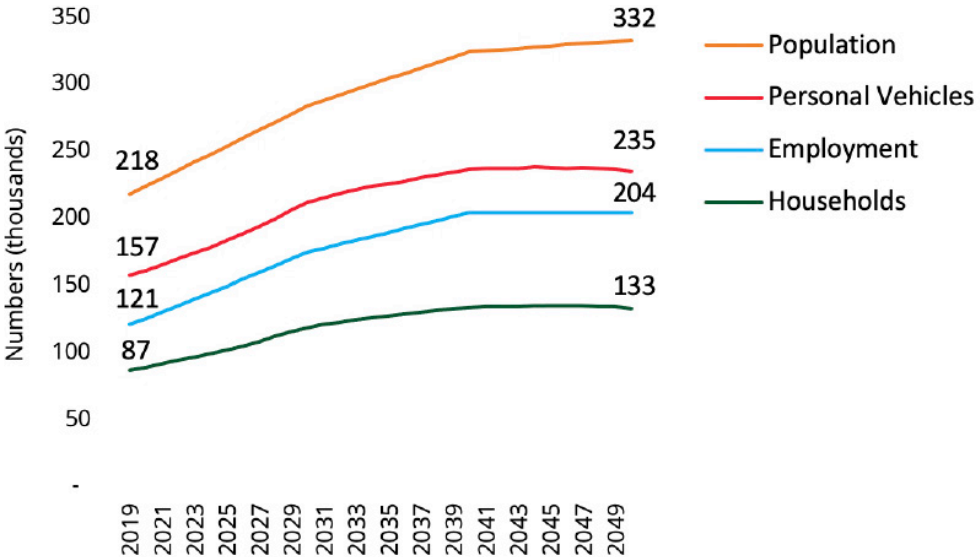

Figure 5. Key demographics for Tacoma from 2019 to 2050.

Table 1. Key demographics in 2019 and 2050.

	2019	2050	DIFFERENCE 2019-2050	% DIFFERENCE 2019-2050
Population	217,834	332,392	114,558	+53%
Personal vehicles	157,326	235,177	77,851	+49%
Employment	121,281	204,108	82,827	+68%
Households	87,016	143,340	56,324	+65%

Population trends, employment trends, vehicle ownership, and expected number of households were important components in modeling Tacoma's current (and estimating its future) energy use and emissions production. The 2019 American Community Survey was used to establish the city's base year (2019) population, household, and employment numbers, and the city's household travel survey was used to establish base year vehicles per household. City projections were then used for estimated growth to the year 2050. Based on these assumptions Tacoma's population is expected to grow at a steady rate until around 2040, after which it will remain relatively stable. A total increase by approximately 50% from 2019 to 2050 is expected. This is an increase of approximately 115,000 people (Table 1, Figure 5). Households are expected to scale with population growth, with 56,000 added over the time period. A total of 83,000 jobs are expected to be added between 2019 and 2050, with an increase to per-capita employment over the time period from 0.56 to 0.61 jobs per resident. Personal vehicle ownership is expected to follow a similar trend to that of household growth based on dwelling unit types. Tacomans owned 1.81 vehicles per household in 2019, which is expected to decrease slightly to 1.77 vehicles per household in 2050. The decrease is due to more infill and apartments being added in the City, which typically have lower vehicle ownership rates compared to single-family homes.

NO NEW ACTIONS PROJECTED ENERGY USE AND EMISSIONS

TOTAL AND PER-CAPITA ENERGY AND EMISSIONS

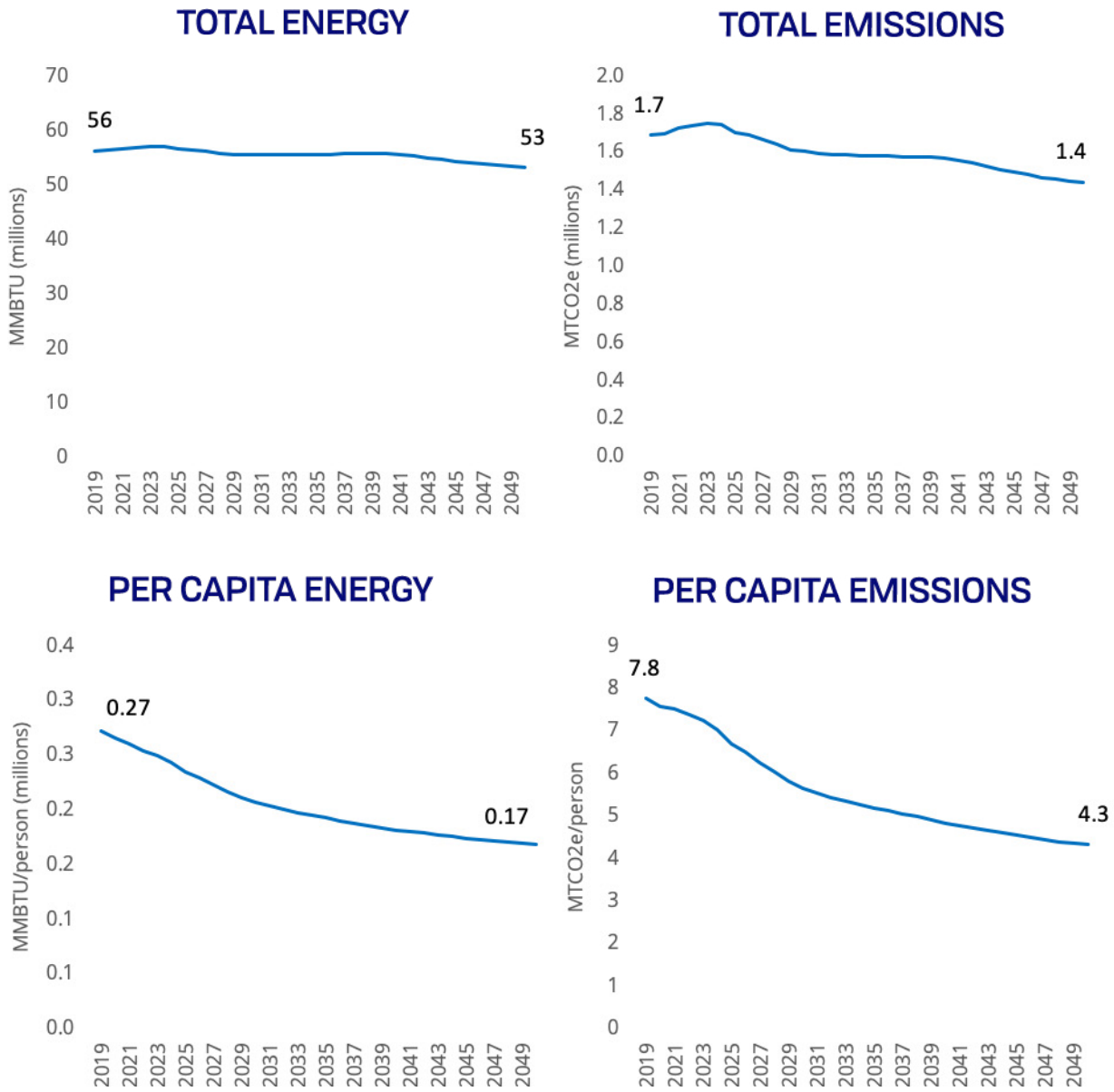

Figure 6. Projected yearly energy use (left) and emissions (right) for the No New Actions Scenario, 2019-2050.

Figure 6 shows the total energy use in Tacoma in 2019, and the projection to 2050. Energy use is expected to drop by approximately 3 million metric million British thermal units (MMBTU), a decrease of 6% compared to 2019. The decrease in per capita energy use is more pronounced, decreasing by nearly 40% over the time period (Figure 6). Total emissions decrease by 15% while per capita emissions decrease by 18%. Improvement to space heating/cooling and water heating demands, due in part to increased energy efficiency resulting from upper-level government regulations on appliances and the building code, are expected to decrease total city energy use despite population increases. Similarly, vehicle fuel efficiencies improve as old vehicles are replaced and electric vehicles' market share increases. Figure 7 and Table 1 show the breakdown of energy and emissions by sector, further discussed in the following sections.

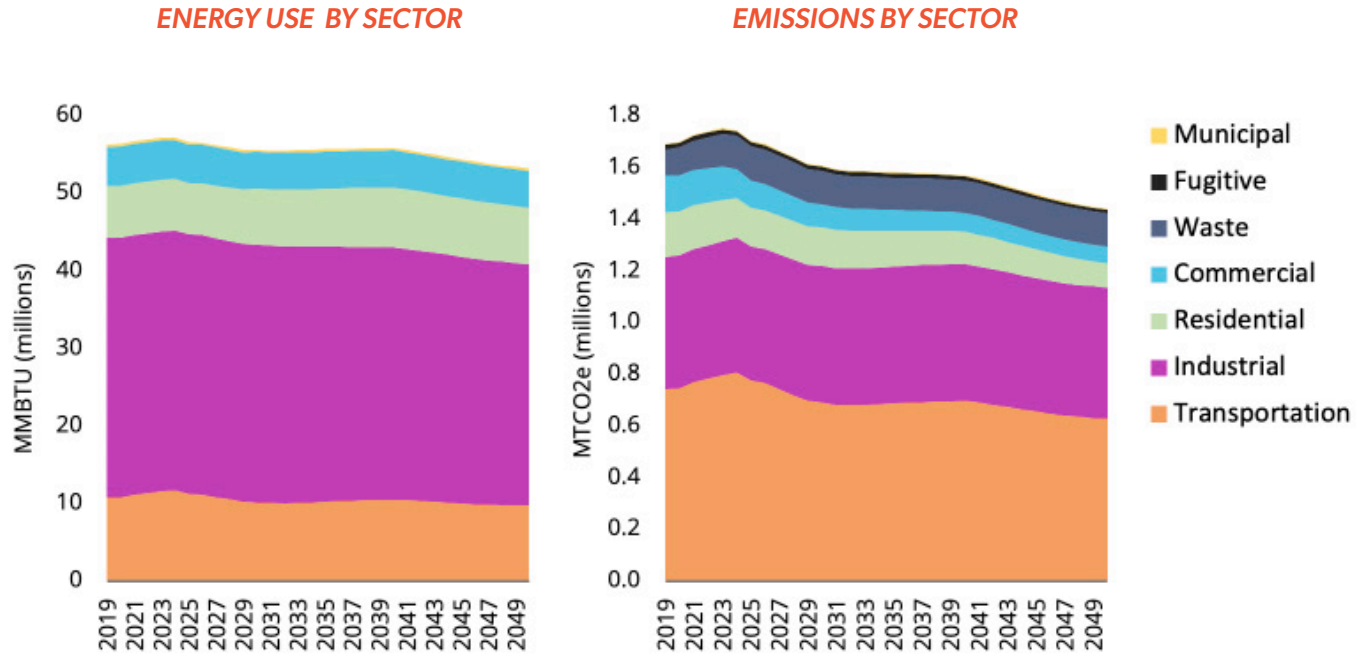

Figure 7. Projected community energy use and emissions by sector, 2019-2050.

Table 2. No New Actions Scenario energy consumption (MMBTU) by sector, 2019 and 2050.

	2019 (MMBTU)	SHARE OF TOTAL 2019	2050 (MMBTU)	SHARE OF TOTAL 2050	% CHANGE 2019-2050
TOTAL (MMBTU) >	**56,324,924**		**53,214,042**		**-6%**
Commercial	5,054,647	9%	4,764,550	9%	-6%
Industrial	33,560,446	60%	31,112,438	58%	-7%
Municipal	329,013	1%	289,275	1%	-12%
Residential	6,619,932	12%	7,299,516	14%	+10%
Transportation	10,760,886	19%	9,748,263	18%	-9%

Table 3. No New Actions Scenario emissions by sector, 2019 and 2050.

