Transit Sustainability Report & Greenhouse Gas Inventory

2021 & 2022

CTRAN the smart way to go

Elmira-Chemung Transportation Council

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Acronyms and Abbreviations

BIL	Bipartisan Infrastructure Law
BEV	battery electric vehicle
CAP	Criteria Air Pollutant
CCF	centum (one hundred) cubic feet
CEC	Clean Energy Communities
CH_4	methane
CLCPA	Climate Leadership and Community Protection Act
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COVID	Coronavirus
CSC	Climate Smart Communities
CTRAN	Chemung County Transit System
DEC	Department of Environmental Conservation
DOE	Department of Energy
eGRID	Emissions & Generation Resource Integrated Database
EPA	Environmental Protection Agency
FTA	Federal Transit Administration
gal	gallon
GHG	greenhouse gas
GHGRP	Greenhouse Gas Reporting Program
GWP	Global Warming Potential
HFCs	hydrofluorocarbons
kWh	kilowatt-hour
lbs	pounds

LNG	liquified natural gas
Low-No	Low- or No-Emission Vehicle Program
MHD	medium- and heavy-duty
MMBtu	metric million British thermal unit
MPG	miles per gallon
$mtCO_2e$	metric tons of carbon dioxide equivalent
MWh	megawatt-hour
MY	model year
N_2O	nitrous oxide
NF_3	nitrogen trifluoride
NO_x	nitrous oxides (NO, NO_2)
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northeast Power Coordinating Council
NY(S)	New York (State)
NYSERDA	New York State Energy Research and Development Authority
NYUP	Upstate New York
PFCs	perfluorocarbons
PM	particulate matter
SF_6	sulfur hexafluoride
STC	Southern Tier Central Regional Planning and Development
STE	Southern Tier East Regional Planning and Development
ULSD	ultra-low-sulfur diesel
US	United States
VMT	vehicle miles traveled

Introduction

Purpose of this report

This report seeks to develop a better understanding of greenhouse gas (GHG) emissions released over the course of a year by CTRAN operations. By quantifying emissions from various sources, performance can be assessed and optimized, and future reduction targets can be set. Developing a report based on the current system over recent years, provides a baseline to build off of and holds CTRAN accountable. The 2021 data compiled in this report will act as the baseline, with the 2022 data acting as the first year of comparison, having made no direct changes to reduce emissions.

As the county transit system, CTRAN should lead efforts to increase mobility and support multi-modal and active transportation. This report is a first step towards reducing emissions and building a more sustainable community.

What is a Greenhouse Gas Inventory

GHGs are gases that trap heat in the atmosphere, keeping the Earth's temperature from dropping drastically at night. However, since the Industrial Revolution, human activities have led to the release of larger quantities of GHGs into the atmosphere, further slowing the rate energy escapes to space. This increase has been linked to rising temperatures and more severe weather events over time. The most commonly known GHGs are carbon dioxide (CO_2) and methane (CH_4), which make up the majority of emissions. Nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3) exist in a much lower percentage but are extremely potent and have higher Global Warming Potential (GWP). While CO_2, CH_4, and N_2O are naturally occurring, their atmospheric concentration is man-made. Fluorinated gases (HFCs, PFCs, SF_6, NF_3) do not occur in nature and are man-made during industrial processes. Due to its abundance, CO_2 is considered the main contributor to climate change.

Global Warming Potential was developed to compare the global warming impacts of different gases, as different GHGs have different effects on the Earth's warming. Specifically, GWP measures how much energy the emissions of 1 ton of a gas will absorb relative to the emissions of 1 ton of CO_2 over a given time period. CO_2 is used as the reference; therefore, it will always have a GWP of 1, regardless the time period. Usually, the time period used for GWP is 100 years. The increase in atmospheric concentrations of CO_2 will last thousands of years, while CH_4 emitted today only lasts about a decade. However, despite its shorter lifetime, its higher energy absorption and the indirect effects from being the cursor to ozone results in an estimated GWP of 27-30 over 100 years. Currently, N_2O has a GWP of 273, with the fluorinated gases reaching GWPs in the thousands or tens of thousands.[1]

Current Trends

Per the New York Department of Environmental Conservation (DEC), energy was the state's largest source of emissions (77%), primarily from fuel emissions and fugitive emissions from imported fossil fuels. More than half of the state's GHG emissions come from buildings (32%) and transportation (29%), followed by electricity, waste, industry, and agriculture when comparing economic sectors. From 1990 to 2019, there

[1] www.epa.gov/ghgemissions/understanding-global-warming-potentials

was a 46% decrease in electricity emissions and a 33% decrease in industrial emissions, but a 16% increase in building emissions and a 10% increase in transportation offset those reductions.[2]

In 2021, transportation accounted for 28% of gross GHG emissions, making it the largest contributor of GHG emissions in the United States.[3] Largely, these emissions come from the burning of fossil fuels for cars, trucks, ships, trains, and planes. Of the transportation-related emissions, passenger cars and light-, medium-, and heavy-duty (MHD) vehicles are the largest source, accounting for over half of the emissions. After passenger cars and trucks, MHD vehicles are the largest source of transportation sector GHG emissions in the United States and are a major contributor to hazardous and smog-forming pollutants – accounting for 30% of GHG emissions, 42% of nitrogen oxides (NO_x) emissions and 51% of direct particulate matter ($PM_{2.5}$) emissions – that harm the environment and public health. The 2.5 subscript on PM describes fine inhalable particles with diameters that are generally 2.5 micrometers and smaller.

Changes in the economy, the price of fuel, and other factors can cause emissions to rise and fall from year to year. Since 1990, total US GHG emissions have decreased by just over 2%. From 1990 to 2021, total transportation emissions from fossil fuel combustion increased by 19%. A continuously increasing demand for travel during this time frame saw the number of vehicle miles traveled (VMT) by light-duty motor vehicles (passenger cars and light-duty trucks) increase 45%. Urban sprawl, population growth, economic growth, and periods of low fuel prices have contributed to this significant change. The start of the pandemic, and subsequent quarantine, saw a sharp decline in emissions, down 13%; however, when economic activity began to rebound in 2021, the US once again saw an increase in its emissions – by 12% – largely driven by increased CO_2 emissions from fossil fuel combustion.[4]

Electricity is the second largest source of US GHG emissions, behind transportation. Electric power sector emissions increased by 7% in 2021; however, emissions from electric power production have decreased by about 15% since 1990, due to a shift to lower- and non-emitting sources and increased end-use energy efficiency.[4]

Per New York's ClimAID analysis, heat waves are predicted to increase, while snow cover decreases, and intense precipitation events occur more often. Climate models projected the effects of an increase of flooding along the Susquehanna River, as well as an invasion of insects, weeds, and other pests that are moving Northward.[5]

Equity Considerations

Exposure to ground-level ozone, NO_x, and $PM_{2.5}$ worsens asthma and other cardio-respiratory illnesses, especially in children and older adults. Exposure to $PM_{2.5}$ can also trigger heart attacks and strokes, exacerbate obesity and diabetes, and contribute to cognitive challenges. Furthermore, recent studies have established a clear link between proximity to traffic pollution and adverse public health impacts. Low-income communities and communities of color are disproportionately impacted by this pollution burden and its health and economic consequences. These communities also experience greater barriers to receiving healthcare and are disproportionately exposed to impacts of climate change.

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[2] https://www.dec.ny.gov/docs/administration_pdf/ghgsumrpt22.pdf
[3] https://www.epa.gov/ghgemissions/overview-greenhouse-gases
[4] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions
[5] https://chemungcountyny.gov/DocumentCenter/View/183/2019-Chemung-County-Hazard-Mitigation-Plan-PDF

This is reflected on the White House's Justice40 screening tool when looking at Chemung County and, more specifically, the City of Elmira. Census tracts 1 and 7, which encompass the bus garage and transportation center, show high rates of asthma, diabetes, heart disease, and low life expectancy. These tracts have a low median income, high rates of poverty, and high rates of unemployment.

As is common in rural communities, there are gaps in the service area where transit is unable to reach everyone or cover all destinations with demand. Rural areas tend to have higher concentrations of elderly and disabled people, with both of these groups tending to have an increased need for accessible public transit. Additionally, members of the workforce may rely on public transportation to connect with a wider array of jobs and economic opportunities.

Due to electric vehicle (EV) education, readiness, and deployment efforts being primarily focused within urban areas, exposure to EV technology has typically been lower within rural areas. This lack of exposure can lead to hesitance surrounding the various technologies and a lack of understanding of the need for these changes to be implemented.

Benefits

By conducting a GHG inventory, the reporting company or organization can establish a baseline for tracking its GHG emissions. An inventory can alert management to inefficiencies in its operations and encourage reflection on the efficiency and cost-effectiveness of existing measures. A sustainability report can aid in risk management, helping to foresee changes and effectively plan for them, as well as providing insight into potential shifts that can impact future decision-making. This report will inform future inventories and reports, and the data will be used to support grant applications.

