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City of Evanston Carbon Neutral Fleet Action Plan

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Center for Neighborhood Technology

Elevate

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Introduction

The Center for Neighborhood Technology (CNT) examined the City of Evanston's municipal fleet and best practices from other communities to recommend strategies for moving towards a carbon neutral fleet. Three scenarios of carbon neutrality were developed, ranging from a nearly zero carbon strategy to a more moderate, but still significant, transformative approach. All three scenarios focus on clean electricity and renewable fuels powering a smaller and efficiently-used fleet with carbon offset purchases used to address the share of fossil fuel vehicles that remain in the 2035 fleet for reasons of technology limitations, special use, or performance needs.

In 2018, Evanston's fleet emitted 2,485 metric tons of carbon dioxide equivalent ($MTCO_2e$) or 8% of the total municipal operations inventory. By 2035, the fleet's GHG emissions could be reduced to 200 to 750 $MTCO_2e$ with an investment in clean technologies at a net financial savings for the City.

The fleet assessment in the appendix describes the 423 vehicles[1] and 156 accessories in the municipal fleet in 2018 and describes the existing vehicles with performance metrics that are used to inform the strategies described here. Decarbonizing Evanston's fleet will need to be a multi-pronged effort that involves fuel switching, additional infrastructure, efficiency of vehicle uses, non-auto modes of transportation, and rightsizing the fleet (Table 1).

The strategies identified here were informed by best-practice strategies from other cities, particularly those in cold weather climates. Other cities pursuing carbon neutral fleets will be a good resource for learning and problem solving in the coming years. The City of Seattle's, "Green Fleet Action Plan," may be a particularly relevant reference as it incorporates, "the City's commitment to race and social justice, equity and inclusion," and seeks to achieve multiple sustainability benefits with its fleet actions.

Most of Evanston's strategies can begin immediately, while others will need to roll out over time to accommodate planning and investment timelines. In some cases, phasing in new technology adoption will allow the City to take advantage of the rapidly changing zero emissions vehicle market. Taken together, the strategies described here can provide Evanston with a best-in-class, high performance transportation portfolio that sets the bar for cities around the world on responding to the climate crisis.

[1] Excluding 51 unknown entries.

Table 1. Carbon Neutral Fleet Scenarios

2035	Scenario 1	Scenario 2	Scenario 3
VMT Reduction from 2018	30%	25%	20%
MPG Improvement of Fleet From 2018 (Includes Electric Vehicles)	174%	109%	80%
Share of 2018 VMT Biofuel	14%	14%	17%
Share of 2018 VMT Electric	50%	40%	30%
Share of Electric Vehicle kWh as On-Site Solar	70%	45%	30%
Offsets (MTCO2e)	260	507	884
Net Emissions MTCO2e	**0**	**0**	**0**

Another result of a cleaner, more efficient fleet is a more cost-effective fleet. The scenarios would create sizable fuel and maintenance savings as described further in the cost impact section of this plan. Each scenario requires a significant infrastructure investment to transform the fleet's fueling system and install onsite solar electric generation, but the investment is more than offset by the savings created. Electric vehicles have a higher upfront cost than comparable internal combustion vehicles, but there are substantial cost reductions created in each scenario by rightsizing the fleet and purchasing fewer vehicles overall as a result.

The financial benefit of transforming the fleet would be an estimated total net savings of $12 million (Scenario 1), $5 million (Scenario 2), or $7 million (Scenario 3) as compared to business as usual over the 15 year period from 2021 to 2035.

Clean Fuels and Technologies

Evanston's carbon neutral fleet will require a transition to alternative fuels. Evanston's current fleet primarily uses fossil fuels, with 27% of the fleet using a "B20" blend of 80% diesel and 20% biodiesel. Evanston's carbon neutral fleet scenarios include a significant shift to electric vehicles paired with the adoption of an appropriate zero emissions fuel for heavy duty vehicles. Fossil fuels may continue to play a small role in specialized vehicles for reasons of technology availability or performance—between 5% and 30% of 2018's fossil usage.

Table 2. Carbon Neutral Fleet Scenarios, Count of Vehicles and Fuel Use in 2035

	Count of Fossil Fuel Vehicles	Count of Electric Vehicles	Count of Biofuel Vehicles	2035 Total Gallons of Fossil Fuel	2035 kWh Electricity	2035 Gallons Biofuel
2018 (Adjusted)	381	0	86	343,480	0	20,468
Scenario 1	31	235	76	17,269	751,951	53,057
Scenario 2	116	178	74	67,566	558,434	46,522
Scenario 3	170	127	83	101,503	378,318	49,975
2018 Values are Adjusted from the 2018 GHG Inventory to Account for Fleet Data Updates						

Electricity

The primary alternative fuel recommended for Evanston's fleet is electricity. Battery electric vehicles (BEVs) are powered by an internal battery that when depleted is recharged by connecting to the electric grid. Electric vehicles in the carbon neutral scenarios comprise 33% to 69% of the fleet in 2035. A 100% electric fleet is not included in the scenarios because electric special purpose vehicles and heavy-duty vehicles may not be fully available to meet Evanston's needs by that date, but Evanston should re-assess this prospect in the coming years.