	2019 (MTCO2E)	SHARE OF TOTAL 2019	2050 (MTCO2E)	SHARE OF TOTAL 2050	% CHANGE 2019-2050
TOTAL (MTCO2E) >	**1,691,149**		**1,441,104**		**-15%**
Commercial	142,110	8%	65,001	5%	-54%
Fugitive	17,986	1%	15,041	1%	-16%
Industrial	511,021	30%	505,382	35%	-1%
Municipal	3,055	0%	3,944	0%	+29%
Residential	173,742	10%	93,781	7%	-46%
Transportation	743,150	44%	629,910	44%	-15%
Waste	100,085	6%	128,046	9%	+28%

INDUSTRY

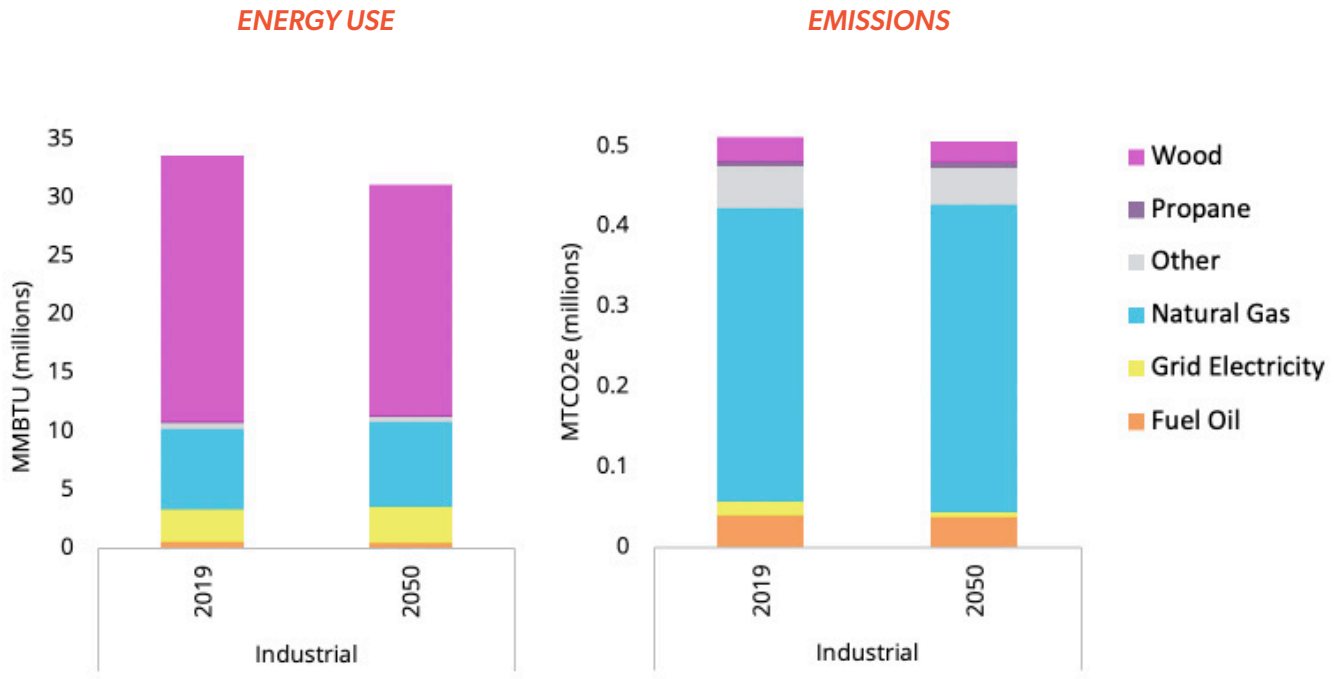

Figure 8. Industrial energy use and emissions by sector and fuel, 2019 and 2050.

Industry accounts for approximately 60% of Tacoma's energy use, both in 2019 and in 2050 (Figure 8, Table 1). As discussed in the Base Year results section, industry makes up a lower proportion of emissions compared to energy due to wood use at the pulp and paper mill, which is considered nearly carbon-neutral per GHG accounting and reporting protocol. Note that industrial energy and emissions reported in this inventory include Tacoma's large emitters (Georgia Pacific Gypsum, the oil refinery, and pulp and paper mill), for which data is available as they are required to report to the EPA, as well as building energy use for industrial accounts from the city's natural gas and electricity utilities. Process energy and emissions from smaller industries have not been included due to data unavailability, nor has energy use for the LNG facility due to be operational in 2021. These should be analyzed and addressed as a follow up and in further iterations of this Plan.

With no new actions, industrial energy use and emissions are anticipated to decrease by just 7% and 1%, respectively over the next 30 years, owing to anticipated building code improvements for new buildings and slight improvements to existing technologies as systems get replaced or upgraded over time.

BUILDINGS

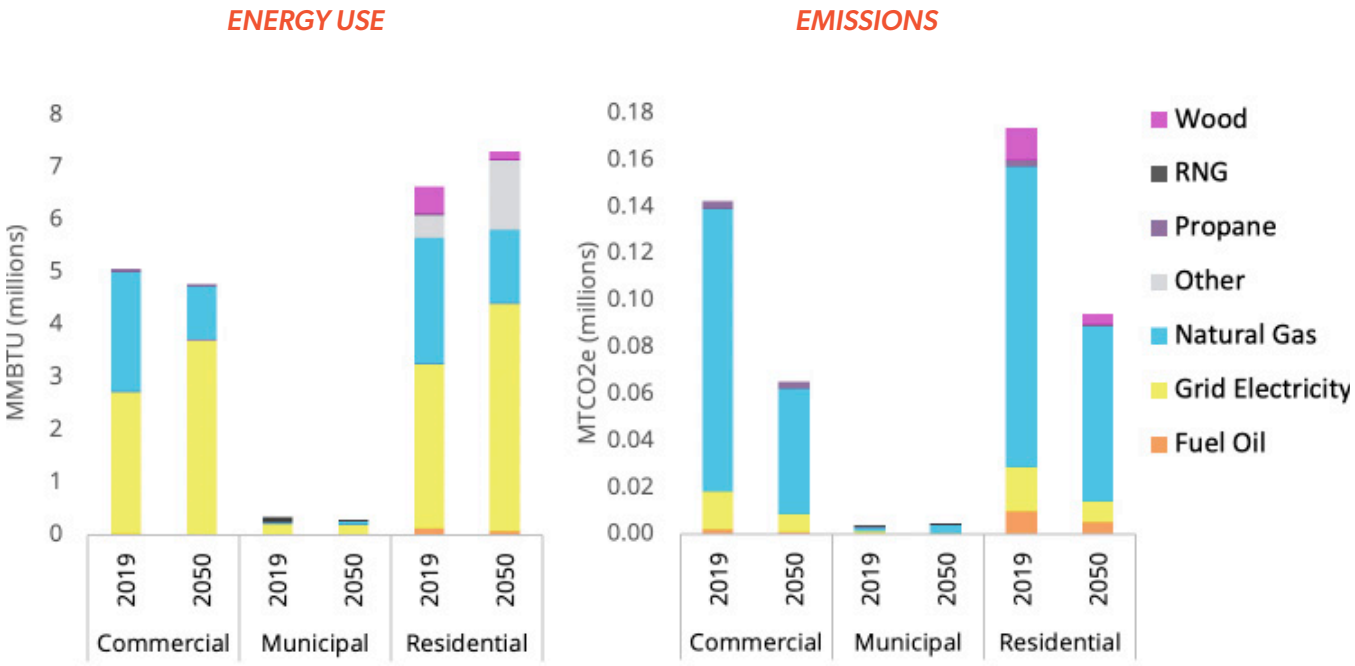

Figure 9. Buildings energy use and emissions by sector and fuel, 2019 and 2050.

Decreases in energy use are expected for commercial (6%) and municipal (12%) buildings from 2019 to 2050. These improvements are expected as regulations for existing buildings' energy performance take effect, including the Clean Buildings Act which is slated to come into play in 2026-2028. Performance of new non-residential buildings is also anticipated to improve with the State building code becoming more stringent over time. Similar improvements to building energy performance are anticipated for new and existing residential buildings, with average energy use per household decreasing by 28% from 76,000 MMBTU to 55,000 MMBTU. In this case, however, city growth outpaces efficiency improvements and residential energy use is anticipated to increase by 10%, indicating that net zero retrofit programs and building code improvements need be implemented sooner than currently planned.

Decreases in building emissions are more pronounced than building energy use, with emissions decreasing by 54% and 46% for commercial and residential buildings, respectively (Figure 9, right side). In both sectors, energy use from electricity increases (by 37% for commercial and 40% for residential buildings) while energy use from natural gas decreases (by 56% for commercial and 42% for residential buildings) as natural gas and other fossil fuel-based heating systems are replaced with electric heat pumps.

One other factor impacting building energy use is degree days, measures of how much heating and cooling is required for buildings based on the temperatures in a particular year. Figure 10 shows that as temperatures warm over the coming years, the need to heat buildings will decrease, while cooling needs will increase. In Tacoma, space and water heating (the green and dark blue bars in Figure 11) represent a much greater proportion of energy requirements and emissions than space cooling (light blue bars in Figure 11), therefore, the impact of a warming climate helps to decrease building energy consumption, for the time being. For more information about municipal energy emissions shown on Figure 11, view "Section 9, Municipal Carbon Neutrality Strategy".

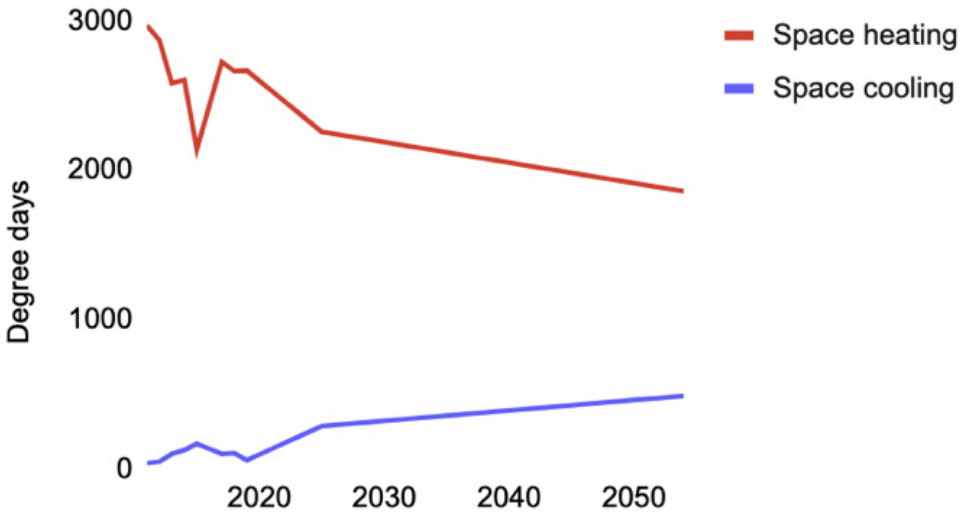

Figure 10. Heating and cooling degree days for Tacoma, 2011-2050.[1]

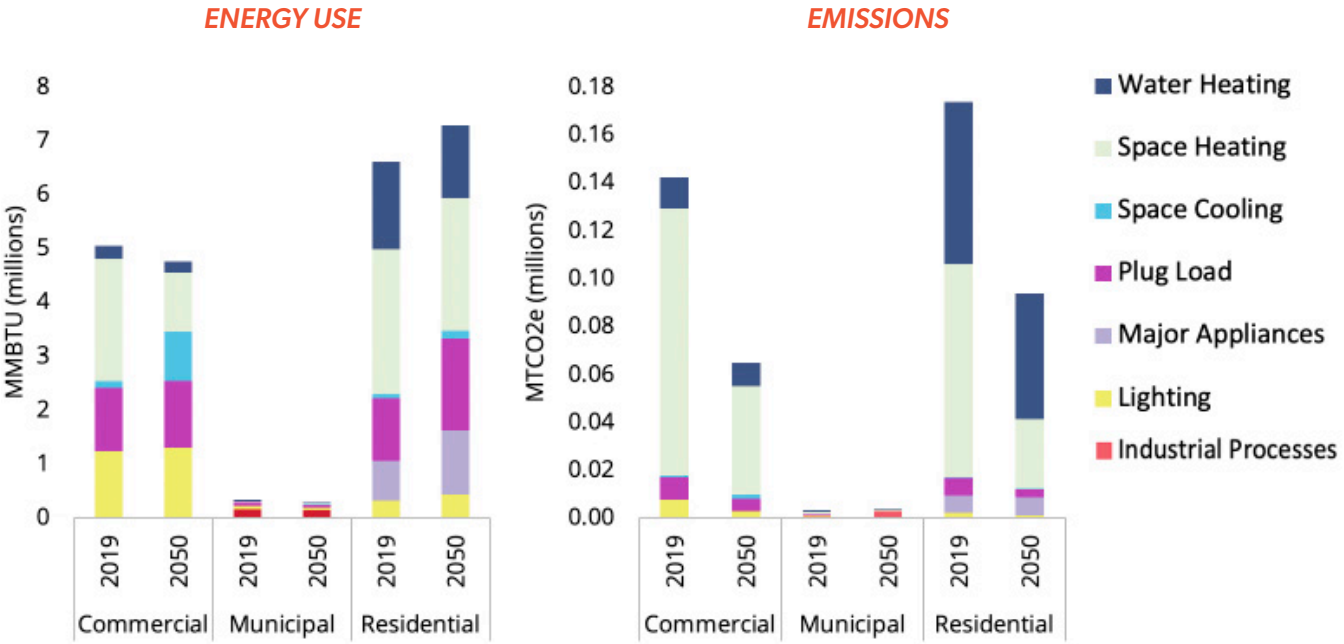

Figure 11. Building energy use by sector and end use, 2019 and 2050.