As legislation continues to establish reduction targets and business standards for emissions, maintaining an inventory can aid CTRAN remain compliant with current and future regulations.

Source inclusions

Emissions sources included in this report are facilities, vehicles, electricity, heating, and employee commuting. Water usage for the reporting years was included for the purpose of setting water use reduction targets but is not included as an emissions source.

Source exclusions

As a transit system that does not act as its own entity, defining its boundaries for the purpose of this report resulted in the exclusion of a number of sources. Due to lack of data and certainty, the following sources were not included: purchased goods and services, transportation and distribution, capital goods, waste generated, and waste disposal.

Emissions from the use of goods and services were not considered at this time, as any goods and services sold by CTRAN are included under other emission sources.

In order to obtain an accurate and overarching report on the excluded sources, an in-depth inventory should be conducted for both TransDev and County operations.

Background and Context

National and State Policies, Initiatives, and Regulations

Federal

In November 2021, the Bipartisan Infrastructure Law (BIL) was passed by Congress. One of the goals of the legislation is to improve transportation options for Americans and reduce GHG emissions through its investment in public transit. The BIL authorizes up to $108 billion to support federal public transportation programs. FTA's Low-No program, provided for by the BIL, makes funding available to buy or lease American-built low- or zero-emission vehicles, make facility and station upgrades to accommodate low- or zero-emission vehicles, and purchase supporting equipment such as chargers for battery electric vehicles (BEVs).[6]

In December 2021, EPA finalized federal GHG emissions standards for passenger cars and light-duty trucks for model year (MY) 2023 to 2026. These standards are the strongest vehicle emissions standards ever established for the light-duty vehicle sector. According to the US Environmental Protection Agency (EPA), the updated standards will result in the avoidance of over 3 billion tons of GHG emissions through 2050 and provide a strong jumping off point for standards for MY 2027 and beyond. EPA is also looking to establish multi-pollutant emissions standards under the Clean Air Act for MY 2027 that will aid in speeding up the transition of the light-duty vehicle fleet toward achieving a zero-emissions future.[7]

Currently, facilities that meet reporting thresholds must report GHG emissions to the Greenhouse Gas Reporting Program (GHGRP) annually, under the Clean Air Act. In June 2022, EPA proposed amendments to specific provisions of the GHGRP to improve the quality of data collected under the program to address changing industry practices, adopt improved circulation and monitoring methods, and collect new data to understand new source categories or emissions sources for specific sectors.

State

The Climate Leadership and Community Protection Act (CLCPA) of 2019 established requirements and directives that include limiting statewide GHG emissions to 60% of 1990 levels by 2030 and 15% of 1990 levels by 2050, and achieving net-zero GHG emissions across the NYS economy.[8]

The New York State Energy Research and Development Authority (NYSERDA) is working to decarbonize New York's buildings, transportation systems, and power generation by transitioning to zero-emission technologies and renewable energy sources. NYSERDA supports the DEC in updating emission methodology, rulemaking, and implementation for the development of a statewide GHG inventory.[9]

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[6] https://www.transit.dot.gov/BIL

[7] https://www.epa.gov/newsreleases/epa-finalizes-greenhouse-gas-standards-passenger-vehicles-paving-way-zero-emissions

[8] https://capandinvest.ny.gov/

[9] https://www.nyserda.ny.gov/Impact-Greenhouse-Gas-Emissions-Reduction

Chemung County Sustainability Initiatives

Climate Smart Communities (CSC)

In September 2022, Chemung County became a Bronze-certified **Climate Smart Community**. In order to become a certified community, Planning Department staff worked to complete a range of actions that aid in mitigation and adaptation to climate change. The County is actively pursuing Silver, the next level of certification, while Southern Tier Central Regional Planning and Development (STC) is working with municipalities within the county to get them certified individually, as well.

Clean Energy Communities (CEC)

NYSERDA's CEC is a separate but parallel program to CSC. This program provides tools and resources to pursue "high impact actions" that focus on energy-efficiency. A regional CEC Coordinator aids the county in completing these actions. Taking part in both CSC and CEC opens up grant funding opportunities that can further support the implementation of mitigation and adaptation strategies.

Cleaner, Greener Southern Tier

This plan was prepared with financial support from the New York State Cleaner, Greener Communities Program, and through the collaboration of the Southern Tier Regional Consortium, Tompkins County Planning Department, STC, Southern Tier East (STE), and the ICF International Team. The plan includes a GHG emissions baseline inventory for the region and identified short- and long-term implementation strategies to meet the emissions goals and establish metrics for tracking regional progress.

The plan outlines the top 22 short-term priority actions of 65 total priority actions. Some of the top priority actions outlined are: promote energy efficiency and renewable energy in residential and commercial buildings, encourage adoption of green fleet policies for public and private fleets, and create a region-wide electric vehicle and alternative fuel infrastructure deployment plan. The former would lead to an estimated reduction of 397,000 metric tons of CO_2 equivalent ($mtCO_2e$) annually by 2032 and the latter two combined would lead to an estimated reduction of 262,000 $mtCO_2e$ annually by 2032.

Two transportation-specific goals were also outlined in the plan: *(1)* Create a regional multi-modal transportation system that offers real transportation choice, reduced costs and impacts, and improved health; *(2)* Reduce fossil fuel consumption and GHG emissions from transportation by reducing VMT, increasing efficiency, improving system operations, and transitioning to less carbon intensive fuels and power sources.

Other County Initiatives

In 2019, a multi-jurisdictional **Hazard Mitigation Plan** for the county was completed and a resolution was adopted to integrate the updated plan on behalf of the Chemung County Office of Fire and Emergency Management. The Hazard Mitigation Plan addresses climate change and provides climate change projections, along with other potential hazards residents of the region may face. The plan also includes results from New York's ClimAID analysis on the state's vulnerabilities. The Chemung County Planning Department received a grant to complete the required five-year update to this plan and the process is currently underway.

In 2022, a **Community GHG Inventory** was completed by the Planning Department to assist in identifying key sources of emissions within the community and provide guidelines and strategies that could help reduce them. This inventory indicated that Chemung County was the third largest total gross emissions generator within the Southern Tier Region, behind Broome and Steuben counties.

In 2023, Chemung County Planning Department was awarded a New York State Department of State grant to complete a **County Resiliency Plan** to incorporate resiliency into the forthcoming Chemung County Comprehensive Plan and Hazard Mitigation Plan. Work on the County Resiliency Plan is anticipated to begin in 2024 with final adoption in 2025.

In 2024, Chemung County is piloting a **Food Scraps Composting** program and will repurpose a decommissioned wastewater treatment plant into a new composting facility in 2025.

CTRAN Operations

The Chemung County Transit System, branded as CTRAN, is owned and managed by Chemung County and operated by TransDev (formerly First Transit). CTRAN provides fixed route service locally with three out-of-county routes and Access Chemung, a dial-a-ride service providing curb-to-curb accessible transportation that acts as the county's paratransit.

As it stands, out-of-county routes generally have low ridership and often run regardless of whether or not there are passengers. However, quarterly and yearly ridership continues on an upward trend and efforts are being made to promote the use of public transit within the county to return to pre-COVID levels.

Data collection and uncertainties

Various calculators and calculations were used to conduct this inventory. While aiming for consistency, some values may not align or add up exactly.

Billing periods vary across the utilities, so the split of the quarters may not be completely aligned. January and December usage was prorated to ensure billing periods fit entirely within the reporting year for 2021 and 2022 (January 1 to December 31).

The employee commute survey was conducted in 2023 with the assumption that the majority of employee commuting habits had not changed significantly since 2021. However, there has been turnover at both TransDev and with the two associated county employees since this time. Additionally, only 37 surveys were completed of the 45 total staff and some employees did not share information to calculate their commute mileage. To account for the employees who participated but did not provide mileage information, the average commute distance (13.7 miles roundtrip) among employees was used in their place, with the exclusion of the extreme outlier of 120 miles.