Electric vehicles are typically more expensive than internal combustion engine vehicles, but they have low maintenance requirements and high fuel efficiency, which can make them more cost effective over their lifespan.

Transitioning to electric vehicles will require charging stations and upgrades to electrical infrastructure to support additional demand. A range of charging technologies will be necessary to accommodate the vehicle types in Evanston's fleet as large vehicles demand more power.[2, 3] Backup generation should be

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[2] Bohn, Theodore. "Multi-Port, 1+MW Charging System for Medium- and Heavy-Duty EVs: What We Know and What Is on the Horizon?" Presented at the U.S. Department of Energy Clean Cities, Online, January 7, 2020. https://cleancities.energy.gov/files/u/news_events/document/document_url/525/ANL_CleanCities_MW_plus_WhatsAhead_Jan7_2020.pdf

[3] Steven Nadel and Eric Junga, "Electrifying Trucks: From Delivery Vans to Buses to 18-Wheelers" (Washington DC: American Council for an Energy-Efficiency Economy, January 2020), 9, https://www.aceee.org/sites/default/files/pdfs/electric_trucks_1.pdf

installed for critical services to ensure vehicles can be charged even in times of power disruption. Evanston should watch for federal and state funding and financing opportunities for these upgrades. Evanston may be able to expand its network of charging infrastructure by making some chargers available for public use at certain hours or by partnering with local private entities and institutions to share chargers. Argonne National Labs has been conducting applied research on electric fleet charging and may be a good partner for Evanston on this topic. The city should also keep apprised of opportunities for state or federal funding for this infrastructure as the U.S. recommits to climate action.

Changes in fleet operations may be required as charging times impact usage patterns [4] One option for decreasing charging time is to have "stationary batteries built into charging stations" that would then charge the vehicles' battery.[5] By including stationary batteries in charging stations, the charging station does not solely depend on the electric grid to charge the vehicle; it can also pull power from the stationary battery. Charging the car with the grid-sourced energy and battery-sourced energy can decrease the required charging time of a vehicle.[6] Charging stationary batteries can also allow electricity load shifting, which may provide financial benefits by decreasing electricity demand charges or enabling charging at lower cost times of electricity use.

Additionally, municipalities need to be observant of BEV charging during winter weather since the range can see up to a 40% reduction. There are several best management practices: using a battery management system to recharge vehicles which will regulate the charge rate appropriately to the weather, maintaining a minimum 20% charge to allow the vehicle to warm itself, and limiting use of unnecessary accessories.[7, 8]

Staff members will need to be trained on electric vehicle use. In the City of Loveland, Colorado electric vehicle ambassadors worked with departments to promote use of the vehicles.[9] Additionally, there was a 10,000-mile challenge to incentivize employees to prioritize using the pooled fleet of Nissan Leafs before any fossil fuel vehicles.[10] These sort of training and encouragement steps may ease the transition to this new technology.

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[4] "AC Transit Zero-Emissions Bus Rollout Plan: Alameda Contra Cost Transit District Oakland, CA," Zero Emissions Future (Oakland, CA: AC Transit, June 10, 2020), http://www.actransit.org/wp-content/uploads/AC-Transit-ZEB-Rollout-Plan_06102020.pdf

[5] "Ready for Work" (Cambridge, MA: Union of Concerned Scientists, December 11, 2019), 11, https://www.ucsusa.org/resources/ready-work

[6] Andy Colthorpe, "Energy Storage and EVs: 'Batteries on Wheels' and ESS for Charging Stations," *Energy Storage News* (blog), March 5, 2020, https://www.energy-storage.news/news/energy-storage-and-evs-batteries-on-wheels-and-ess-for-charging-stations.