[1] Climate Map (*http://www.climatewna.com/default.aspx*) for 47.25513° N, -122.44164° E and elevation of 74m. RCP 8.5 Average of CanESM2, CNRM-CM5 and HadGEM2-ES models

TRANSPORTATION

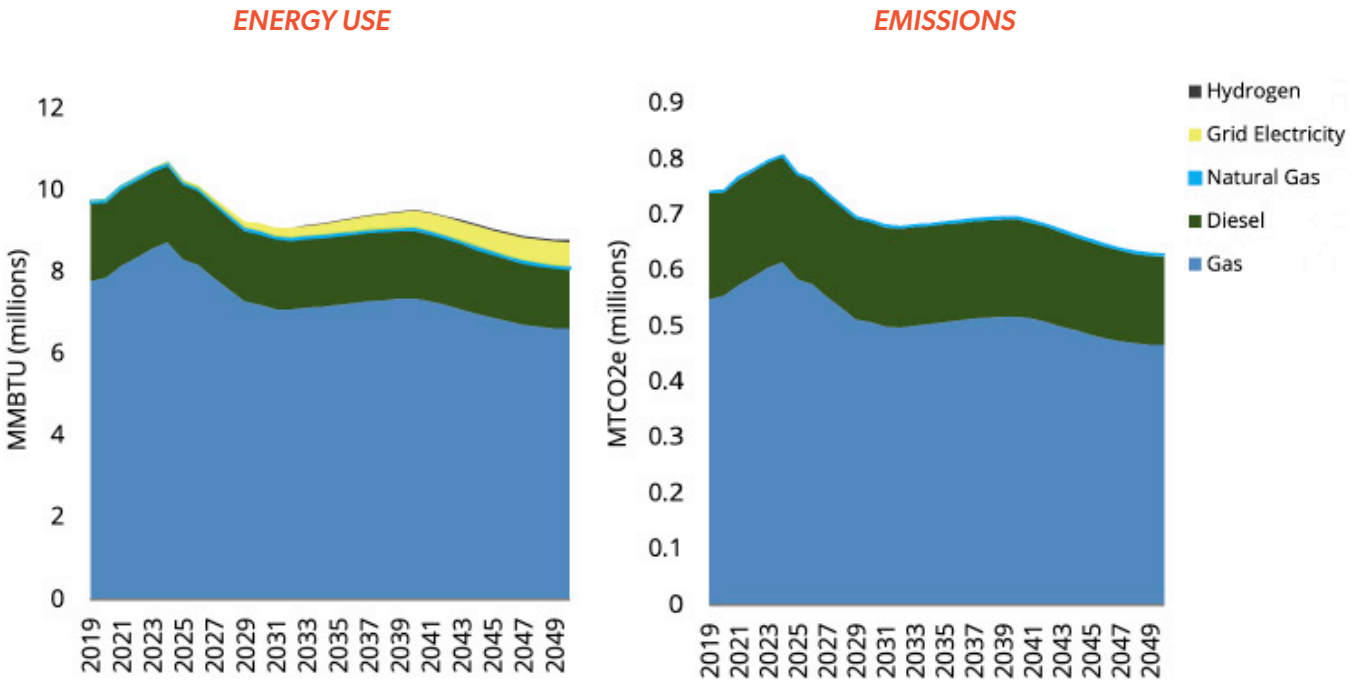

Figure 12. Transportation energy use and emissions, 2019-2050.

From 2019-2050, though the yearly personal vehicle miles traveled (VMT) in Tacoma is anticipated to decrease on average, the overall miles traveled is anticipated to increase as the city's population grows. Despite this, energy use for transportation is anticipated to decrease by approximately 10%, owing to modest improvements to transit and active travel mode shares, older vehicles being replaced with newer more efficient vehicles, and market-based uptake of commercial and personal use electric vehicles, which are more energy efficient than internal combustion engine vehicles. These improvements also result in a 15% decrease in emissions from transportation.

WASTE

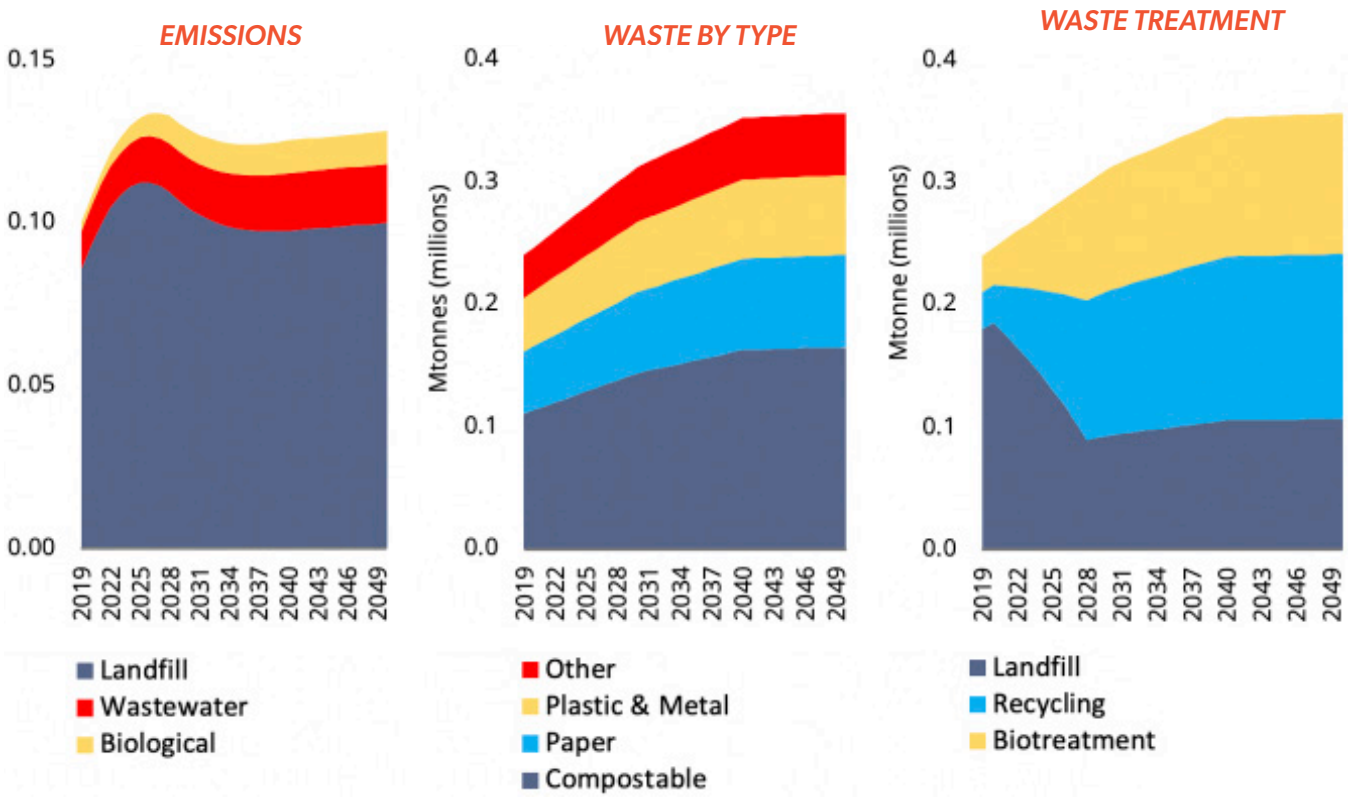

Figure 13. Emissions from waste (left), waste tonnage by type (middle), and waste treatment (right), 2019-2050.

Emissions from waste increase by 28% from 2019 to 2050. This increase occurs alongside population growth, which is in part balanced by increases in diversion, as the City meets its target of 70% by 2028 (from 23% in 2019). Emissions from waste increase from 2019-2025, decrease to the year 2035, and then continue to increase at a relatively steady rate to 2050.

ENERGY

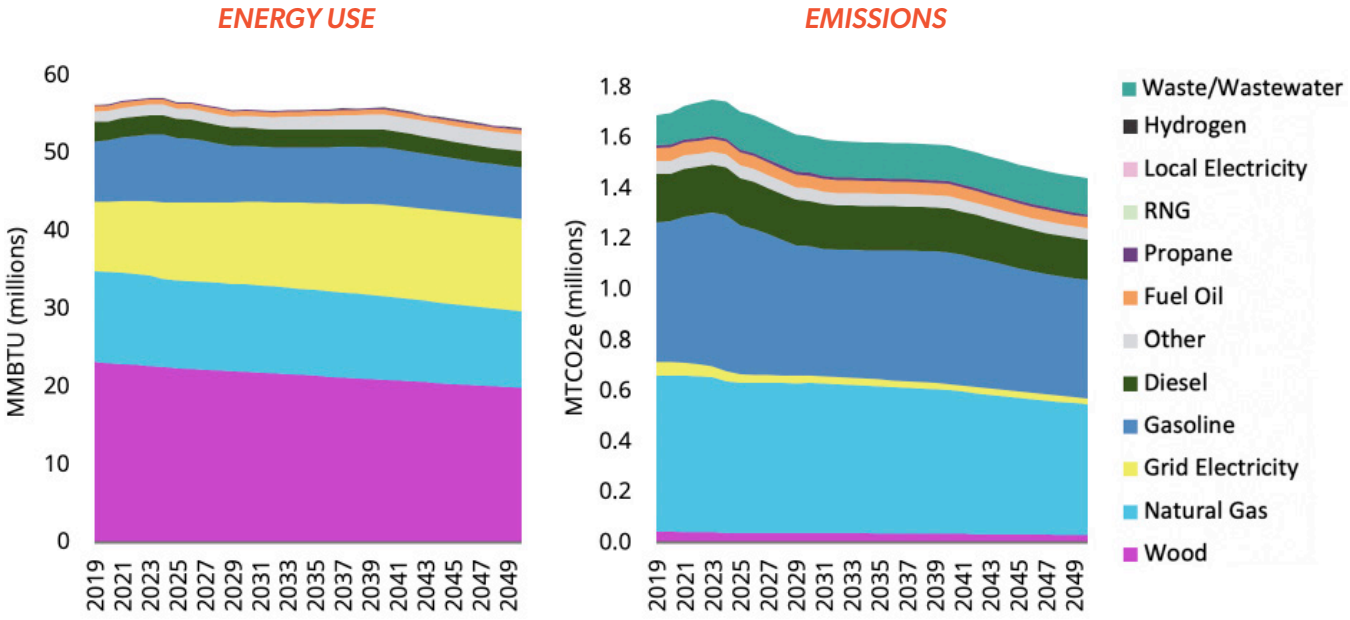

Figure 14. City-wide energy use (left) and emissions (right) by fuel type, 2019-2050.

Figure 14 Shows Tacoma's energy use and emissions by fuel type. By 2050, grid electricity makes up 22% of Tacoma's energy consumption, while accounting for just 2% of its total emissions. Under the No New Actions Scenario, electricity use increases by 22% from 2019 to 2050, by approximately 3.1 million MMBTU. Wood from the pulp and paper mill accounts for nearly half of the city's energy use, but less than 1% of its emissions since it is considered nearly carbon neutral from a GHG emissions perspective.

NET-ZERO SCENARIO RESULTS

After the No New Actions Scenario was modeled, a Net-Zero Scenario was developed. In consultation with City staff, local technical teams, and others, a suite of target assumptions were established to help the city reach its ultimate target of net zero GHG emissions by 2050. These assumptions are listed in the tables at the beginning of each sector's results section.