GHG Inventory Results

Direct

Facilities

CTRAN operates out of two facilities – a 5,000 square foot transportation center in downtown Elmira and a 31,000 square foot bus garage, which also houses the dispatch and administrative offices. Both of these facilities use natural gas for their heating systems. *See Tables 1 and 2 for the Quarterly Natural Gas Usage for both facilities for 2021 and 2022. See Table 10 for totals.*

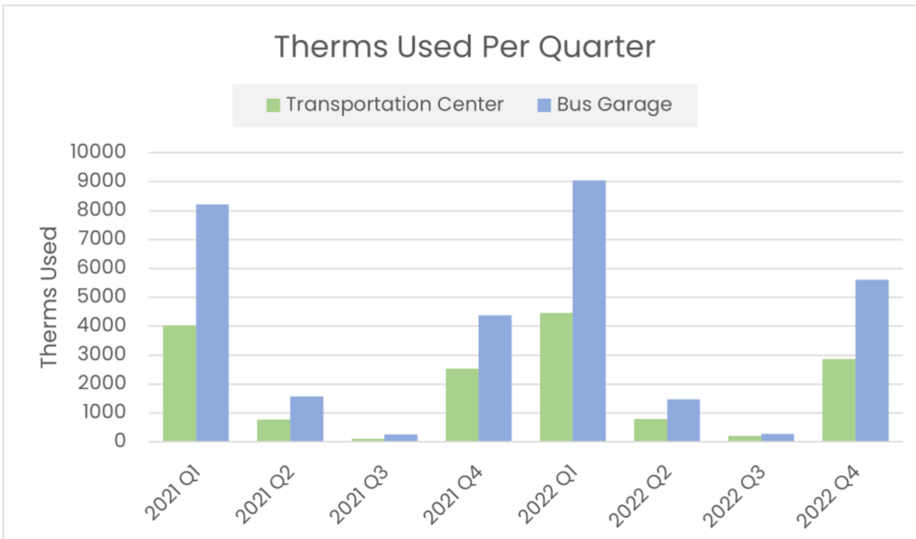

Figure 1

*Per EPA's calculations, **0.0053 mtCO$_2$e** is emitted per therm. This value was multiplied by **therms used** to determine the mtCO$_2$e generated per quarter.*

Table 1: 2021 Natural Gas Usage by Quarter

Transportation Center			**Bus Garage**		
Quarter	**Therms Used**	**mtCO$_2$e**	**Quarter**	**Therms Used**	**mtCO$_2$e**
1	4,029.10	21.35423	1	8,210.60	43.51618
2	771.60	4.08948	2	1,564.90	8.29397
3	109.00	0.5777	3	268.30	1.42199
4	2,534.80	13.43444	4	4,374.00	23.1822
Prorated	+115.82	+0.61385	*Prorated*	+258.20	+1.36946

Table 2: 2022 Natural Gas Usage by Quarter

Transportation Center			**Bus Garage**		
Quarter	**Therms Used**	**mtCO$_2$e**	**Quarter**	**Therms Used**	**mtCO$_2$e**
1	4,461.90	23.64807	1	9,053.40	47.98302
2	790.90	4.19177	2	1,473.40	7.80902
3	210.50	1.11565	3	273.1	1.44743
4	2,871.20	15.21736	4	5,604.7	29.70491
Prorated	+48.30	+0.25599	*Prorated*	-129.97	-0.68884

Vehicles

CTRAN has 26 vehicles in its fleet; 13 diesel buses, 11 gas buses, and two non-revenue gas vehicles used for shuttling employees. In 2021, a total of 712,372 miles were driven by buses and 35,988 miles by non-revenue vehicles, which generated 1,239.07 and 13.81 mtCO$_2$e, respectively. In 2022, a total of 719,564 miles were driven by buses and 36,347 miles by non-revenue vehicles, which generated 1,262.64 and 19.04 mtCO$_2$e, respectively. Diesel buses accounted for three quarters of the total bus mileage. According to the International Council on Clean Transportation, the combustion of 1 liter of diesel fuel releases approximately 13% more CO_2 than the same amount of gasoline.[10] *See Figures 2 and 3 for the emissions source breakdown for CTRAN's vehicles.*

[10] https://theicct.org/wp-content/uploads/2022/01/Gas-_v-_Diesel_-CO2_emissions_-EN_-Fact-_Sheet-2019_05_07_0.pdf

Gilligs and the EZ Rider II have a useful life of 12 years or 500,000 miles, ARBOCs have a useful life of 7 years or 200,000 miles, and Ford buses have a useful life of 5 years or 150,000 miles.

The ARBOCs in CTRAN's fleet have reached their useful life and will be replaced with 5 gas-powered Ford Cutaway buses.

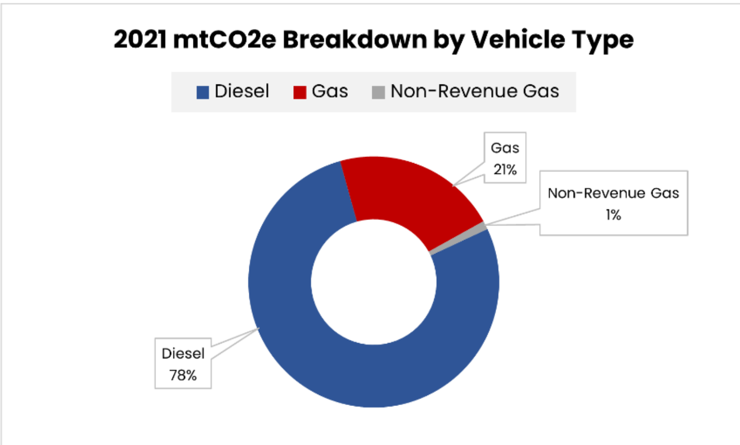

Figure 2

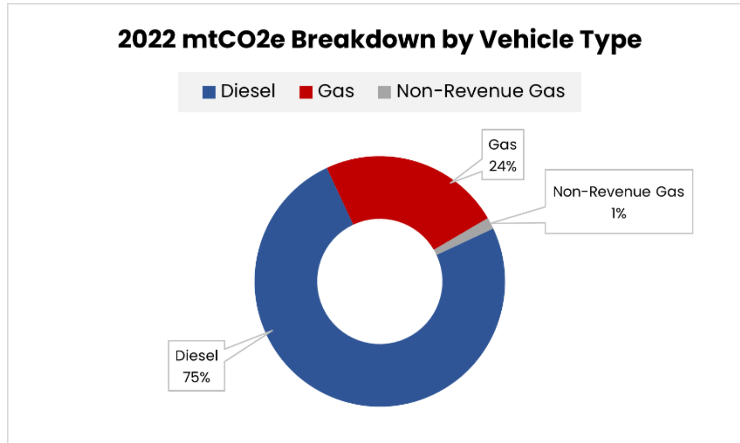

Figure 3

Per EPA's calculations, ***0.01018 mtCO₂*** *is emitted per gallon of diesel. To calculate gallons per mile, the reciprocal of each bus's MPG was taken and multiplied by the* ***mileage*** *for each of the diesel buses, then multiplied by the* $mtCO_2e$ *value. Table with fuel issued and MPG breakdown is available in the appendix.*

0.008887 $\boldsymbol{mtCO_2e}$ *is emitted per gallon of gasoline. To calculate gallons per mile, the reciprocal of each bus's MPG was taken and multiplied by the* ***mileage*** *for each of the gas buses, then multiplied by the* $mtCO_2e$ *value. Table with fuel issued and MPG breakdown is available in the appendix.*

Table 3: CTRAN Buses Mileage and Emissions by Type

Vehicle ID	Model	Type	2021 Mileage	2021 $mtCO_2e$	2022 Mileage	2022 $mtCO_2e$
01204	Gillig	Diesel	35,362	72.82976	23,330	48.63495
1201	Gillig	Diesel	30,572	64.61653	29,951	61.77326
1202	Gillig	Diesel	25,744	52.38832	24,915	53.19355
1203	Gillig	Diesel	34,084	74.69168	40,839	89.60131
1401	Gillig	Diesel	40,909	89.85173	46,833	96.42191
1402	Gillig	Diesel	32,777	71.06862	31,181	65.04715
1403	Gillig	Diesel	46,332	105.6256	38,213	88.75433
1404	Gillig	Diesel	44,973	85.43463	40,533	79.81629
1405	Gillig	Diesel	42,563	87.548	45,343	97.44703
1406	Gillig	Diesel	38,122	75.28517	50,507	109.0655
1407	Gillig	Diesel	48,990	87.42482	27,292	54.72361
1501	Gillig	Diesel	26,110	51.08324	35,482	70.23691
1901	EZ Rider	Diesel	31,941	54.55991	26,699	46.43403
1450	ARBOC	Gas	11,844	12.57244	25,454	28.27132
1451	ARBOC	Gas	18,163	18.98619	22,243	25.8274
1601	ARBOC	Gas	19,809	19.19237	24,928	23.94069
1602	ARBOC	Gas	39,820	37.12811	31,842	30.98364
1603	ARBOC	Gas	12,169	12.10498	20,796	21.66029
1850	Ford	Gas	30,559	35.83949	15,681	22.34103
1851	Ford	Gas	22,121	27.64568	19,626	25.8745
1852	Ford	Gas	14,648	20.72271	20,380	25.43193
1853	Ford	Gas	28,264	37.55824	36,030	44.73271
1854	Ford	Gas	21,212	26.33574	19,983	25.39549
1855	Ford	Gas	15,284	18.57472	21,483	27.02626
		Total	712,372	1,239.07	719,564	1,262.64