[7] Gregory Van Tighem, "Tips to Managing Electric Vehicle Range in Winter," Fleet Forward, July 9, 2019, https://www.fleetforward.com/335711/tips-to-managing-electric-vehicle-range-in-winter

[8] Phil Romba, "Extreme Temps Affect Electric Truck Batteries," Transport Topics, April 26, 2019, https://www.ttnews.com/articles/extreme-temps-affect-electric-truck-batteries

[9] Electrification Coalition, "Drive Electric Northern Colorado: Establishing an EV Accelerator Community," Case Study (Washington (DC): Electrification Coalition, February 2018), https://driveevfleets.org/wp-content/uploads/2018/08/DENC-Full-Case-Study.pdf

[10] Electrification Coalition, "Drive Electric Northern Colorado: Establishing an EV Accelerator Community," Case Study (Washington (DC): Electrification Coalition, February 2018), https://driveevfleets.org/wp-content/uploads/2018/08/DENC-Full-Case-Study.pdf

Grid-sourced battery electric vehicles are not zero emissions—the U.S. EPA reports that electricity sources in the Evanston subregion (RFC West) emitted approximately 0.5 kg CO_2e per kWh in 2018. The electricity grid has been decarbonizing in recent years, and that trend is expected to continue, but electricity in the region is not projected to be zero carbon by 2035. For that reason, the Evanston carbon neutral fleet scenarios include on-site renewable generation to meet at least 30% to 70% of fleet demand.

Evanston intends to use offsite renewable energy to make its operations fully carbon neutral. The RFC West emissions factor stays relevant even in that scenario, because GHG accounting protocols typically require "location-based" accounting of electricity GHGs, which would entail applying the RFC West emissions factor to all grid-connected electricity use. The purchase of renewable energy toward the goal of carbon neutrality is accounted for with a second "market-based" emissions accounting approach, and both location-based and market-based GHG emissions must be reported. A full explanation of these dual accounting approaches is provided in the *GHG Protocol Scope 2 Guidance*.[11] Strategies to reduce grid-sourced electricity use, such as through demand reduction and on-site renewable electricity production, will reduce GHG emissions for both reporting approaches.

As Evanston pursues renewable energy investments it should seek to align that with its equity goals, such through job opportunities as Seattle, WA[12] or conducting racial equity impact analysis like Minneapolis, MN.[13] Considering project investment dollars through an equity lens can create opportunities to support businesses and communities of color. For example, the location of offsite renewable energy could provide a resilient energy resource and jobs in an underinvested community in the region with a well-designed partnership.

Biofuels

Biofuels, such as biodiesel, ethanol, and renewable diesel, produce carbon emissions upon combustion, but those emissions are considered biogenic. The fuel feedstock comes from currently living biological material which releases CO_2 as part of the global carbon cycle, as opposed to fossil fuels which release carbon previously stored underground for thousands of years.[14] Thus, biofuels can be low-carbon fuels when sourced responsibly, despite showing significant tailpipe carbon emissions. Evanston's carbon neutral fleet scenarios include 20% to 22% biofuel powered vehicles.

RENEWABLE DIESEL

Of the newer biofuels available on the market today, Renewable Diesel (RD) may be the best fit for Evanston's needs as a replacement fuel for heavy-duty vehicles. It can be distributed in the same

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[11] World Resources Institute, "GHG Protocol Scope 2 Guidance: An Amendment to the GHG Protocol Corporate Standard," 2015. https://ghgprotocol.org/sites/default/files/standards/Scope%202%20Guidance_Final_Sept26.pdf The *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories* includes similar guidance.

[12] Philip Saunders, "Green Fleet Action Plan: An Updated Action Plan for the City of Seattle" (Seattle, WA: City of Seattle Department of Finance and Administrative Services, Fleet Management, 2019), https://www.seattle.gov/Documents/Departments/FAS/FleetManagement/2019-Green-Fleet-Action-Plan.pdf.

[13] Brette Hjelle et al., "Green Fleet Policy Update - REIA (Standard)," Legislative Information Management System of Minneapolis, MN, February 3, 2021, https://lims.minneapolismn.gov/File/RacialEquity/7421

[14] IEA Bioenergy, "Fossil vs Biogenic CO2 Emissions | Bioenergy," *Technology Collaboration Programme* (blog), 2020, https://www.ieabioenergy.com/iea-publications/faq/woodybiomass/biogenic-co2/; UC Davis, "Biogenic Carbon," *Science and Climate* (blog), accessed July 16, 2020, https://climatechange.ucdavis.edu/climate-change-definitions/biogenic-carbon/

facilities and used in the same engines as conventional diesel fuel. Sources of RD include corn stover, palm oil, fatty acid distillate, tallow (animal fat), and used cooking oil. The largest domestic market of RD fuel is California due to that state's low carbon fuel standard.[15] Several heavy-duty vehicle fleets have transitioned to RD: 375 diesel-powered vehicles in Oakland, Eugene Water & Electric Board in Oregon, and Charlotte Water in North Carolina.[16]

If RD becomes fully viable for Evanston by 2035, it could replace all diesel usage and eliminate the need for any fossil fuels in the portfolio, but RD has several drawbacks at this time.