MODELING RESULTS

Table 1 below summarizes the Net-Zero Scenario modeling results by sector. The most significant emissions reductions potential is from the transportation sector, accounting for 52% of cumulative emissions reductions, followed by industrial improvements at 30%. This is shown in more detail in Figure 15, which breaks down the emissions reductions by sector and target area, which will be discussed further in the subsequent sections.

Table 4. Net-Zero Scenario modeling results summary.

SECTOR	GHG REDUCTION (MTCO2E) RELATIVE TO 2050 NO NEW ACTION SCENARIO	CONTRIBUTION TO CUMULATIVE EMISSIONS REDUCTIONS (2019-2050)
Industry	462	30%
Buildings	172	15%
Transportation	633	52%
Waste Diversion and Reduction	70	3%
TOTAL	1,337	

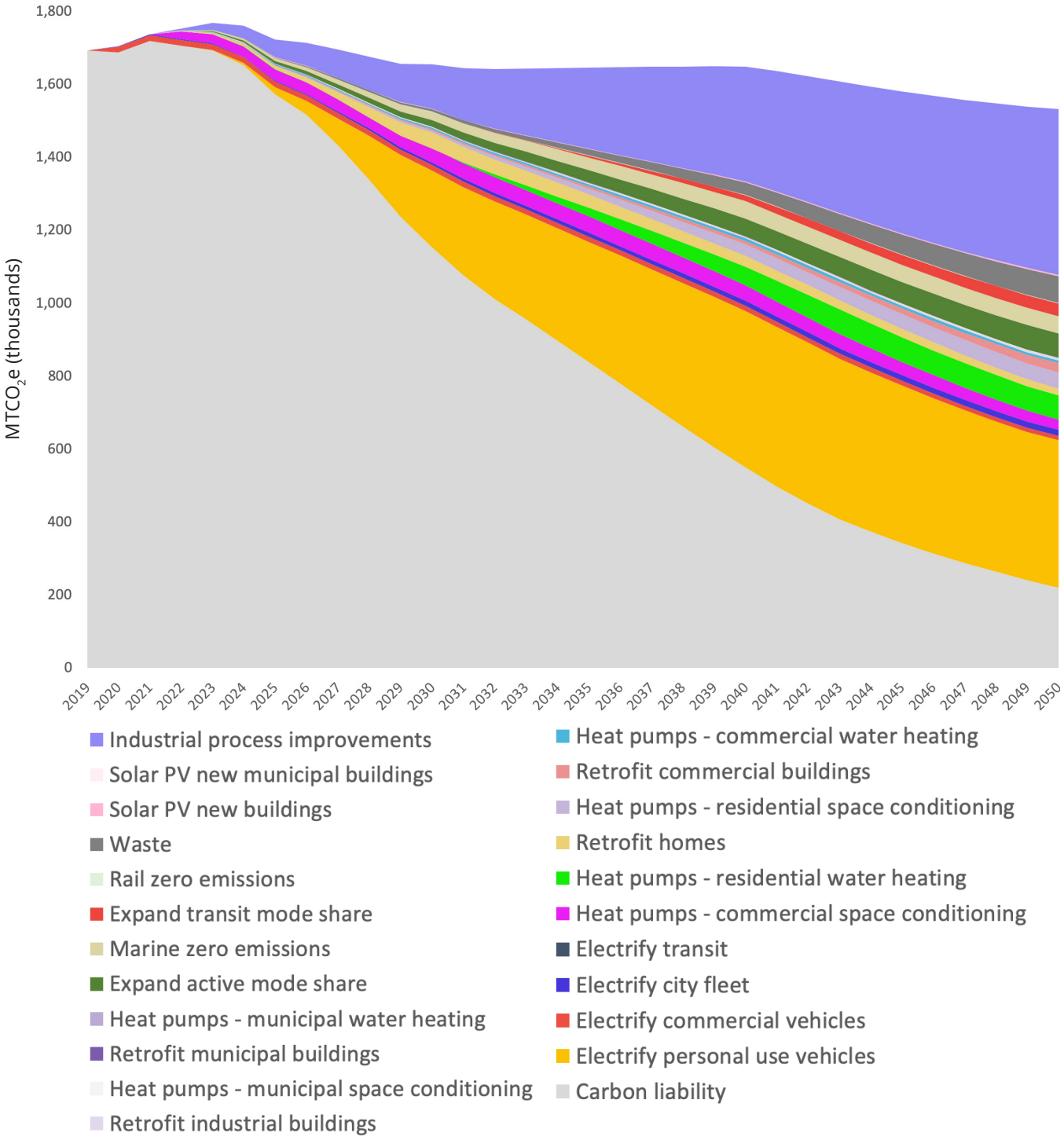

Figure 15. Scenario emissions and emissions reductions wedges from the Net-Zero targets.

NET-ZERO SCENARIO ENERGY AND EMISSIONS

The Net-Zero Scenario results in total energy decreases of 43% from 2019 to 2050, while emissions decrease by 89% (Figure 16). Figure 17 shows that by 2050, industry is responsible for 30% of Tacoma's emissions, while waste is responsible for 37%. Thirty three percent of emissions in 2050 come from residual fossil fuels used in residential, commercial, and municipal buildings, as well as from vehicles, trains, and marine vessels that have not yet been switched to zero-carbon sources. For Tacoma to reach its net-zero target, these remaining emissions need to be addressed through additional actions such as: switching out remaining carbon-emitting technologies being used in buildings and transportation, capturing landfill emissions, and sequestering carbon through carbon capture and storage technologies as well as nature-based solutions.

A steep decline in emissions until 2030 (Figure 16, right) is a key component of the Net-Zero Scenario. This is needed in order for Tacoma to maximize cost savings from energy and emissions reductions, to put itself on track to achieve its target, to avoid the need for even more drastic measures to reduce emissions in the future, and to decrease the risk of catastrophic climate change.

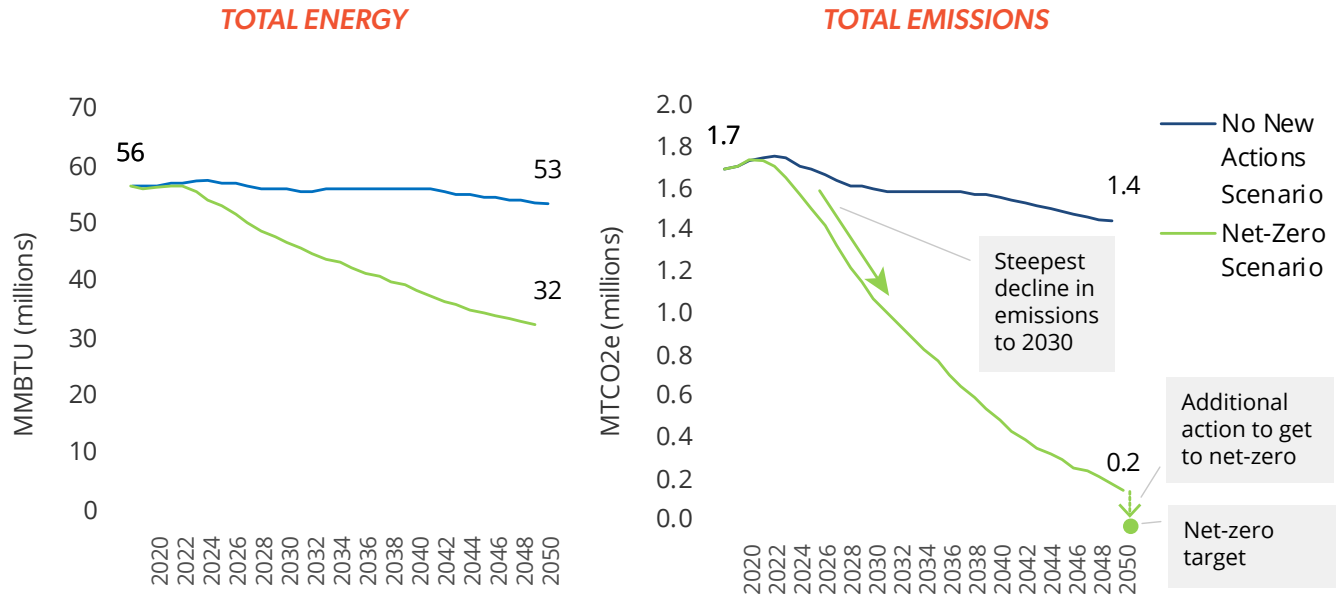

Figure 16. Projected yearly energy use (left) and emissions (right) for the Net-Zero and No New Actions Scenarios, 2019-2050.

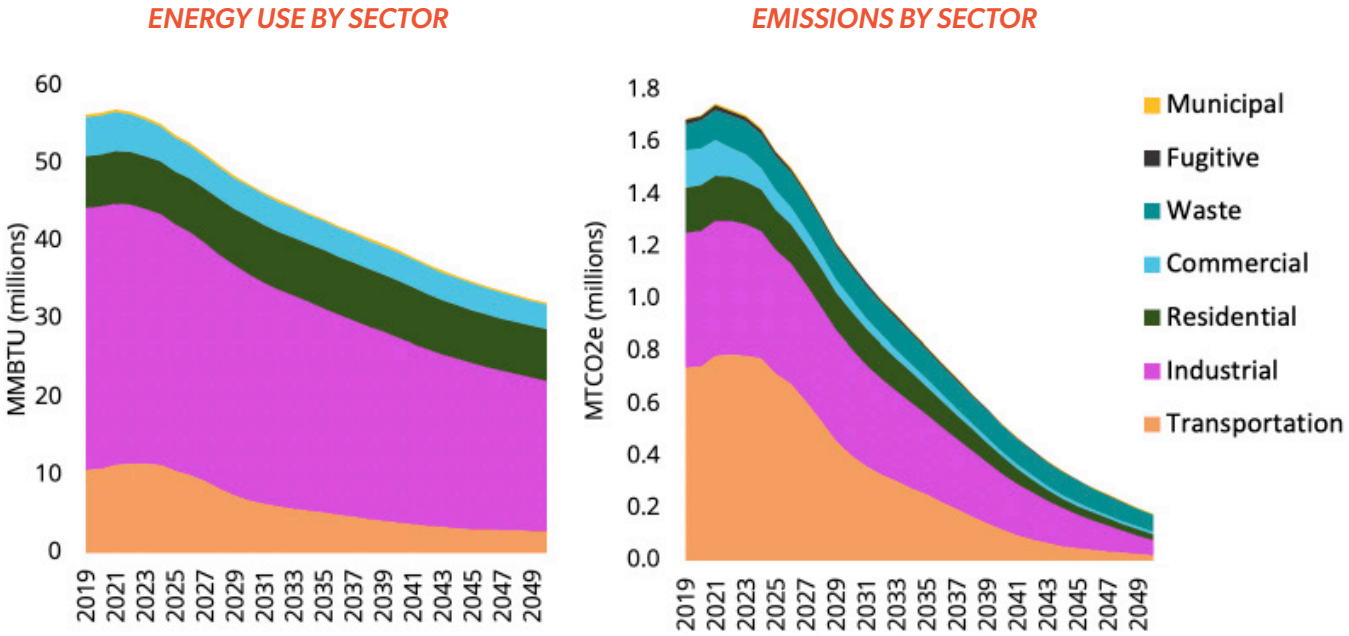

Figure 17. Projected community energy use and emissions by sector, 2019-2050.

Table 5. Net-Zero Scenario energy consumption (MMBTU) by sector, 2019 and 2050.

	2019 (MMBTU)	SHARE OF TOTAL 2019	2050 (MMBTU)	SHARE OF TOTAL 2050	% CHANGE 2019-2050
TOTAL (MMBTU) >	**56,324,924**		**32,132,265**		**-43%**
Industrial	33,560,446	60%	19,275,683	60%	-43%
Transportation	10,760,886	19%	2,852,814	9%	-73%
Commercial	5,054,647	9%	3,205,598	10%	-37%
Residential	6,619,932	12%	6,564,560	20%	-1%
Municipal	329,013	1%	233,611	1%	-29%

Table 6. Net-Zero Scenario emissions by sector, 2019 and 2050.