*Per EPA's calculations, **0.008887 $mtCO_2$** is emitted per gallon of gasoline. To calculate gallons per mile, the reciprocal of each vehicle's MPG was taken and multiplied by the **mileage**, then multiplied by the $mtCO_2$ value. Table with the MPG breakdown is available in the appendix.*

Table 4: CTRAN Non-revenue Gas Vehicles Mileage and Emissions

Make	Model	2021 Mileage	2021 $mtCO_2e$	2022 Mileage	2022 $mtCO_2e$
Ford	Crown Victoria	22,998	6.498212	23,255	10.427716
Chevrolet	Tahoe	12,990	7.30939	13,092	8.6150843
Total		35,988	13.81	36,347	19.04

Indirect

Electricity

Chemung County is located within the NPCC NYUP Subregion of the United States utility grid. The eGRID is issued by EPA and is a comprehensive source of data on the environmental characteristics of almost all electric power generated in the US. Per the 2020 eGRID emissions rates, the carbon-intensity of electricity generated in the NYUP subregion was 235.4lbs/MWh, the lowest in the US. As of June 2023, NYUP's average has decreased to 233.1 lbs/MWh, compared to the National average of 852.3 lbs/MWh.[11]

Emissions from purchased electricity were calculated using the location-based method that reflects the average emissions intensity of grids on which energy consumption occurs.[12]

In 2021, the transportation center's purchased electricity generated 28,410.2 lbs of CO_2, 1.8 lbs CH_4, and 0.2 lb of N_2O emissions. The bus garage generated 41,836.8 lbs of CO_2, 2.7 lbs CH_4, and 0.4 lb of N_2O emissions. From a total of 301,360 kWh purchased, 32 $mtCO_2e$ were generated. *See Table 5 for the 2021 quarterly breakdown of usage and generated $mtCO_2e$.*

In 2022, the transportation center's purchased electricity generated 29,007 lbs of CO_2, 1.9 lbs of CH_4, and 0.2 lb of N_2O emissions. The bus garage generated 44,400.9 lbs of CO_2, 2.9 lbs of CH_4, and 0.4 lb of N_2O emissions. From a total of 314,920 kWh purchased, 33.4 $mtCO_2e$ were generated. *See Table 6 for the 2022 quarterly breakdown of usage and generated $mtCO_2e$.*

[11] https://www.epa.gov/egrid/power-profiler#/NYUP
[12] https://www.epa.gov/climateleadership/simplified-ghg-emissions-calculator

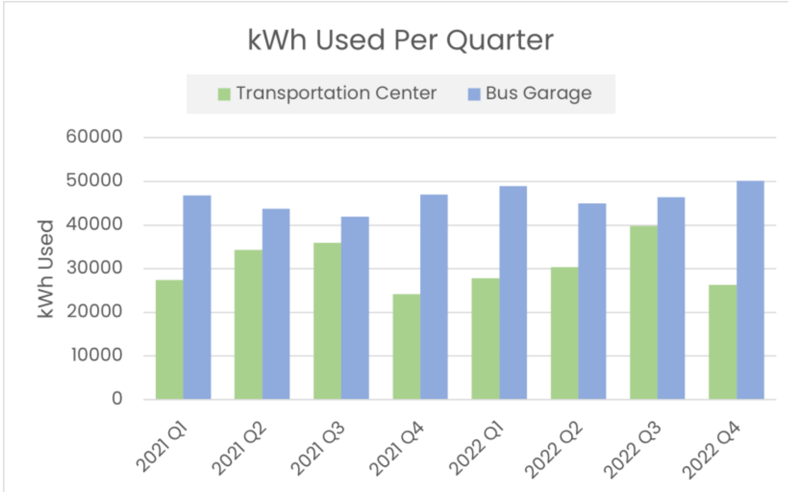

Figure 4

Per EPA's calculations, ***0.000433 $mtCO_2e$*** *is emitted per kWh. This value was multiplied by* ***kWh used*** *to determine the $mtCO_2e$ generated per quarter.*

Table 5: 2021 Quarterly Electricity Usage

Transportation Center			Bus Garage		
Quarter	**kWh Used**	**$mtCO_2e$**	**Quarter**	**kWh Used**	**$mtCO_2e$**
1	27,440	11.88152	1	46,800	20.2644
2	34,360	14.87788	2	43,720	18.93076
3	35,920	15.55336	3	41,920	18.15136
4	24,160	10.46128	4	47,040	20.2272
Prorated	+344.97	+0.14937	*Prorated*	+1,418.74	+0.61431

Table 6: 2022 Quarterly Electricity Usage

Transportation Center			Bus Garage		
Quarter	**kWh Used**	**$mtCO_2e$**	**Quarter**	**kWh Used**	**$mtCO_2e$**
1	27,880	12.07204	1	48,960	21.19968
2	30,400	13.1632	2	45,000	19.485
3	39,800	17.2334	3	46,360	20.07388
4	26,360	11.41388	4	50,160	21.71928
Prorated	-200.58	-0.08685	*Prorated*	-2,119.47	-0.91773

Water usage

The bus garage did not have a functional bus wash throughout the duration of 2022 which may contribute to its decrease in water usage. There is an additional fire suppression system for the Transportation Center that is charged bimonthly, but usage remains at zero and was thus excluded from this report. *See Tables 7 and 8 for each year's usage breakdown by billing period.*

One hundred cubic feet (1 CCF) is equivalent to 748 gallons of water.

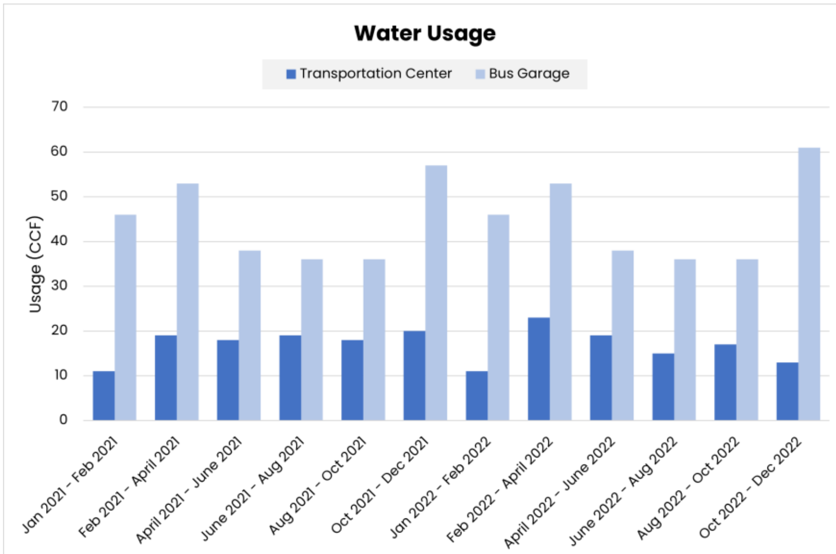

Figure 5

**Adjusted Service Period; usage has been prorated*

Table 7: 2021 Water Usage by Service Period

Transportation Center			Bus Garage		
Service Period	**Usage (CCF)**	**Usage (gal)**	**Service Period**	**Usage (CCF)**	**Usage (gal)**
1/1/21* - 2/11/21	11.00	8,228.57	1/1/21* - 2/17/21	46.00	34,410.40
2/11/21 - 4/15/21	19.00	14,213.00	2/17/21 - 4/19/21	53.00	39,646.80
4/15/21 - 6/11/21	18.00	13,464.90	4/19/21 - 6/18/21	38.00	28,426.00
6/11/21 - 8/12/21	19.00	14,213.00	6/18/21 - 8/18/21	36.00	26,929.90
8/12/21 - 10/13/21	18.00	13,464.90	8/18/21 - 10/18/21	36.00	26,929.90
10/13/21 - 12/15/21	15.00	11,220.80	10/18/21 - 12/17/21	44.00	32,914.30
12/15/21 - 12/31/21*	5.00	3,740.26	12/17/21 - 12/31/21*	13.00	9,724.68
Prorated	-6.00	-4,488.31	*Prorated*	-60.00	-44,883.10

Table 8: 2022 Water Usage by Service Period

Transportation Center			Bus Garage		
Service Period	**Usage (CCF)**	**Usage (gal)**	**Service Period**	**Usage (CCF)**	**Usage (gal)**
1/1/22* - 2/11/22	11.00	8,228.57	1/1/22* - 2/16/22	46.00	34,410.40
2/11/22 - 4/13/22	23.00	17,205.20	2/16/22 - 4/18/22	53.00	39,646.80
4/13/22 - 6/13/22	19.00	14,213.00	4/18/22 - 6/17/22	38.00	28,426.00
6/13/22 - 8/10/22	15.00	11,220.80	6/17/22 - 8/15/22	36.00	26,929.90
8/10/22 - 10/7/22	17.00	12,716.90	8/15/22 - 10/14/22	36.00	26,929.90
10/7/22 - 12/6/22	13.00	9,724.68	10/14/22 - 12/12/22	44.00	32,914.30
12/6/22 - 12/31/22*	3.00	2,244.16	12/12/22 - 12/31/22*	17.00	12,716.90
Prorated	-8.00	-5,984.42	*Prorated*	-43.00	-32,166.20

Employee commuting

CTRAN is staffed by 43 TransDev employees and 2 County employees. All TransDev employees commute to the bus garage to begin their shift. The Transit Manager and Transit Specialist commute to the Chamber of Commerce building.