1) Foremost, it is of limited availability outside the west coast—a RD manufacturing facility is slated for construction in Illinois, but until that or another source is online it may be difficult for Evanston to source this fuel.[17] Several other zero carbon options for heavy duty vehicles are discussed in this action plan for that reason. Initiating a buying pool with other local fleets may enable a local stronger RD market.

2) Another consideration is that RD emits nitrogen oxide (NO_x) and other criterial air pollutants that are harmful to health—though at slightly lower rates than conventional diesel.[18,19]

3) There are concerns about the sustainability and scalability of this fuel source nationwide, so RD may ultimately be a transitional or niche use fuel, and Evanston should consider that in its planning.

B100

B100 biofuels are produced from the transesterification of oils and fats, as opposed to RD, which is a hydrocarbon manufactured through other processes.[20] B100 can require technology changes in heavy duty vehicles and it has performance limitations in cold weather that may require operations adjustments.[21,22] RD is a better fit for Evanston's fleet needs if it can be accessed in the market, however

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[15] Jonathan Leonard and Patrick Couch, "The Potential – and Challenges – of Renewable Diesel Fuel for Heavy-Duty Vehicles," GNA, January 10, 2017, https://www.gladstein.org/the-potential-and-challenges-of-renewable-diesel-fuel-for-heavy-duty-vehicles/

[16] Shelley Ernst, "Is Renewable Diesel Still a 'Miracle Fuel'?," Government Fleet, January 8, 2020, https://www.government-fleet.com/348069/is-renewable-diesel-still-a-miracle-fuel

[17] "$400 Million Renewable Biodiesel Plant to Be Built in Illinois," Renewable Energy Magazine, May 21, 2020, https://www.renewableenergymagazine.com/biofuels/400-million-renewable-biodiesel-plant-to-20200521.

[18] Richard W. Corey and Tom Howard, "Renewable Diesel Should Be Treated the Same as Conventional Diesel" (State of California, July 31, 2013), https://ww2.arb.ca.gov/sites/default/files/2018-08/Renewable_Diesel_Joint_Statement_7-31-13.pdf
"4 Things To Know About Renewable Diesel," Puget Sound Clean Air Agency, WA, January 10, 2017, https://pscleanair.gov/469/4-Things-To-Know-About-Renewable-Diesel.

[19] Leonard and Couch, "The Potential – and Challenges – of Renewable Diesel Fuel for Heavy-Duty Vehicles."

[20] https://afdc.energy.gov/fuels/emerging_hydrocarbon.html

[21] "Biodiesel in Winter Time," Triangle Biofuels Industries, February 24, 2015, https://www.trianglebiofuels.com/biodiesel-in-winter-time/

[22] "Biodiesel Cold Flow Basics: Information for Petroleum Distributors, Blenders, and End-Users on Issues Affecting Biodiesel in the Winter Months" (National Biodiesel Board, 2014), https://www.biodiesel.org/docs/default-source/fact-sheets/cold-flow-basics.ppt?sfvrsn=3a918a6c_5#:~:text=Biodiesel%20Cold%20Flow%20Basics&text=Operability%20is%20defined%20as%20the,of%20the%20fuel%20delivery%20system.&text=Diesel%20fuels%20composition%20and%20cold,greatly%20across%20the%20United%20States

B100 has been included in this assessment because it may be a necessary low-carbon fuel for Evanston if RD is not available.

Hydrogen

Fuel cell electric vehicles (FCEVs) contain an electrochemical reactor to convert hydrogen and an oxidant to energy. FCEVs create no tailpipe GHG or criteria air pollutant emissions; the chemical byproduct is water vapor and warm air.[23,24] While hydrogen production has the potential to be low or zero carbon if produced with renewable electricity, today it is typically produced from natural gas and therefore has a fairly high lifecycle GHG footprint (see appendix).[25]

Hydrogen can be produced on-site or procured from an off-site source, but requires a significant fueling infrastructure investment.[26, 27] Currently, FCEVs are 40% to 90% more expensive than conventional vehicles due to lack of economies of scale and fuel cell technology. Projected wide-use applications of fuel cells include heavy duty trucks, logistic vehicles, forklifts, buses, and passenger vehicles.[28,29] However, for example, only four transit agencies in the country use this technology in buses at this time.[30]

The Evanston carbon neutral fleet scenarios do not include hydrogen in the 2035 fleet, but it is recommended that Evanston stay apprised of developments in this market and reassess this option in 2 to 3 years, especially if federal or state grants become available for the capital costs associated with hydrogen.