	2019 (MTCO2E)	SHARE OF TOTAL 2019	2050 (MTCO2E)	SHARE OF TOTAL 2050	% CHANGE 2019-2050
TOTAL (MTCO2E) >	**1,691,149**		**181,187**		**-89%**
Transportation	743,150	44%	24,857	14%	-97%
Industrial	511,021	30%	53,956	30%	-89%
Residential	173,742	10%	22,666	13%	-87%
Commercial	142,110	8%	9,265	5%	-93%
Waste	100,085	6%	67,119	37%	-33%
Fugitive	17,986	1%	930	1%	-95%
Municipal	3,055	0%	2,395	1%	-22%

INDUSTRY

2050 NET-ZERO SCENARIO ASSUMPTIONS	2050 GHG REDUCTION (MTCO2E) RELATIVE TO NO NEW ACTIONS	CONTRIBUTION TO CUMULATIVE EMISSIONS REDUCTIONS (2019-2050)
• **2%** per year general efficiency improvements to industry • **75%** decrease in refining and mining to reflect reduced demand • Fuel switching to electricity in **50%** of process heating, **100%** of machine drives, and **98%** of building heating and cooling in industry by **2050**; remainder is hydrogen	462	30%

EMISSIONS

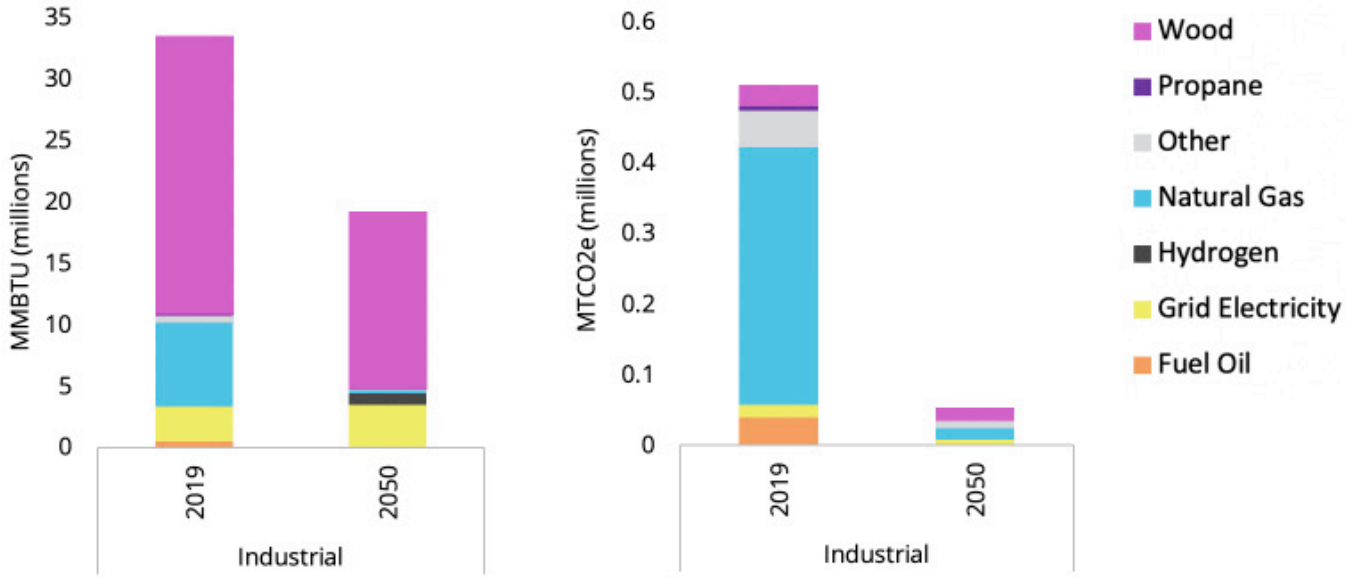

Figure 18. Industrial energy use and emissions by fuel, 2019 and 2050.

Industrial emissions are significantly reduced in the Net-Zero Scenario, by 89% from 2019 to 2050. These are achieved through efforts made across Tacoma's industrial sector that collectively lead to energy and emissions reductions. Efforts include efficiency improvements alongside fuel switching from fossil fuels to electricity and green hydrogen for process heating, machine drives, and building heating and cooling to nearly eliminate fossil fuel-based emissions. By 2050, industry accounts for 30% of Tacoma's emissions, 35% of which are from wood (pulp and paper mill), 31% from natural gas, 20% from other fossil fuels, and 13% from grid electricity.

BUILDINGS

NET-ZERO SCENARIO ASSUMPTIONS	2050 GHG REDUCTION (MTCO2E) RELATIVE TO NO NEW ACTIONS	CONTRIBUTION TO CUMULATIVE EMISSIONS REDUCTIONS (2019-2050)
• **100%** of new buildings are built to net zero emissions standards by **2030** • By **2050**, **5%** of new residential buildings are single family, dwelling sizes decrease by **15%** • Decrease sqft floorspace per employee by **42%** • **98%** of existing commercial buildings built before **2020** are retrofit to passive house standards by **2050**; • **20%** of existing industrial buildings built before **2020** are retrofit to passive house standards by **2050**; • **98%** of systems are converted to air source heat pumps by **2050** • No new natural gas in new buildings from **2020** onwards	172	15%

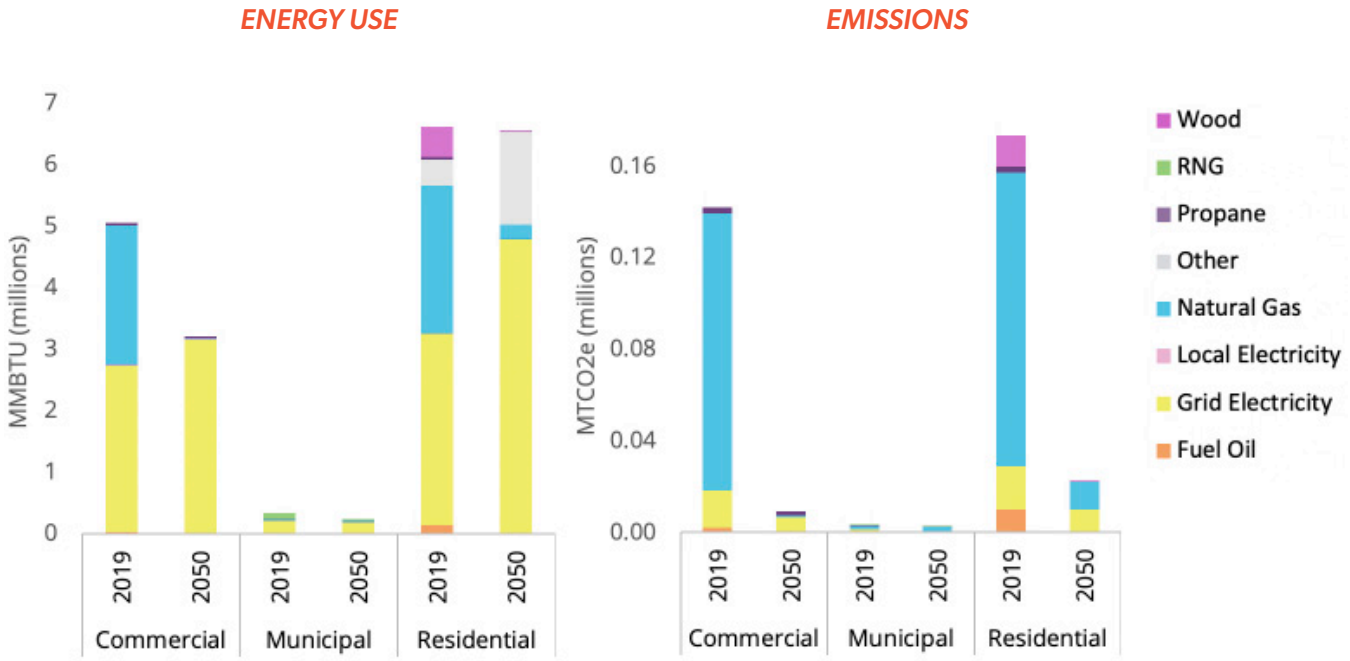

Figure 19. Buildings energy use and emissions by sector and fuel, 2019 and 2050.

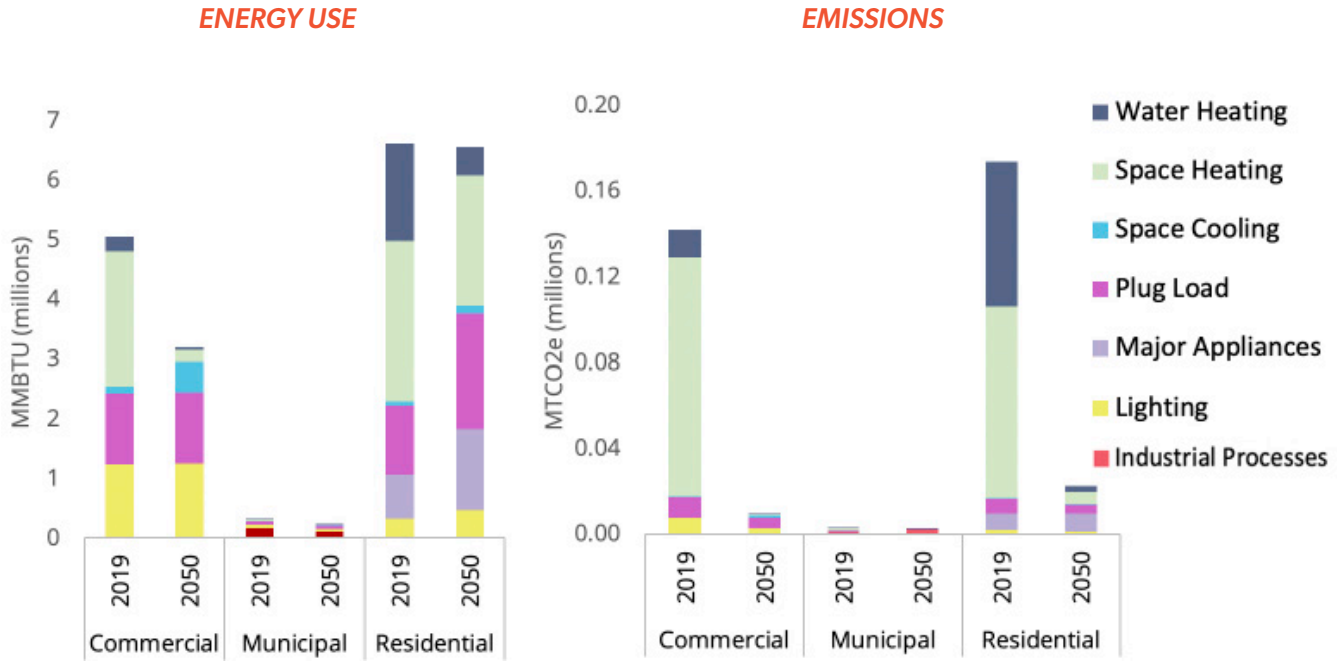

Figure 20. Building energy use by sector and end use, 2019 and 2050.

Figures 19 and 20 show energy use and emissions from buildings in the Net-Zero Scenario by fuel type and end use, respectively. Buildings' emissions decrease by 89% overall, with commercial buildings decreasing by 93%, municipal by 22%, and residential by 87%. As space and water heating are responsible for the majority of building emissions in 2019 (nearly 90%), switching from fossil fuel-based heating systems to electric heat pumps represents the greatest opportunity for emissions reductions from buildings in Tacoma. Space cooling, which represents a smaller portion of Tacoma's energy use and emissions from buildings will also improve with the addition of heat pumps, however, this is overweighted by increased cooling demands as summer temperatures increase due to anticipated climate change. Increasing envelope efficiencies remain an important step in this effort to mitigate grid electricity consumption and demand as new systems are brought online.