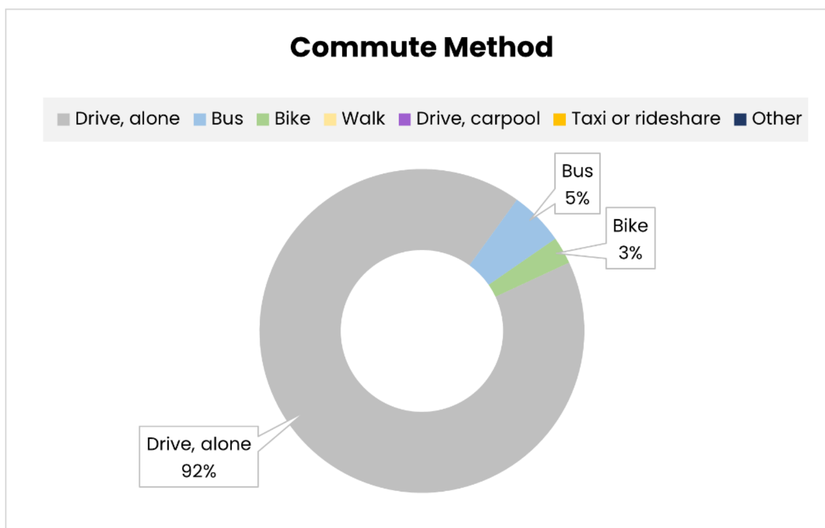

Figure 6

A commute survey was distributed to TransDev and associated County employees. Of the 37 surveys returned, 92% drive alone. Two employees ride the bus and one utilizes an e-bike. Some noted they walk a portion of their trip or occasionally walk the whole way for their short commute. Employees commute between 5 and 6 days per week and drive approximately 8.7 miles one way on average (this is inclusive of the outlier of 120 miles). Thirty-four percent of respondents drive 10 or more miles one way.

Primary reasons given for taking a personal vehicle as their main mode of transport were ease, convenience, and reliability. Other reasons mentioned included weather, time constraints, lack of access to alternative options, physical limitations, and errands done during lunch or after work.

Per the EPA Simplified GHG Emissions Calculator, these SOV commute miles release 103,626.08 lbs of CO_2, 2.65 lbs of CH_4, and 2.32 lbs of N_2O over the course of a year, generating approximately 47.30 $mtCO_2e$.[12]

Strategies, Targets, & Challenges

Strategies and targets

Short-term

Because the market is everchanging and evolving, CTRAN should look to others' implementation experiences with alternative fuel buses, particularly those operated by early-adopter agencies. Before making a decision, it is crucial to determine the alternative fuel that will best serve Chemung County and reduce CTRAN's impact on the environment and surrounding community. In 2023, the Elmira-Chemung Transportation Council (ECTC) purchased a plug-in hybrid staff vehicle with the goal of piloting this new technology for wider adoption.

Adaptations to CTRAN facilities to support alternative fuel vehicles should be determined prior to making final decisions on additional vehicles. Chemung County received grant funding to develop a transition plan for the bus garage to support alternative fuel vehicles and determine which fuel type would be best suited for CTRAN's needs.

The county is preparing to conduct a microtransit feasibility study with the goal of microtransit being implemented alongside the existing transit system and utilized to fill system gaps, improve paratransit, and reduce GHG emissions by using smaller vehicles. As gaps are recognized, efforts should be made to expand bus service and microtransit to meet the needs of the community and meet sustainability goals.

Continuous efforts should be made to encourage transit use and active transportation. The county and CTRAN should participate in and support various programs that encourage alternative modes of transportation such as, 511NY Rideshare and Walk, Bike, and Roll to School days. Incentives should be established by the county, CTRAN, and other local employers to encourage a modal shift from their employees. Outreach should be conducted at schools and workplaces, and with community organizations to spread awareness of alternative modes and to garner feedback on how the transit system could improve.

Long-term

When funds are available, or as current buses reach their useful life, CTRAN should seek to actively increase the percentage of the fleet that uses hybrid or alternative fuel. CTRAN and the county should monitor funding opportunities as they continue to expand support for alternative fuel infrastructure and vehicles.

Beyond the results of the transition plan for the bus garage, CTRAN should look to upgrade to water- and energy-efficient fixtures and other sustainable features in both the bus garage and transportation center. Operation scheduling may need to be adapted to accommodate charging and refueling times based on the desired alternative fuel type.

Electric micromobility users are becoming more common and are considered to be "vulnerable road users" due to potential conflict with other road users and increased safety risks. Multi-modal travelers and micromobility users rely on safe and connected bicycle and pedestrian infrastructure for travel. Continuous bicycle and pedestrian infrastructure and improved connections to bus routes can ensure vulnerable road users are able to travel safely. By providing various alternative options to SOVs for daily trips and maintaining safe routes, the county can encourage a reduction in GHG emissions at the community level.

Chemung County should continue to support and drive efforts to create complete streets and improve sidewalks and bike lanes.

Targets

CTRAN is aiming for a 30% reduction in its GHG emissions by 2027, with an aggressive goal of becoming net zero by 2035.

As the leading source of emissions, the shift of CTRAN vehicles to alternative fuels will make the greatest impact on CTRAN's emissions reduction goal. As CTRAN begins replacing its fleet with alternative fuel vehicles and pursuing microtransit opportunities, the emissions from its vehicles should notably decrease; however, the estimated emissions reductions from the vehicles will vary depending on the alternative fuel selected. By optimizing and expanding public transportation and advocating for connected, continuous pedestrian and cyclist infrastructure, CTRAN can also encourage emissions reductions from the community through a modal shift.

The transition of the bus garage to support alternative fuels, and upgrades to low-flow fixtures, energy-efficiency improvements, and weatherization in both facilities can lead to a reduction in electricity, therms, and water used.

Per the Cleaner, Greener Southern Tier plan, energy efficiency, green fleets, and EV and alternative fuel infrastructure deployment being implemented across the region can lead to an estimated reduction of over 500,000 $mtCO_2e$ annually by 2032.

While these upgrades will contribute to CTRAN's goal of 30% reduction in 5 years, in order to achieve its secondary goal of net zero, CTRAN must counterbalance its emissions through carbon removal efforts.

Technical and operational challenges

As a transit system, the primary challenge when considering the transition to alternative fuel and its infrastructure is keeping headway down and operations running smoothly, while also remaining cost-effective. As it stands, the current replacement rate to electrify CTRAN's fleet is 2:1 and, in some cases, 3:1 for one route. This is due to the variability of battery range and charging times. Unlike electric school buses that have several hours to recharge in between trips, CTRAN would require en-route charging or rapid charging while stopped at the transportation center to retain current runtimes and headways with one vehicle per route. The initial expense of EV charging infrastructure and the higher cost of EVs available today, as well as a continuously adapting preferred alternative fuel option, poses a barrier to pursuing a timely full-fleet transition.