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[23] Notably, San Francisco includes hydrogen fuel cells to be part of its electric vehicle pathway. Electric Mobility Subcommittee, "Electric Vehicle Roadmap for San Francisco" (The Mayor's Electric Vehicle Working Group (EVWG), June 2019), https://static1.squarespace.com/static/5489e34ce4b0a7bfc8ca7a0d/t/5d671018e683a900013a4953/1567035419028/EV+Roadmap_Final.pdf

[24] U.S. Department of Energy, "Alternative Fuels Data Center: Fuel Cell Electric Vehicles," Government, Energy Efficiency & Renewable Energy, accessed August 13, 2020, https://afdc.energy.gov/vehicles/fuel_cell.html

[25] Argonne National Laboratory, GREET 2020 Model, September 2020. https://greet.es.anl.gov/

[26] SunLine Transit Agency in California has invested at least $27 million in electric hydrogen production technology and fuel cell buses. https://www.nytimes.com/2020/11/11/business/hydrogen-fuel-california.html A 2013 study found a cost of at $2.65 million for state of the art hydrogen fueling stations. https://www.nrel.gov/docs/fy13osti/56412.pdf

[27] "AC Transit Zero-Emissions Bus Rollout Plan: Alameda Contra Cost Transit District Oakland, CA," Zero Emissions Future (Oakland, CA: AC Transit, June 10, 2020), http://www.actransit.org/wp-content/uploads/AC-Transit-ZEB-Rollout-Plan_06102020.pdf

[28] Alan MacCharles et al., "Fueling the Future of Mobility Hydrogen and Fuel Cell Solutions for Transportation," White Paper (China: Deloitte and Ballard, January 7, 2020), https://info.ballard.com/hubfs/Other%20Reports/Deloitte%20Volume%201%20Powering%20the%20Future%20of%20Mobility.pdf?hsCtaTracking=5de5914f-7cb0-42a5-b9d0-8248b33f03ae%7Ccc91e1e5-d73e-4bea-b2a0-82c826394bf3

[29] Alan MacCharles et al., "Fueling the Future of Mobility Hydrogen and Fuel Cell Solutions for Transportation," White Paper (China: Deloitte and Ballard, January 7, 2020), https://info.ballard.com/hubfs/Other%20Reports/Deloitte%20Volume%201%20Powering%20the%20Future%20of%20Mobility.pdf?hsCtaTracking=5de5914f-7cb0-42a5-b9d0-8248b33f03ae%7Ccc91e1e5-d73e-4bea-b2a0-82c826394bf3, 20.

[30] National Transit Database

Fossil Fuel

All the climate neutral fleet scenarios for Evanston include some amount of fossil fuel use in 2035, because more special use vehicle types may require it, but under the most transformative scenario it would be 5% of today's use. RD, if viable, would be 22% of today's fuel volume under that scenario. At this time, Evanston operates a fossil fuel fueling station that is being considered for an upgrade. It is recommended to analyze the option of procuring diesel and gasoline offsite, as it may be more aligned with Evanston's carbon neutral goals to pursue development of alternative fueling infrastructure.

Vehicles

SEDANS AND MOTORCYCLES

Beginning in 2021, it is recommended that every sedan the City purchases is electric. The electric sedan market is well-established, and performance will meet Evanston's needs in terms of driving range between charges. These vehicles are most efficient at mid-range speeds so they work well for urban settings at speeds below 45 mph.[31] BEVs can be useful for vehicles on fixed routes within the city which drive a limited range.[32] Current light-duty BEVs range from 110 to 373 miles per charge.[33] Evanston also has several motorcycles in its fleet that could become electric by 2035.

Evanston should install at least 3 to 5 electric charging stations in locations these sedans are to be parked by early 2021. This will support the procurement of EVs to begin while planning continues for more fleet-wide electrification infrastructure.

The City of Cambridge, MA was contacted and provided information about the electric vehicles in their fleet, which faces similar use conditions as Evanston.[34] Table 2 shows the usage, charging time and energy use data for five Nissan Leafs acquired for their fleet in July 2020. Cambridge also has older Chevy Volt electric vehicles in their fleet and stated the battery efficiency of those models has declined with disuse (of note, many electric vehicles are sold with an 8-year/100,000 mile warranty for the battery). At an average of 29.6 kWh per 100 miles, the Leafs are achieving typical fuel economy for current electric sedans. At approximately 3 minutes of charging time per mile, the Nissan Leafs would easily charge during off hours for the average 3,185 annual miles of use of the current sedans in Evanston's fleet.