TRANSPORTATION

2050 NET-ZERO SCENARIO ASSUMPTIONS	2050 GHG REDUCTION (MTCO2E) RELATIVE TO NO NEW ACTIONS	CONTRIBUTION TO CUMULATIVE EMISSIONS REDUCTIONS (2019-2050)
ELECTRIC VEHICLES (EV) • **100%** of new personal vehicles sales are EV by **2030** • **100%** new sales EV by 2030 for light-duty, **50%** hydrogen/**50%** EV for new heavy duty sales by **2050**	444	37%
TRANSIT AND TRAVEL BEHAVIOR • Improve mode shares to reach **15%** biking, **15%** walking, and **19%** transit by **2050** • Commercial vehicle strategies to reduce last mile delivery result in **15%** reduction in VMT from **2020** by **2050** • **25%** reduction in commuting due to increased work-from-home	140	11%
RAIL/MARINE • All marine terminals are using shore power by 2040, and net-zero by **2050** • Rail fuel switching and/or efficiency improvements result in **100%** emissions reductions by **2050**; Alternative vehicles are **50%** hydrogen/**50%** electric	49	4%
TOTAL	633	52%

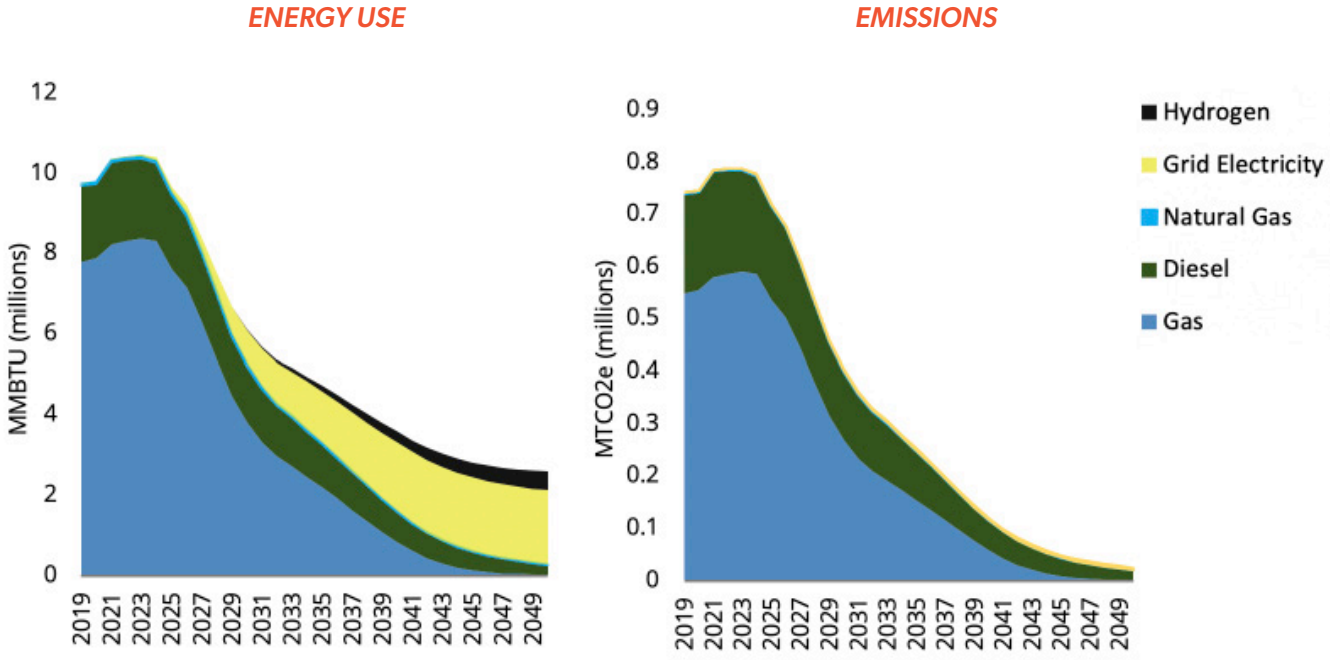

Figure 21. Transportation energy use and emissions, 2019-2050. No New Actions Scenario (top) and Net-Zero Scenario (bottom).

Transportation energy decreases by 73% and emissions by 97% in the Net-Zero Scenario. Figure 21 shows the near-elimination of gasoline as commercial and personal use internal combustion engine vehicles are replaced by electric and green hydrogen-based ones. This action alone is responsible for 37% of Tacoma's modeled emissions reductions from 2019-2050. The majority of transportation emissions remaining in 2050 are from diesel used in heavy trucks, which the City anticipates will be more difficult to influence/control.

Vehicle electrification alone is responsible for 37% of Tacoma's total cumulative emissions reductions from 2019 to 2050 in the Net-Zero Scenario over the No New Actions Scenario.

The figures below show improvements to mode shares for internal trips in Tacoma, where personal vehicle use is reduced from 90% to 51% of trips. The lower two figures show trip distances and mode shares. In 2050 there are more miles traveled in Tacoma, due to a greater population, however, the uptake of active transportation and transit means that there are fewer personal use vehicle miles traveled overall by 2050. One item to note is that the modeling follows an accounting methodology that calculates all trips starting and ending in Tacoma, as well as half the distance of trips that start or end outside of Tacoma. This methodology does not calculate trips passing through Tacoma, which the City has less control over, however, .

By 2050, diesel from heavy trucks is responsible for 74% of emissions, with 17% coming from grid electricity.

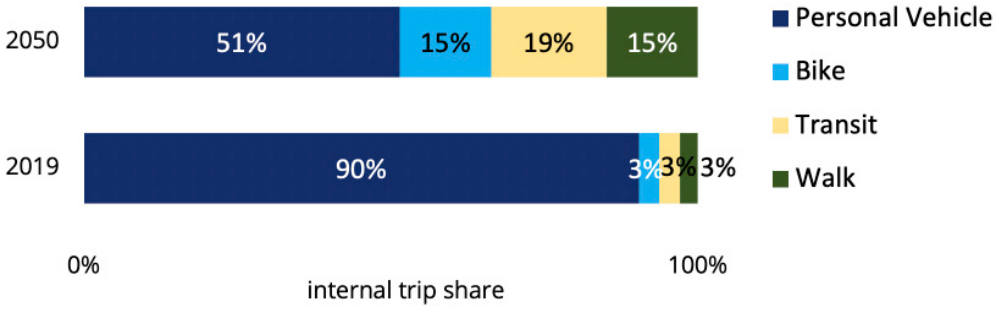

Figure 22. Mode shares for internal trips, Net-Zero Scenario, 2019 and 2050.

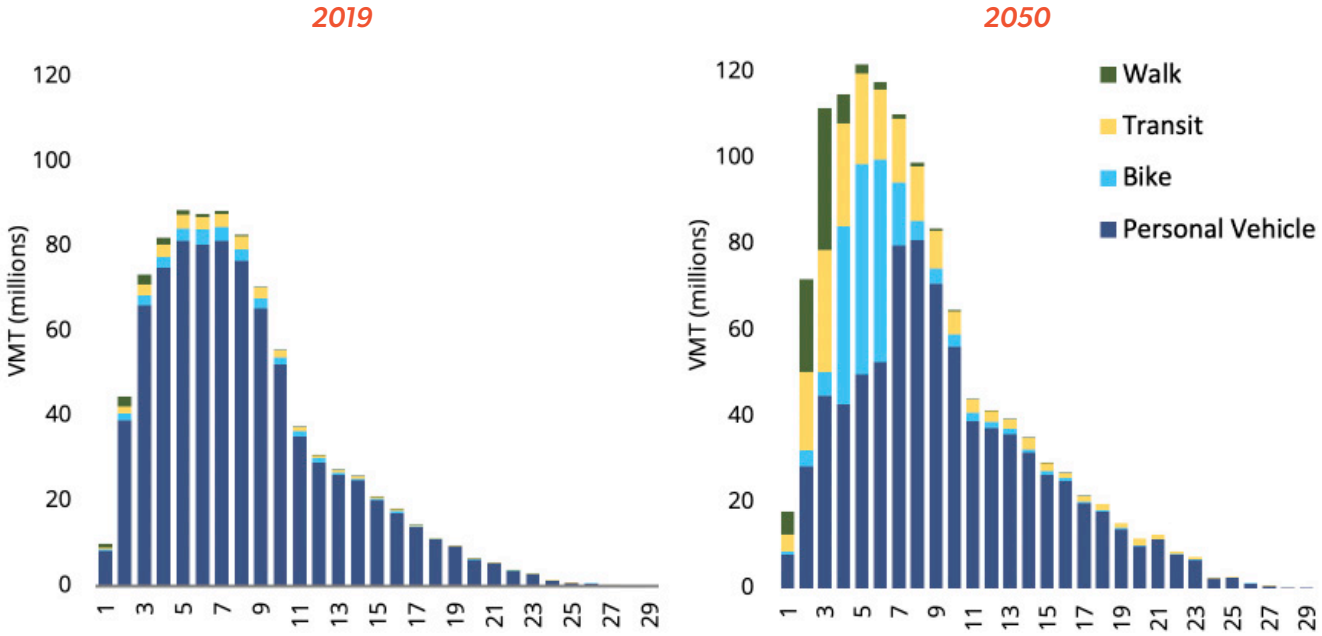

Figure 23. Vehicle miles traveled by trip distance and mode share in the Net-Zero Scenario, 2019 (left) and 2050 (right).

WASTE

NET-ZERO SCENARIO ASSUMPTIONS	2050 GHG REDUCTION (MTCO2E) RELATIVE TO NO NEW ACTIONS	CONTRIBUTION TO CUMULATIVE EMISSIONS REDUCTIONS (2019-2050)
• Per capita waste generation reduces by **2%** (of **2019** rate) each year to **2050** • **95%** diversion from landfill by **2050** • Increase methane capture and flaring to **100%** by **2050**	70	3%

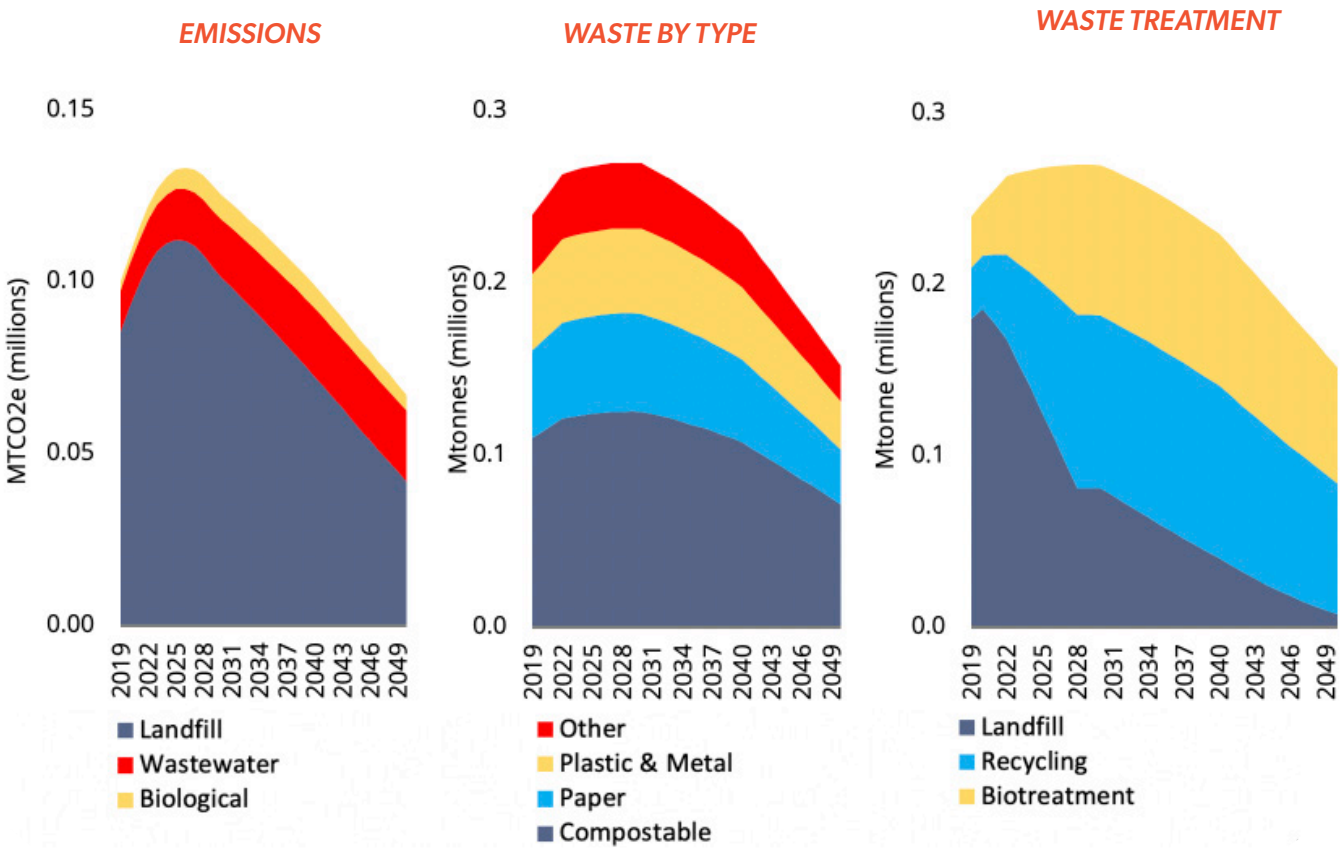

Figure 24. Emissions from waste (left), waste tonnage by type (middle), and waste treatment (right), 2019-2050.