To meet demands of larger or faster charging installations, it will be necessary to upgrade the electrical-service wiring running to a facility and may even require an upgrade of components of local power distribution infrastructure. Conversations with NYSEG and other relevant utility providers should take place very early on to ensure adequate availability of power. Transitioning to alternative fuel vehicles will also require an updated fleet design, planning for upfront costs, and development of staff capabilities to operate and maintain them.[13]

[13] https://www.transportation.gov/rural/electric-vehicles/ev-toolkit/benefits-and

Alternative Fuel options

Electric

Electric buses do not produce harmful emissions at the tailpipe, and the lack of exhaust and low vibration reduce noise pollution. While they are cheaper to run and maintain, this type of bus has a significantly higher upfront cost. The limited range of electric buses can impact system efficiency. Charging stations or en-route charging stops, or a larger fleet are needed to maintain current operations standards, which adds to the upfront and utility costs. However, Greensboro, North Carolina calculated the savings from switching from a diesel to electric bus and determined the transition would save nearly $160,000 in fuel and $185,000 in maintenance over the bus's lifetime.[14]

Compressed Natural Gas

The fuel cost for CNG is the lowest and its bus purchase cost is moderate, but its implementation requires major infrastructure upgrades. CNG generally creates fewer smog-related tailpipe emissions than gasoline and can reduce tailpipe GHGs by about 20%. However, there are GHG emissions associated with extracting, processing, and distributing CNG.[15]

Liquified Natural Gas

To support LNG as an alternative fuel, major infrastructure upgrades are needed. While the bus purchase cost is lower than other alternatives, the overall cost is the highest. This alternative also has the largest GHG & CAP emissions.[15]

Diesel/Hybrid Electric

A hybrid-electric bus is powered by an electric motor and a smaller than normal conventional internal combustion engine. Ultra-low-sulfur diesel (ULSD) is the most common fuel used for the combustion engine in hybrids, although gasoline, CNG, LNG, biodiesel, and hydrogen have also been used. Electric drive and ULSD fuel use, in conjunction with PM trap technology and the improved fuel economy from the hybrid system, allow hybrid buses to cut emissions by up to an estimated 75% when compared to conventional diesel buses. In-use testing and industry reports show that PM emissions from hybrid buses with PM filters are almost 90% lower than a conventional diesel bus without a filter. Hybrid buses exhibited the lowest CO emissions of any tested buses, including CNG and conventional diesel, had 30-40% lower NO_x emissions than conventional diesel, and demonstrated lower GHG emissions due to improved fuel economy. The upfront cost for hybrid buses is also considerably higher than a conventional diesel bus, but this price can be offset by various federal incentives and grant programs.[15, 16]

Hydrogen Fuel Cell

Fuel cells improve performance of electric buses by generating onboard power from hydrogen to recharge the batteries. They are a one-to-one replacement for diesel and CNG buses. This alternative fueled bus can be refueled in less than 10 minutes, eliminating the need for roadside charging infrastructure, with a range of up to 300 miles between refueling. This source offers consistent power delivery in heat and cold, and is

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[14] https://www.advancedenergy.org/2020/02/24/beneficial-buses-electric-buses-bring-benefits-to-businesses-communities-and-utilities/

[15] https://www.cmu.edu/traffic21/pdfs/alternative-fuels-policy-brief-buses_web.pdf

[16] https://www.eesi.org/papers/view/fact-sheet-hybrid-buses-costs-and-benefits

zero-emission at the tailpipe. In many cases, agencies can install hydrogen refueling infrastructure with a similar footprint to CNG refueling.[17]

Propane

Although propane buses emit less NO_x than diesel, they still emit air pollutants like CO and non-methane hydrocarbons. West Virginia University conducted in-use emissions and performance testing of propane-fueled school buses in 2018. The average CO_2 emissions were higher for the propane school bus than the diesel school bus during hot- and cold-start tests. Because CO_2 is directly related to fuel consumption, it can be influenced heavily by traffic, acceleration and deceleration, and stoplights while operating on public roads. For the stop-and-go tests, the diesel bus emitted more CO_2 on average than the propane bus, however, the diesel buses emitted less CO_2 during city and interstate driving[18]

Conclusion and Recommendations

Summary of key findings

The base year (or "starting" year), 2021, and the following reporting year, 2022, were consecutive La Niña years. A La Niña year typically indicates a warmer, wetter winter for upstate NY. The National Oceanic and Atmospheric Administration (NOAA) anticipated a higher likelihood of these conditions for Winter 2021 and 2022. The observed conditions for 2021 showed near normal temperatures for the area and below the median precipitation.[19] The observed conditions for 2022 showed above normal temperatures and above the median precipitation.[20]

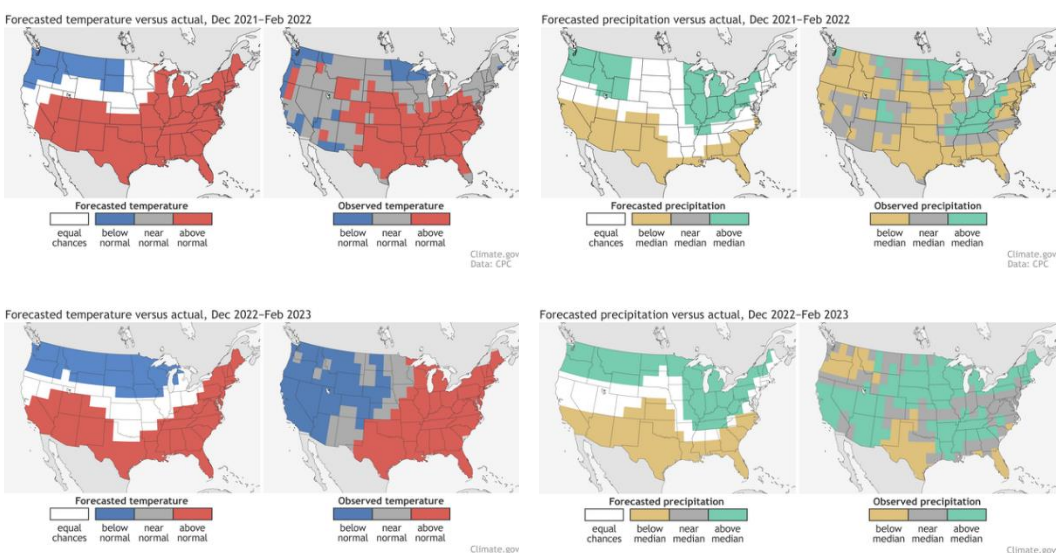

Figure 7

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[17] https://www.ballard.com/markets/transit-bus
[18] https://cloudinary.propane.com/images/v1601044101/website-media/WVU-School-Bus-Emissions-Final-Report-June-2019/WVU-School-Bus-Emissions-Final-Report-June-2019.pdf?_i=AA
[19] https://www.climate.gov/news-features/blogs/enso/2021-22-winter-outlook-how-well-did-it-do
[20] https://www.climate.gov/news-features/blogs/enso/verification-2022-2023-us-winter-outlook

With no specific GHG reduction efforts being made, 2022 saw an increase in emissions across the board; although, the percent of emissions each source contributed to was nearly the same between the two years. Based on observed temperatures for Winter 2022 being above normal, therms used would be assumed to decrease; however, the increase could be attributed to usage normalizing as the US gets further out from the quarantine. Therms saw the greatest percentage of change with a 10.89% increase for 2022. The kWh for electricity usage increased significantly, yet, the percent increase was only 3.13% for 2022. Reducing personal energy use at the office can be as simple as switching off lights when not in the room and turning off computers at the end of the day. While these may not reduce energy use as much as installing energy efficient features would, it is a change that can be made immediately.

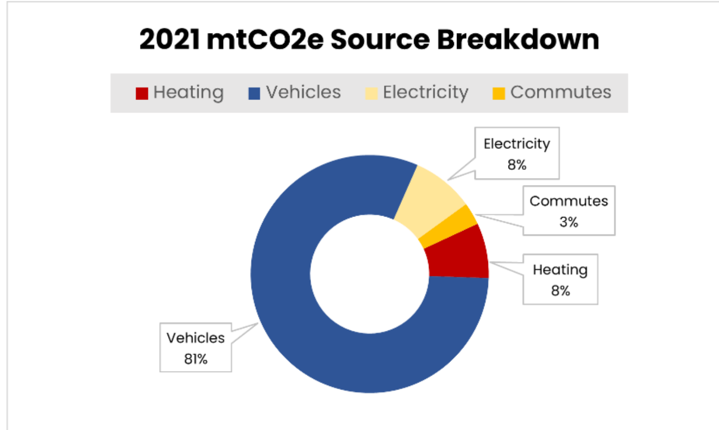

Figure 9

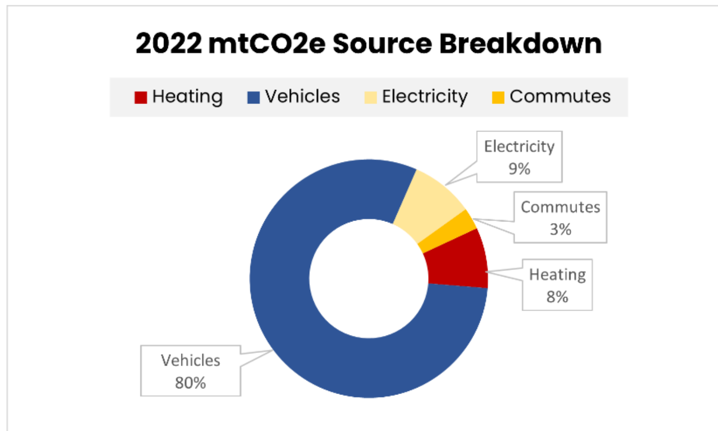

Figure 10

Water usage was the only factor to decrease – doing so by nearly 5% – in 2022. Water inefficiencies are common in the built environment due to leaks, outdated technology, malfunctions, and human error.[21] Repairing leaks and malfunctions can drastically reduce water waste over the course of a year. Additionally, the installation of water-efficient fixtures, such as low-flow toilets and sinks, can reduce the amount of water being used. If fiscally viable, an onsite non-potable water system could further reduce water waste through water recycling. Non-potable water could be utilized for landscaping, bus washing, flushing toilets, and cleaning floors.