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[31] Fleets for the Future, "Electric Vehicle Procurement Best Practices Guide," Guide (Washington (DC): National Association of Regional Councils, 2016), https://static1.squarespace.com/static/57a0a284d2b857f883096ab0/t/5c3e30734ae237da7d84cf2c/1547579509097/Electric%2BVehicle%2BProcurement%2BBest%2BPractices%2BGuide%2BFinal.pdf

[32] Gordon Feller, "Rotterdam's Municipal EV Fleet: Lessons for Utilities and Cities," T&D World, December 9, 2019, https://www.tdworld.com/electrification/article/21112387/rotterdams-municipal-ev-fleet-lessons-for-utilities-and-cities

[33] Dave Vanderwerp, "EV Range: Everything You Need to Know," Car and Driver, May 22, 2020, https://www.caranddriver.com/shopping-advice/a32603216/ev-range-explained/

[34] Personal Communication Sidorenko, Irina, Energy and Sustainability Analyst at *City of* Cambridge, MA, December 2020. (isidorenko@cambridgema.gov)

Table 3. Cambridge, MA 2020 Nissan Leaf Usage, Charging Time, and Energy use

	Odometer when registered	Odometer now	Odometer date	Charging time	Miles driven	Sum of Energy	Miles per kWh	kWh / 100 miles	Miles Per Gallon Gasoline Equivalent
Nissan 1	25	5,991	12/9/2020	299:27:59	5,966	1,710.3	3.5	28.7	117.6
Nissan 2	31	2,584	12/4/2020	150:30:03	2,553	863.0	3.0	33.8	99.7
Nissan 3	32	246	12/8/2020	9:06:18	214	49.3	4.3	23.1	146.2
Nissan 4	8	2,422	12/8/2020	155:05:31	2,414	734.5	3.3	30.4	110.8
Nissan 5	9	5,690	12/7/2020	274:51:31	5,681	1,620.1	3.5	28.5	118.2

As a point of comparison, the list price for a 2020 Nissan Leaf was $31,600-$38,200, which is approximately $6,000 more than the list price of a 2021 Chevrolet Malibu gasoline vehicle. Driven 10,000 per year in Evanston, the Nissan Leaf would use $217 per in electricity, while the Chevrolet Malibu would use $691 per year in gasoline. Consumer Reports estimates the average maintenance cost of an electric vehicle at $0.02 per mile for the first 100,000 miles and an internal combustion vehicle at $0.044 per mile.[35] At those rates, the annualized cost of ownership over 10 years of the Nissan Leaf is $3,907 in today's dollars, as compared to $3,999 for the Chevrolet Malibu. At 2018 GHG rates for grid-connected electricity the Nissan Leaf's carbon footprint would be 1.6 $MTCO_2e$ and the Chevrolet Malibu's would be 2.7 $MTCO_2e$. The Nissan Leaf's carbon footprint is expected to decrease as the grid electricity decarbonizes and on-site solar electric generation could offset the emissions of a given electric vehicle entirely. A table comparing cost and performance of several other models is in the Appendix.

The City of New York has found the maintenance cost of their battery electric vehicles is "dramatically less" than that of gasoline or hybrid models; a factor which increases the lifecycle savings of electric vehicles even more. New York's 2018 average annual maintenance costs by vehicle model ranged from $205 to $386 for electric sedans, while hybrid and gasoline models ranged from $496 to $1,805.[36]

SUVS

Evanston's climate neutral fleet scenarios anticipate the SUVs in the fleet will be electric by 2035 and some SUVs will be downsized to sedans. There are several electric SUVs on the market today, so Evanston should explore procuring 1-3 electric SUVs in 2021 to begin integrating them into the fleet. Given the rapid change of this technology it may suit Evanston to lease these SUVs with the intention of upgrading them in 2-3 years as battery life and other technology improvements are deployed. Evanston should plan to no longer purchase fossil fuel SUVs by the year 2025. If Evanston finds it necessary to purchase fossil fuel powered SUVs between 2021 and 2024 it should aim for those to be hybrid electric

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[35] Harto, Chris, Adam Winer, and David Friedman. "Electric Vehicle Owners Spending Half as Much on Maintenance Compared to Gas-Powered Vehicle Owners, Finds New CR Analysis." Consumer Reports, September 24, 2020. https://advocacy.consumerreports.org/press_release/electric-vehicle-owners-spending-half-as-much-on-maintenance-compared-to-gas-powered-vehicle-owners-finds-new-cr-analysis

[36] City of New York, "Reducing Maintenance Costs with Electric Vehicles," NYC Fleet Newsletter, March 8, 2019. https://www1.nyc.gov/assets/dcas/downloads/pdf/fleet/NYC-Fleet-Newsletter-255-March-8-2019-Reducing-Maintenance-Costs-With-Electric-Vehicles.pdf

models with high fuel economy. A table comparing cost and performance of several models is in the Appendix.