Waste emissions decrease by 33% from 2019 to 2050 under the Net-Zero Scenario. Waste generation increases with population growth until 2028, after which point reduction efforts and a reduced rate of population growth cause it to decline. Increases in diversion from landfill and methane capture and flaring further reduce emissions, leaving 67,000 MtCO2e of emissions from waste in Tacoma by 2050.

ENERGY

ENERGY USE

EMISSIONS

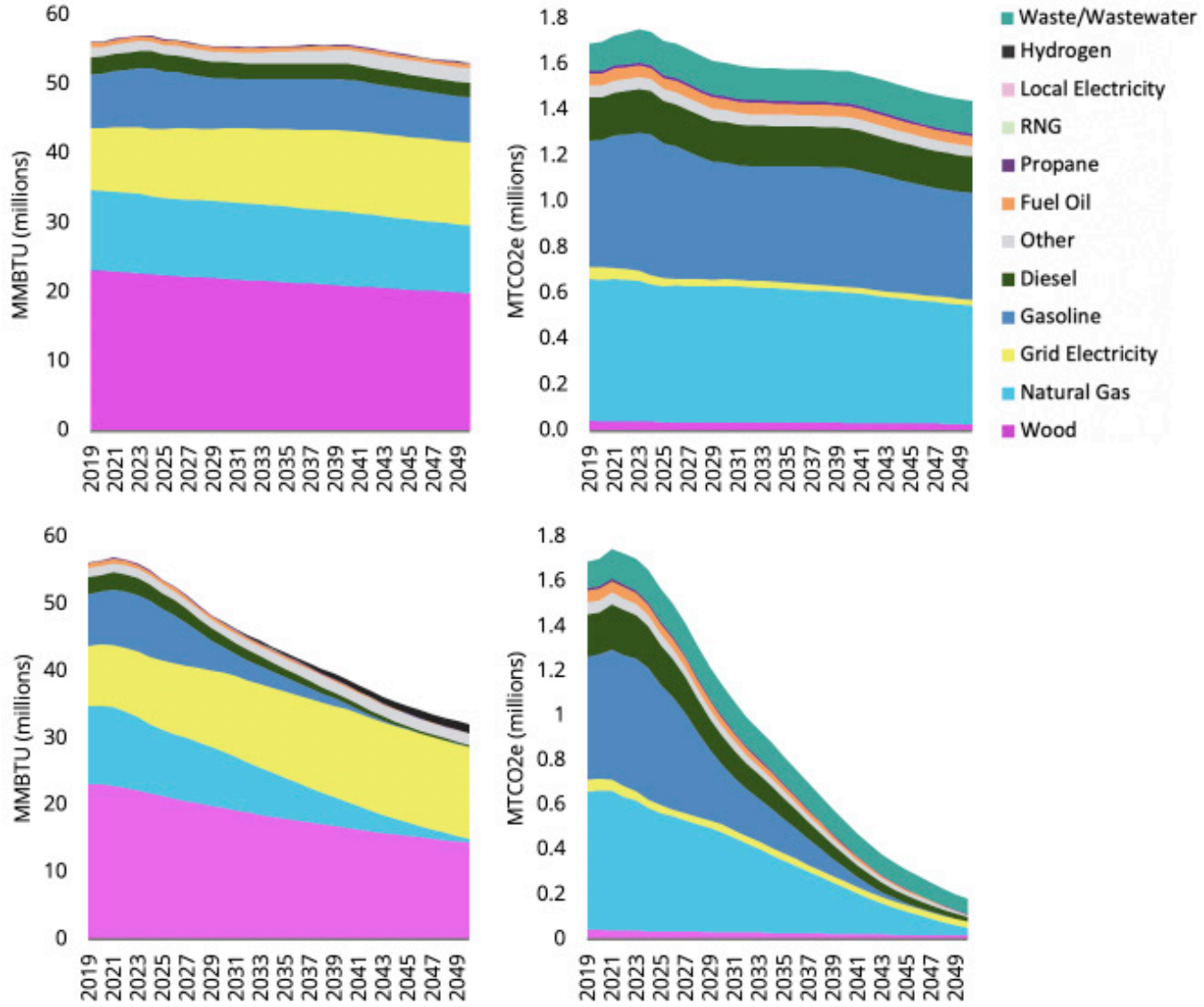

Figure 25. City-wide energy use (left) and emissions (right) by fuel type, 2019-2050. No New Actions Scenario is shown on top, and the Net-Zero Scenario on the bottom.

Figure 25 shows the comparison of energy use by fuel type for the Net-Zero Scenario (bottom) versus the No New Actions Scenario (top). Emissions reductions of 89% are achieved in the Net-Zero Scenario through efforts to **1) reduce** energy use and consumption (for example, improved travel behaviors, smaller building sizes, waste reduction), **2) improve** efficiency (for example, building retrofits, industrial technologies), and **3) switch** to carbon-free end use technologies (such as heat pumps, electric vehicles). This paradigm is particularly relevant to concerns about electrical grid capacity. Much of this concern can be mitigated if reductions and efficiency gains are made prior to switching fuels. Through these efforts, the Net-Zero Scenario results in just a 17% increase in electricity consumption over the No New Actions Scenario by 2050 (Figure 26). The use of electric vehicles can help to mitigate impacts on peak electricity demand, as vehicles

that are charged overnight can actually serve as batteries for building energy when not being used during the day.

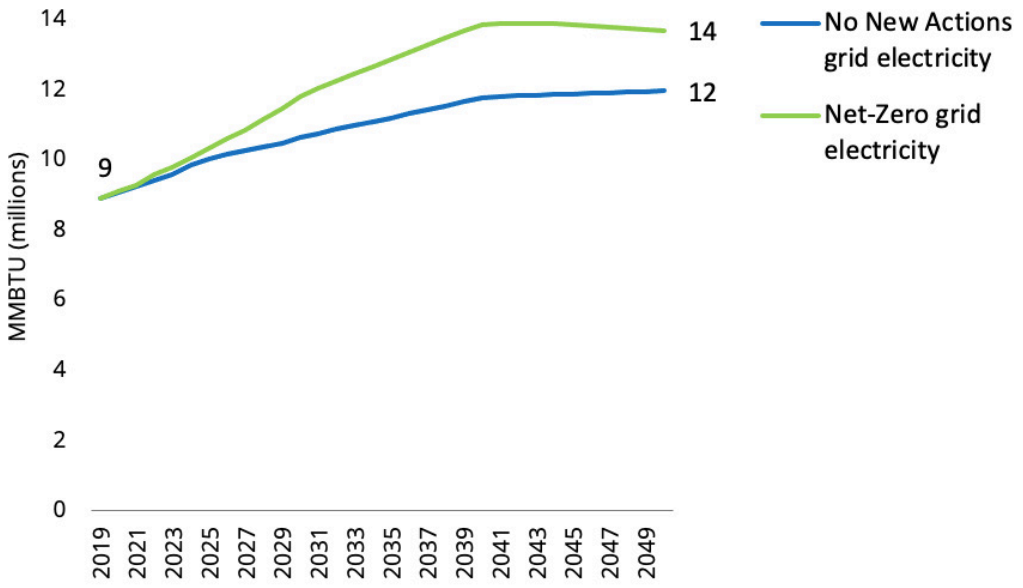

Figure 26. Grid electricity use in the No New Actions Scenario versus Net-Zero Scenario, 2019-2050.

DATA AND ASSUMPTIONS

Table 7. Key data and assumptions for the No New Actions Scenario. Note that the year 2019 was used for the base year. All assumptions and sources were reviewed with City Staff and Steering Committee members.

	NO NEW ACTIONS SCENARIO ASSUMPTION	SOURCE
DEMOGRAPHICS		
Population & employment		
Population	Population grows according to City projections	Base year households from federal census 2019 American Community Survey for base year population and employment Population and employment growth to 2050 from City Planning for mixed use centers traffic zones (includes 35% decrease from regional projections); Growth in non mixed use center traffic zones allocated in proportion to growth in those zones in the Land Use Vision V2 projections

	NO NEW ACTIONS SCENARIO ASSUMPTION	SOURCE
Employment	Employment grows according to City projections	
BUILDINGS		
New buildings growth		
Residential buildings	Buildings added alongside population growth; building types added based on zoning district of zone where population growth is happening Assumed half of new dwellings were replacing demolitions, and half were new builds	2019 buildings by type and zone from Pierce County Assessor (2019 ACS for control check) Housing type proportions (i.e. proportions of single family, semi-detached, townhouses, and apartments) by zone from the Land Use Vision Growth Projections and Urban Form Element One Tacoma Plan Assumption for half new builds and half replacements from Tacoma Planning
Non-residential buildings	Growth based on projected growth in employment	
New buildings energy performance		
Residential	2019-2020 100% of all new construction built to 2015 WSEC Used Washington average residential Energy Use Intensity (EUI) Code improvement schedules: 2021-2024: 2018 WSEC After 2024, improvements approximately each 4 years starting at 6% and gradually decreasing Performance under code improves by: 6% every code change, from 2018-2020, 2021-2024, 2025-2030 inclusive 3% every code change, from 2031-2034 2035-2038,2039-2043 2% every code change thereafter 2044-2047, 2048-2050	2015 IECC/WA State Energy Code (WSEC) current code *2018 IECC/WSEC* effective Feb. 1, 2021 *2021 IECC/WSEC* effective 2024 *Residential New Construction Code Study* (Northwest Energy Efficiency Alliance) Base year EUI for commercial and multi-res: *Washing State Commercial Energy Code*, *Technical Roadmap*

	NO NEW ACTIONS SCENARIO ASSUMPTION	SOURCE
Multi-residential	Improvement steps to parallel residential	
Commercial and institutional	New commercial improvement schedule- performance under code improves by: 6% every code change, from 2018-2020, 2021-2024, 2025-2030 inclusive 3% every code change, from 2031-2034 2035-2038,2039-2043 2% every code change thereafter 2044-2047, 2048-2050	*WA State Commercial Energy Code Technical Roadmap* Washington State has set a legislative goal to reduce annual net site energy consumption for commercial buildings under the 2030 energy code by 70% relative to the 2006 Washington State Energy Code (WSEC) 2030 Targets: Large office- 19.3 kBtu/sf Med office- 12.7 kBtu/sf Standalone retail- 17.4 kBtu/sf Secondary school- 15.9 kBtu/sf Mid-rise apt- 12.3 kBtu/sf
Industrial	Industrial efficiency (minor) improvements according to U.S. Energy Information Administration (EIA) projections	Annual Energy Outlook 2020 *Table 6*. Industrial Sector Key Indicators and Consumption
Existing buildings energy performance		
Residential	Existing building stock efficiency remains constant	Baseline efficiency based on a combination of building archetypes, assessment data, and utility data *The Clean Buildings Act (House Bill 1257)* (Although as of Dec 2020 the EUI targets had not been announced) Proposed EUI targets by building type and climate zone were adopted in Oct 2020 under *WAC 194-50* Table 7-2a Building Activity Site Energy Targets (EUIt1) (I-P Units) *- Annex Z* Compliance Schedule - section Z3.1 >220,000 sqft, June 2026 90,000-220,000 sqft, June 2027 50,000-220,000 sqft, June 2028 *Tacoma Power Conservation Plan 2020-2021*

	NO NEW ACTIONS SCENARIO ASSUMPTION	SOURCE
Multi-residential	Existing building stock efficiency remains constant	
Commercial & Institutional	Existing Buildings >50,000 square feet to comply with The Clean Buildings Act starting in 2026	
Industrial	Assumed improvements same as for new industrial buildings (above) from U.S. EIA data	
End use		
Space heating/ Water heating/ Space cooling	Baseline building equipment types/ stocks held from 2019-2050 For new builds, assumed 75% of new heating systems were heat pumps; 25% natural gas For stock turnover, assumed a small percentage of heat pump uptake	Residential Energy Consumption Survey (RECS) for baseline building equipment types State Energy Data System (SEDS) for building equipment efficiencies *Tacoma Power Conservation Potential Assessment* *Buildings energy systems simulator* for baseline energy use by building/system type/fuel type (Canadian-based model, using City of Vancouver weather and buildings characteristics)
ENERGY GENERATION		
Low or zero carbon energy generation (community scale)		
Rooftop Solar PV	Existing solar photovoltaic (PV) 4127 kW (Q12021), included 569 different installations 2020-2021 Anticipated 660 net metering participants; 990 community solar participants	City provided 2019 PV Tacoma Energy Research & Development for Q12021 capacity *2020-2021 Conservation Plan p.26*
Wind	None forecast	*Tacoma Power 2020 Integrated Resource Plan*