Vehicles made up more than ¾ of the $mtCO_2e$ emitted by CTRAN operations. While public transportation is a preferred alternative to driving, it still contributes to emissions. However, buses can transport a greater number of people at a time, reducing the number of individual vehicles each burning fuel and emitting GHGs for the same trip. In 2020, the most popular car size emitted 0.60 lbs of CO_2 per vehicle mile, with one category of large pickup trucks built that year emitting 1.18 lbs on average. Emissions from buses, which encompassed several kinds of bus operations with varying emissions, averaged 0.39 lbs per passenger mile. However, transit buses, which typically do not operate at full capacity, averaged 0.95 lbs per passenger mile.[22] This is likely the case for current CTRAN operations, which frequently runs with no or low ridership. The higher the number of occupants, the lower the emissions per passenger mile, and the greater the benefit. Since buses will run regardless of the number of riders, opting to utilize an already

[21] https://www.waterworld.com/water-utility-management/press-release/14270126/water-waste-results-in-carbon-emissions
[22] https://www.cbo.gov/publication/58861

established system can reduce emissions. Similarly, a modal shift from SOVs to alternative transit reduces congestion, in turn reducing emissions from idling.

While employee commutes contributed the least to CTRAN's overall emissions, commutes by passenger vehicles are the leading contributor of GHG emissions in the transportation sector.[23] Shifting from an SOV to an alternative mode for commuting does not require new infrastructure or cost money to implement – in fact, riding the bus can be more affordable than a personal vehicle in the long run. Encouraging a change in habit can be done *now* and can have a major impact on local emissions.

While working to transition the fleet and bus garage to support alternative fuels, CTRAN can take steps to reduce its current vehicle emissions. When stationary for a period of time such as when stopped at the transportation center between runs, the bus should not idle. CTRAN should follow state regulations for idling that limit idling time to 5 minutes maximum; however, a primary idle reduction strategy is to turn the vehicle off when parked or stopped for more than 10 seconds (except in traffic).[24] To combat winter conditions while limiting idling time, as many buses as possible are brought inside the bus garage the night before. CTRAN's diesel buses have preheaters that alleviate the issue of fuel gelling, reduce pollution and engine wear, and save fuel.

CTRAN should aim to conduct an annual inventory of its GHG emissions going forward. This will allow CTRAN to make informed decisions when considering upgrades to its facilities, vehicles, heating and cooling systems, and fixtures. An annual inventory can show progress being made toward emissions reduction goals and what areas may need improvement. By committing to creating a more efficient and sustainable system, CTRAN can not only reduce its environmental impacts, but see cost savings and improved operational efficiency.

Table 9: Difference Between Annual Totals

Year	Heating (Therms)	Vehicles (Miles)	Electricity (kWh)	Water (CCF)	Total $mtCO_2e$
2021	22,236.32	748,360	303,123.71	382	1,546.39
2022	24,657.43	755,911	312,599.95	363	1,596.45
Difference	+2,421.11 | +10.89%	+7,551 | +1.01%	+9,476.24 | +3.13%	-19 | -4.97%	+50.06 | +3.24%

[23] https://www.epa.gov/system/files/documents/2022-04/us-ghg-inventory-2022-main-text.pdf
[24] https://afdc.energy.gov/conserve/idle_reduction_medium.html

Appendix

Inventory details

Detailed Annual Results for 2021 and 2022

Table 10: Annual Totals for Natural Gas Usage

Facility	Therms (2021)	2021 $mtCO_2e$	Therms (2022)	2022 $mtCO_2e$
Transportation Center	7,560.32	39.46	8,382.80	44.17
Bus Garage	14,676.00	76.41	16,274.63	86.94
Total	22,236.32	115.87	24,657.43	131.11

Table 11: Annual Totals for Electricity Usage

Facility	kWh (2021)	2021 $mtCO_2e$	kWh (2022)	2022 $mtCO_2e$
Transportation Center	122,224.97	52.77	124,239.42	53.88
Bus Garage	180,898.74	77.57	188,360.53	82.48
Total	303,123.71	130.34	312,599.95	136.36

Table 12: Annual Totals for Water Usage

Facility	2021 Usage		2022 Usage	
Transportation Center	116 CCF	86,774 gal	101 CCF	75,553.20 gal
Bus Garage	266 CCF	198,982 gal	262 CCF	195,990 gal
Total	382 CCF	285,756 gal	363 CCF	271,543 gal

Table 13: 2021 Monthly Natural Gas Usage

Transportation Center			Bus Garage		
Billing Period	**Therms Used**	**$mtCO_2e$**	**Billing Period**	**Therms Used**	**$mtCO_2e$**
1/5/2021 - 2/3/2021	1,633.50	8.65755	1/8/2021 - 2/5/2021	2,412.20	12.78466
2/4/2021 - 3/4/2021	1,584.90	8.39997	2/6/2021 - 3/9/2021	3,834.30	20.32179
3/5/2021 - 3/30/2021	810.70	4.29671	3/10/2021 - 4/6/2021	1,964.10	10.40973
3/31/2021 - 4/29/2021	492.40	2.60972	4/7/2021 - 5/4/2021	957.10	5.07263
4/30/2021 - 6/1/2021	235.00	1.2455	5/5/2021 - 6/4/2021	520.50	2.75865
6/2/2021 - 6/30/2021	44.20	0.23426	6/5/2021 - 7/8/2021	87.30	0.46269
7/1/2021 - 8/2/2021	33.90	0.17967	7/9/2021 - 8/3/2021	47.20	0.25016
8/3/2021 - 8/31/2021	22.60	0.11978	8/4/2021 - 9/2/2021	35.00	0.1855
9/1/2021 - 9/29/2021	52.50	0.27825	9/3/2021 - 10/4/2021	186.10	0.98633
9/30/2021 - 11/1/2021	258.20	1.36846	10/5/2021 - 11/2/2021	465.00	2.4645
11/2/2021 - 11/30/2021	1,072.20	5.68266	11/3/2021 - 12/3/2021	1,702.00	9.0206
12/1/2021 - 1/3/2022	1,204.40	6.38332	12/4/2021 - 1/5/2022	2,207.00	11.6971

Table 14: 2022 Monthly Natural Gas Usage

Transportation Center			Bus Garage		
Billing Period	**Therms Used**	**$mtCO_2e$**	**Billing Period**	**Therms Used**	**$mtCO_2e$**
1/4/2022 - 2/1/2022	1,890.90	10.02177	1/6/2022 - 2/2/2022	3,702.70	19.62431
2/2/2022 - 3/1/2022	1,506.20	7.98286	2/3/2022 - 3/7/2022	3,334.60	17.67338
3/2/2022 - 4/1/2022	1,064.80	5.64344	3/8/2022 - 4/7/2022	2,016.10	10.68533
4/2/2022 - 5/4/2022	664.50	3.52185	4/8/2022 - 5/6/2022	1,132.50	6.00225
5/5/2022 -5/31/2022	88.40	0.46852	5/7/2022 - 6/3/2022	230.10	1.21953
6/1/2022 - 6/30/2022	38.00	0.2014	6/4/2022 - 7/6/2022	110.80	0.58724
7/1/2022 - 8/1/2022	29.80	0.15794	7/7/2022 - 8/3/2022	43.10	0.22843
8/2/2022 - 8/30/2022	27.70	0.14681	8/4/2022 - 9/7/2022	52.40	0.27772
8/31/2022 - 10/3/2022	153.00	0.8109	9/8/2022 - 10/4/2022	177.60	0.94128
10/4/2022 - 10/31/2022	576.90	3.05757	10/5/2022 - 11/2/2022	648.90	3.43917
11/1/2022 - 12/3/20212	751.30	3.98189	11/3/2022 - 12/5/2022	1,783.90	9.45467
12/4/2022 - 1/3/2023	1,543.00	8.1779	12/6/2022 - 1/10/2023	3,171.90	16.81107