PICKUP TRUCKS AND VANS

It is expected that Ford will release an electric version of its F150 truck in 2022 and there are several other electric pickup truck makes coming on the market. [37] The F150 is a smaller truck and Evanston only has 3 of this size in its current fleet. It is recommended to downsize some of the larger truck models in the fleet, if detailed usage analysis shows downsizing as a possibility. This will allow Evanston's pickup truck fleet to electrify (and decarbonize) more quickly.

Evanston's carbon neutral fleet scenarios anticipate a mix of fuel technologies among its pickup trucks in 2035. Where possible, electric is preferred, and up to 90% of the pickup trucks in the fleet could become electric under the most transformative scenario. The technology trajectory is somewhat uncertain, so the more moderate carbon neutral scenarios assume 24-31 pickups continue to be fossil fuel (likely diesel) powered in 2035. The remaining trucks should be biofuel (or hydrogen) powered. The best fuel economy possible should be chosen when purchasing fossil fuel and biofuel vehicles.

Vans in the fleet should follow a similar pattern—90% could be electric if the technology enables that; 10-12 may continue to be fossil fuel powered under the more moderate scenarios, if needed for performance reasons; and the remainder should be biofuel powered. Ford has announced an electric version of its Transit van for the 2022 model year.[38]

Other Medium and Heavy-Duty Vehicles

Evanston's fleet includes many medium- and heavy-duty vehicles that provide critical services. Vehicles of these type are at least 30% of the fleet. The market is much smaller for these vehicles, with limited supply chains, vehicle availability, and use.[39] The most transformative carbon neutral fleet scenario recommends Evanston's heavy trucks, construction trucks, fire trucks, garbage trucks, specialty trucks, landscape vehicles, ambulances, buses, watercraft, and street sweepers as a whole become 39% electric, 42% biodiesel and 19% fossil fuel by 2035. If the technology is slower to become available, the more fossil fuel dependent scenario would include 11% electric and 8% biofuel vehicles among these types.

Working in partnership with other cities will be an essential part of Evanston's carbon neutral strategies for these vehicle types. A multi-city request for information (RFI) came out in 2017 for a quick market survey of medium and heavy-duty vehicle development to signal to manufacturers that there is demand

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[37] "2023 Ford F-150 Electric: What We Know So Far," Car and Driver, October 15, 2020, https://www.caranddriver.com/ford/f-150-electric

[38] "Ford to Offer All-Electric Transit; U.S.-Made, Zero-Emissions Van to Join All-Electric Mustang Mach-E and F-150 in Lineup," Ford Media Center, March 3, 2020, https://media.ford.com/content/fordmedia/fna/us/en/news/2020/03/03/ford-to-offer-all-electric-transit.html

[39] Fleets for the Future, "Electric Vehicle Procurement Best Practices Guide"; Northwest Regional Planning Commission, "Regional Energy Plan" (2017), https://publicservice.vermont.gov/sites/dps/files/documents/Pubs_Plans_Reports/Act_174/NRPC/NRPC%20Energy%20Plan.pdf

for zero-emission medium and heavy-duty vehicles.[40] Several cities (Chicago; Seneca, SC; King County, WA; Twin Rivers, CA) have begun electrification of their buses first.[41] Los Angeles has announced that it will fully electrify its garbage trucks by 2035.[42] The image below from Fleets for the Future displays BEV applications for medium and heavy-duty trucks, including one plugin hybrid electric vehicle (PHEV), as well as where they are used.[43]



	Transit Buses	Step Van	Cab Chassis
Category	BEV	BEV	BEV
Battery Size	135-395 kWh	60-125 kWh	145-207 kWh
All-Electric Range	140-160 miles	90-150 miles	100-155 miles
Example Fleet	City of Denver	UPS FedEx	Frito Lay



	Terminal Trucks	Refuse	Bucket Trucks
Category	BEV	BEV	PHEV[9]
Battery Size	200 kWh	210 kWh	14.2-28.4 kWh
All-Electric Range	30-60 miles	50-85 miles	40 miles
Example Fleet	Port of Los Angeles	City of Chicago	Pacific Gas and Electric (PG&E)

Figure 0-A. Battery Electric Vehicle (BEV) Medium and Heavy-Duty Truck Examples[44]