	NO NEW ACTIONS SCENARIO ASSUMPTION	SOURCE
TRANSPORT		
Transit		
Expanded transit	Transit is expanded as seen in Pierce County's Transportation Model Mode share 2019 / 2050 Bike 3% / 7% SOV 90% / 78% Transit 3% / 9% Walk 3% / 6%	Pierce County Trip Based Travel Model (EMME) trip lengths and types from 2019-2040 (home to work, school, other...) ClearPath for transit fuel use Puget Sound Regional Council, *Regional Transportation Plan* - Used the mode shares from this plan to adjust/ calibrate the EMME model shares
Electrify transit system	None assumed. Note that Pierce County has a transit goal to electrify 30% of their vehicles (no date), therefore, moved this to Net Zero Scenario	Pierce County Transit Press Release for target electrification Base year (2019) transit fleet and fuel use from ClearPath
Active transportation		
Cycling & walking infrastructure	Active transportation infrastructure expanded as seen in Pierce County's Transportation Model Mode share 2019 / 2050 Bike 3% / 7% SOV 90% / 78% Transit 3% / 9% Walk 3% / 6%	Pierce County Trip Based Travel Model (EMME) trip lengths and types from 2019-2040 ClearPath transit fuel use Puget Sound Regional Council, *Regional Transportation Plan* - Used the mode shares from this plan to adjust/ calibrate the EMME model shares
Mulit-modality for City Business	As above	As above
Private/personal transportation		
Electrify personal vehicles	14% new sales by 2030; 23% 2050	EV data for Tacoma by zip code and point location saved as EV Tacoma Registration for baseline year *EIA Energy Transportation Outlook for projected sales* (Mountain Census Division) Note that the EIA projections were for 'alternative car sales', and EV-only numbers were in fact lower than those used for the No New Actions Scenario. Higher numbers were used, since most other national projections projected much greater numbers (*for example, 28% by 2030*).

	NO NEW ACTIONS SCENARIO ASSUMPTION	SOURCE
Zero emissions commercial vehicles	Assumed same EV penetration for light-duty vehicles as for personal vehicles Some electrification of heavy-duty vehicles (38% of new sales by 2050) Some uptake of hydrogen (12% of new sales by 2050)	Puget Sound Clean Air Agency July 2020 Report- 1) All trucks zero emissions 2) Port drayage trucks all electric 3) Delivery vehicles all zero emissions Note that there is no date specified for these targets.
Vehicle miles traveled	Personal vehicle miles traveled as seen in Pierce County's Transportation Model Assume that commercial vehicle miles traveled grows alongside commercial floorspace growth	Pierce County Trip-Based Travel Model (EMME) trip lengths and types for personal vehicle miles traveled 2019-2040
Vehicle fuel efficiencies / tailpipe emission standards	CAFE Fuel standards: Vehicle fuel consumption rates reflected the implementation of the U.S. Corporate Average Fuel Economy (CAFE) Fuel Standard for Light-Duty Vehicles, and Phase 1 and Phase 2 of EPA HDV Fuel Standards for Medium- and Heavy-Duty Vehicles. --- Light duty: 2015: 200gCO2e/km 2025: 119 gCO2e/km 2030: 105gCO2e/km --- Heavy Duty: 20% reduction in emissions intensity by 2025 relative to 2015, 24% reduction in emissions intensity in 2030 relative to 2015	EPA. (2012) (CAFE standards). EPA and NHTSA set standards to reduce greenhouse gases and improve fuel economy for model years 2017-2025 cars and light trucks. Retrieved from
Total vehicle ownership	Personal vehicle stock growth alongside household growth	Household travel survey for base year vehicles per household Washington State 2019 vehicle registration for shares of vehicles by type (base year) EV data for Tacoma by zip code and point location saved as EV Tacoma Registration (overrode State registration data for EVs) Building growth projections from Land Use Vision used with base year vehicles per household to project future City vehicle stock

	NO NEW ACTIONS SCENARIO ASSUMPTION	SOURCE
Rail	Base year use held constant	Sound Transit use from Clearpath Amtrak assumed 4 trains per day going through Tacoma
Marine	Base year use held constant	Base year ferry use from ClearPath; freight use from Marine Emissions Inventory
WASTE		
Waste generation	Usage grew based on base year per capita waste generation	2015 City of Tacoma Waste Characterization Study
Waste diversion	Base year waste diversion rate 23% 2008 goal to divert 70% of solid waste by 2028	Base year (2019) diversion from Environmental Services Solid Waste Management Team *Sustainable Material Management Plan*
Municipal water	Facilities' energy use increased with population growth	Tacoma Water
Waste treatment	Current capture and flaring rates held constant (71%)	Methane recovered/flared from ClearPath
Wastewater	Volume grows with population 100% digester gas is captured with some flared and some used for boilers After 2021, some of the captured gas will be used as renewable natural gas (RNG) for vehicles	Base year data from City and ClearPath
INDUSTRY		
Industrial efficiencies	Base year efficiencies held constant	ClearPath to calibrate industrial fuel use Efficiencies from default values from North American Energy System Simulator model
EMISSIONS FACTORS		
Grid emissions factor	Assumed 2020 value increased by 75%	Mid-range increase based on modeled portfolios out to 2040, described in the Tacoma Public Utilities Integrated Resource Plan (page 113) *Tacoma Power 2020 Integrated Resource Plan* p.62 Figure 47 (updated Jan 2021)

GPC INVENTORY TABLES, 2019

The inventory table starting on the following page was produced in accordance with the accounting and reporting standards of the Global Protocol for Community Scale Greenhouse Gas Inventories (GPC). Below is a series of tables that briefly summarize the formats and specifications for GPC-compliant GHG inventories. For more details, please see *Chapter 4 - Reporting Requirements* of the GPC.

Table 8. Scopes for GHG inventory reporting according to the GPC.

Scope	Definition
1	GHG emissions from sources located within the city boundary.
2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.
3	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

Table 9. GPC's GHG inventory reporting frameworks. This inventory covers BASIC+ and follows the scopes framework.

Reporting Approach	Definition
City-induced framework	
BASIC	Stationary energy, in-boundary transportation, in-boundary generated waste.
BASIC+	BASIC sources, plus IPPU (industrial processes and product use), AFOLU (agriculture, forestry and other land use), transboundary transportation, and energy transmission and distribution losses.
Scopes framework	
General	Emissions are divided into scopes 1-3.
Territorial	Emissions generated within the city (scope 1 only).

Table 10. Notation key for missing data, and color codes for reporting frameworks.

Notation	Reason for exclusion:
IE	Included elsewhere (in another category)
NE	Not estimated (reason provided)
NO	Not occurring within the inventory boundary

Row color	
	Sources required for BASIC reporting and BASIC+ reporting
	Sources required for BASIC+ reporting
	Sources included in Other Scope 3
	Sources required for Scope 1 (territorial) total but not for BASIC/BASIC+ reporting

Table 11. Community-wide GPC inventory for Tacoma, 2019.

					IN TONS			
GPC REF NO.	SCOPE	GHG EMISSIONS SOURCE	INCLUSION	REASON FOR EXCLUSION (IF APPLICABLE)	CO2	CH4	N2O	TOTAL CO2E
I	STATIONARY ENERGY SOURCES							
I.1	Residential buildings							
I.1.1	1	Emissions from fuel combustion within the city boundary	Yes		140,931	12,774	1,215	154,921
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes		18,215			18,215
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes		606			606
I.2	Commercial and institutional buildings/facilities							
I.2.1	1	Emissions from fuel combustion within the city boundary	Yes		127,340	84	140	127,563
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes		17,034			17,034
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes		567			567
I.3	Manufacturing industry and construction							
I.3.1	1	Emissions from fuel combustion within the city boundary	Yes		463,191	4,570	25,976	493,737
I.3.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes		16,728			16,728
I.3.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes		557			557
I.4	Energy industries							
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary	No	NO				
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary	No	NO				

					IN TONS			
GPC REF NO.	SCOPE	GHG EMISSIONS SOURCE	INCLUSION	REASON FOR EXCLUSION (IF APPLICABLE)	CO2	CH4	N2O	TOTAL CO2E
I.4.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations	No	NO				
I.4.4	1	Emissions from energy generation supplied to the grid	No	NO				
I.5		Agriculture, forestry and fishing activities						
I.5.1	1	Emissions from fuel combustion within the city boundary	No	NO				
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary	No	NO				
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	No	NO				
I.6		Non-specified sources						
I.6.1	1	Emissions from fuel combustion within the city boundary	No	NO				
I.6.2	2	Emissions from grid-supplied energy consumed within the city boundary	No	NO				
I.6.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	No	NO				
I.7		Fugitive emissions from mining, processing, storage, and transportation of coal						
I.7.1	1	Emissions from fugitive emissions within the city boundary	No	NO				
I.8		Fugitive emissions from oil and natural gas systems						
I.8.1	1	Emissions from fugitive emissions within the city boundary	Yes		11	17,975		17,986

					IN TONS			
GPC REF NO.	SCOPE	GHG EMISSIONS SOURCE	INCLUSION	REASON FOR EXCLUSION (IF APPLICABLE)	CO2	CH4	N2O	TOTAL CO2E
II	TRANSPORTATION							
II.1	On-road transportation							
II.1.1	1	Emissions from fuel combustion for on-road transportation occurring within the city boundary	Yes		515,007	945	3,179	519,130
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	Yes		61			61
II.1.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	Yes		172,848	254	1,299	174,401
II.2	Railways							
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary	Yes		894	2	109	1,005
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways	No	NO				
II.2.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No	NO				
II.3	Water-borne navigation							
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary	Yes		43,206	82	5,265	48,553
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation	No	NE (insufficient data)				

					IN TONS			
GPC REF NO.	SCOPE	GHG EMISSIONS SOURCE	INCLUSION	REASON FOR EXCLUSION (IF APPLICABLE)	CO2	CH4	N2O	TOTAL CO2E
II.3.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No	NE (insufficient data)				
II.4	Aviation							
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary	No	NO				
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation	No	NO				
II.4.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No	NO				
II.5	Off-road							
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary	No	NE (insufficient data)				
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation	No	NE (insufficient data)				
III	**WASTE**							
III.1	Solid waste disposal							
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary	Yes			85,540		85,540

					IN TONS			
GPC REF NO.	SCOPE	GHG EMISSIONS SOURCE	INCLUSION	REASON FOR EXCLUSION (IF APPLICABLE)	CO2	CH4	N2O	TOTAL CO2E
III.1.2	3	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary	No	IE				
III.1.3	1	Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary	No	NO				
III.2	Biological treatment of waste							
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary	Yes			621	1,998	2,619
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary	No	NO				
III.2.3	1	Emissions from waste generated outside the city boundary but treated biologically within the city boundary	No	NO				
III.3	Incineration and open burning							
III.3.1	1	Emissions from solid waste generated and treated within the city boundary	No	NO				
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary	No	NO				
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city boundary	No	NO				
III.4	Wastewater treatment and discharge							
III.4.1	1	Emissions from wastewater generated and treated within the city boundary	Yes				11,926	11,926

					IN TONS			
GPC REF NO.	SCOPE	GHG EMISSIONS SOURCE	INCLUSION	REASON FOR EXCLUSION (IF APPLICABLE)	CO2	CH4	N2O	TOTAL CO2E
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary	No	NO				
III.4.3	1	Emissions from wastewater generated outside the city boundary	No	NO				
IV	**INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)**							
IV.1	1	Emissions from industrial processes occurring within the city boundary	No	NE (insufficient data)				
IV.2	1	Emissions from product use occurring within the city boundary	No	NE (insufficient data)				
V	**AGRICULTURE, FORESTRY AND LAND USE (AFOLU)**							
V.1	1	Emissions from livestock within the city boundary	No	NO				
V.2	1	Emissions from land within the city boundary	No	NE (insufficient data)				
V.3	1	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary	No	NO				
VI	**OTHER SCOPE 3**							
VI.1	3	Other Scope 3	No	NE				
							TOTAL	1,691,149