Table 15: 2021 Monthly Electricity Usage

Transportation Center			Bus Garage		
Billing Period	**kWh Used**	**$mtCO_2e$**	**Billing Period**	**kWh Used**	**$mtCO_2e$**
1/5/2021 - 2/3/2021	8,960	3.87968	1/8/2021 - 2/5/2021	16,200	7.01460
2/4/2021 - 3/4/2021	9,800	4.24340	2/6/2021 - 3/9/2021	16,600	7.18780
3/5/2021 - 3/30/2021	8,680	3.75844	3/10/2021 - 4/6/2021	14,000	6.06200
3/31/2021 - 4/29/2021	10,040	4.34732	4/7/2021 - 5/4/2021	13,080	5.66364
4/30/2021 - 6/1/2021	10,120	4.38196	5/5/2021 - 6/4/2021	13,920	6.02736
6/2/2021 - 6/30/2021	14,200	6.14860	6/5/2021 - 7/8/2021	16,720	7.23976
7/1/2021 - 8/2/2021	13,880	6.01004	7/9/2021 - 8/3/2021	12,440	5.38652
8/3/2021 - 8/31/2021	13,080	5.66364	8/4/2021 - 9/2/2021	14,920	6.46036
9/1/2021 - 9/29/2021	8,960	3.87968	9/3/2021 - 10/4/2021	14,560	6.30448
9/30/2021 - 11/1/2021	8,320	3.60256	10/5/2021 - 11/2/2021	14,040	6.07932
11/2/2021 - 11/30/2021	6,040	2.61532	11/3/2021 - 12/3/2021	16,160	6.99728
12/1/2021 - 1/3/2022	9,800	4.24340	12/4/2021 - 1/5/2022	16,840	7.29172

Table 16: 2022 Monthly Electricity Usage

Transportation Center			Bus Garage		
Billing Period	**kWh Used**	**$mtCO_2e$**	**Billing Period**	**kWh Used**	**$mtCO_2e$**
1/4/2022 - 2/1/2022	9,440	4.08752	1/6/2022 - 2/2/2022	15,160	6.56428
2/2/2022 - 3/1/2022	9,120	3.94896	2/3/2022 - 3/7/2022	17,440	7.55152
3/2/2022 - 4/1/2022	9,320	4.03556	3/8/2022 - 4/7/2022	16,360	7.08388
4/2/2022 - 5/4/2022	9,080	3.93164	4/8/2022 - 5/6/2022	15,160	6.56428
5/5/2022 -5/31/2022	9,160	3.96628	5/7/2022 - 6/3/2022	13,360	5.78488
6/1/2022 - 6/30/2022	12,160	5.26528	6/4/2022 - 7/6/2022	16,480	7.13584
7/1/2022 - 8/1/2022	16,600	7.18780	7/7/2022 - 8/3/2022	13,760	5.95808
8/2/2022 - 8/30/2022	13,440	5.81952	8/4/2022 - 9/7/2022	17,320	7.49956
8/31/2022 - 10/3/2022	9,760	4.22608	9/8/2022 - 10/4/2022	15,280	6.61624
10/4/2022 - 10/31/2022	6,400	2.77120	10/5/2022 - 11/2/2022	14,200	6.14860
11/1/2022 - 12/3/20212	7,840	3.39472	11/3/2022 - 12/5/2022	16,800	7.27440
12/4/2022 - 1/3/2023	12,120	5.24796	12/6/2022 - 1/10/2023	19,160	8.29628

Table 17: 2021 Water Usage Breakdown

Transportation Center			Bus Garage		
Service Period	**Water Usage (CCF)**	**Water Usage (gal)**	**Service Period**	**Water Usage (CCF)**	**Water Usage (gal)**
12/11/20 - 2/11/21	17.00	12,716.90	12/16/20 - 2/17/21	61.00	45,631.20
2/11/21 - 4/15/21	19.00	14,213.00	2/17/21 - 4/19/21	53.00	39,646.80
4/15/21 - 6/11/21	18.00	13,464.90	4/19/21 - 6/18/21	38.00	28,426.00
6/11/21 - 8/12/21	19.00	14,213.00	6/18/21 - 8/18/21	36.00	26,929.90
8/12/21 - 10/13/21	18.00	13,464.90	8/18/21 - 10/18/21	36.00	26,929.90
10/13/21 - 12/15/21	15.00	11,220.80	10/18/21 - 12/17/21	44.00	32,914.30
12/15/21 - 2/11/22	16.00	11,968.80	12/17/21 - 2/16/22	58.00	43,387.00

Table 18: 2022 Water Usage Breakdown

Transportation Center			Bus Garage		
Service Period	**Water Usage (CCF)**	**Water Usage (gal)**	**Service Period**	**Water Usage (CCF)**	**Water Usage (gal)**
12/15/21 - 2/11/22	16.00	11,968.80	12/17/21 - 2/16/22	58.00	43,387.00
2/11/22 - 4/13/22	23.00	17,205.20	2/16/22 - 4/18/22	55.00	41,142.90
4/13/22 - 6/13/22	19.00	14,213.00	4/18/22 - 6/17/22	46.00	34,410.40
6/13/22 - 8/10/22	15.00	11,220.80	6/17/22 - 8/15/22	36.00	26,929.90
8/10/22 - 10/7/22	17.00	12,716.90	8/15/22 - 10/14/22	31.00	23,189.60
10/7/22 - 12/6/22	13.00	9,724.68	10/14/22 - 12/12/22	33.00	24,685.70
12/6/22 - 2/2/23	6.00	4,488.31	12/12/22 - 2/9/23	54.00	40,394.80

Table 19: Fuel Issued & MPG for Each Bus

Vehicle ID	Fuel Type	2021 Fuel Issued	2021 MPG	2022 Fuel Issued	2022 MPG
01204	Diesel	7,154.2	4.9	4,777.5	4.9
1201	Diesel	6,347.4	4.8	6,068.1	4.9
1202	Diesel	5,146.2	5.0	5,225.3	4.8
1203	Diesel	7,337.1	4.6	8,801.7	4.6
1401	Diesel	8,826.3	4.6	9,471.7	4.9
1402	Diesel	6,981.2	4.7	6,389.7	4.9
1403	Diesel	10,375.8	4.5	8,718.5	4.4
1404	Diesel	8,392.4	5.4	7,840.5	5.2
1405	Diesel	8,600.0	4.9	9,572.4	4.7
1406	Diesel	7,395.4	5.2	10,713.7	4.7
1407	Diesel	8,587.9	5.7	5,375.6	5.1
1501	Diesel	5,018.0	5.2	6,899.5	5.1
1901	Diesel	5,359.5	6.0	4,561.3	5.9
1450	Gas	1,414.7	8.4	3,181.2	8.0
1451	Gas	2,136.4	8.5	2,906.2	7.7
1601	Gas	2,159.6	9.2	2,693.9	9.3
1602	Gas	4,177.8	9.5	3,486.4	9.1
1603	Gas	1,362.1	8.9	2,437.3	8.5
1850	Gas	4,032.8	7.6	2,513.9	6.2
1851	Gas	3,110.8	7.1	2,911.5	6.7
1852	Gas	2,331.8	6.3	2,861.7	7.1
1853	Gas	4,226.2	6.7	5,033.5	7.2
1854	Gas	2,963.4	7.2	2,857.6	7.0
1855	Gas	2,090.1	7.3	3,041.1	7.1

Table 20: Fuel Issued & MPG for Non-Revenue Vehicles

Vehicle	2021 Fuel Issued	2021 MPG	2022 Fuel Issued	2022 MPG
Ford Crown Victoria	731.0	19.1	1,173.4	19.6
Chevrolet Tahoe	820.0	13.3	967.0	13.4

Calculations

Emissions from Therms Used

0.1 MMBtu/1 therm × 14.43 kg C/MMBtu × 44 kg CO_2/12 kg C × 1 metric ton/1,000 kg = **0.0053 metric tons CO_2/therm**

Emissions from kWh Used

884.2 lbs CO_2/MWh × 1 metric ton/2,204.6 lbs × 1/(1-0.073) MWh delivered/MWh generated × 1 MWh/1,000 kWh × = **4.33×10^{-4} metric tons CO_2/kWh**
(eGRID, U.S. annual CO_2 total output emission rate [lb/MWh], year 2019 data)

Emissions from gallons of diesel consumed

10,180 grams of CO_2/gallon of diesel = **10.180×10^{-3} metric tons CO_2/gallon of diesel**

Reciprocal of each diesel bus's MPG to get gallons per mile

0.01018 $mtCO_2e$ × (gallons per mile × *diesel bus mileage)*

Emissions from gallons of gasoline consumed

8,887 grams of CO_2/gallon of gasoline = **8.887×10^{-3} metric tons CO_2/gallon of gasoline**

Reciprocal of each gas bus's MPG to get gallons per mile

0.008887 $mtCO_2e$ × (gallons per mile × *gas bus mileage)*

Emissions from Gasoline-powered Passenger Vehicle

8.89×10^{-3} metric tons CO_2/gallon gasoline × 1/22.9 miles per gallon $_{\text{car/truck average}}$ × 1 CO_2, CH_4, and N_2O/0.993 CO_2 = **3.90×10^{-4} metric tons CO_2E/mile**

CCF to Gallons

CCF value × 748 = water usage in gallons

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