Some cities have requested vehicles that do not exist yet, such as electric fire engines and heavy-duty trucks. In late 2019, the US Department of Energy "listed 61 all-electric truck models: 36 buses, 10 vocational trucks, 9 vans and step vans, 3 tractors, 2 street sweepers, and 1 refuse truck."[45] Current models have range limitations and high cost differentials to internal combustion engine models, which is why the carbon neutral fleet scenarios anticipate later adoption for these vehicle types. The California

[40] Joe Ryan, "Cities Shop for $10 Billion of Electric Cars to Defy Trump - Bloomberg," March 14, 2017, https://www.bloomberg.com/news/articles/2017-03-14/cities-shop-for-10-billion-of-electric-vehicles-to-defy-trump
[41] Matt Casale, Morgan Folger, and James Horrox, "Electric Buses in America | U.S. PIRG," U.S. PIRG, October 10, 2019, https://uspirg.org/feature/usp/electric-buses-america
[42] "LA Sanitation Announces Public Commitment to 100% Electric Refuse Truck Fleet as Los Angeles Leaders Discuss Zero-Emissions Plans," LA County Electric Bus and Truck Coalition, accessed December 8, 2020, https://laelectrictruckandbus.org/press-releases-1/2020/1/23/la-sanitation-announces-public-commitment-to-100-electric-refuse-truck-fleet-as-los-angeles-leaders-discuss-zero-emissions-plans
[43] Fleets for the Future, "Electric Vehicle Procurement Best Practices Guide."
[44] Fleets for the Future, "Electric Vehicle Procurement Best Practices Guide."
[45] Nadel and Junga, "Electrifying Trucks: From Delivery Vans to Buses to 18-Wheelers," 7.

Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program (HVIP) website includes a catalogue of heavy-duty vehicles that are available in the market.[46]

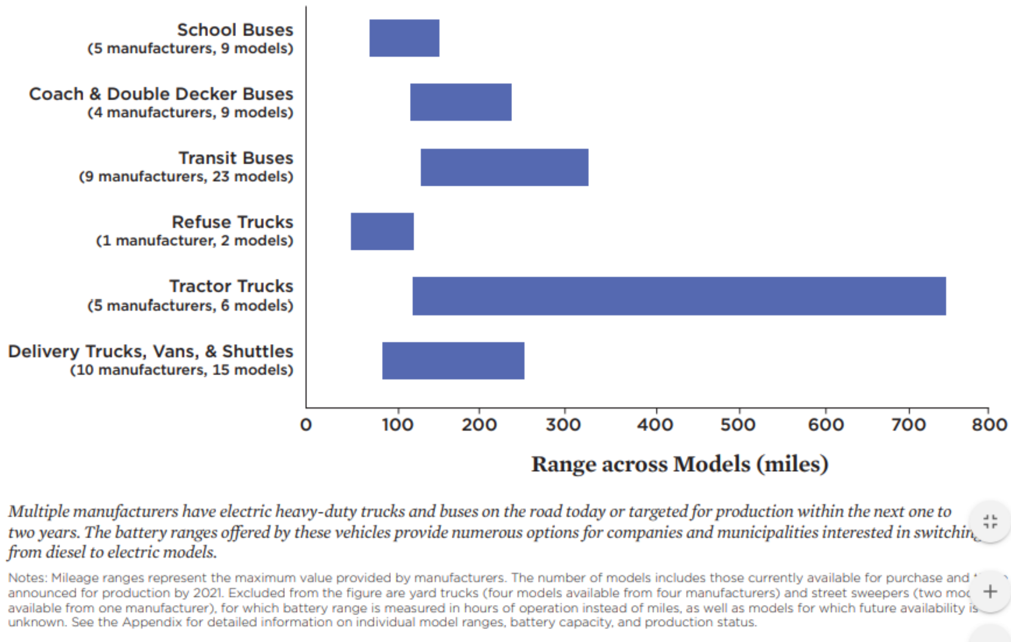

Figure 0-B. Current Electric Truck and Bus Ranges[47]

While the market continues to grow, there are other ways that municipalities can work towards zero-emissions in their medium and heavy-duty vehicles. Two options include installing auxiliary power units and converting the drivetrain. Some of these vehicles experience many hours idling. During this time, diesel powers auxiliary services within the vehicle. Vehicles with electric auxiliary power units (APUs) could replace diesel-only vehicles so that when the truck is idling for accessory use, power switches to electric instead of using diesel.[48] The APU is charged when the vehicle is running on diesel,[49] so it could be used as a transition to a zero-emission fleet. Additionally, municipalities can consider converting to an electric drivetrain to make vehicle movement electric.[50] An electric drivetrain is optimal in congested areas where fossil fuel engines are least efficient.[51] U.S. EPA Certified installers, often smaller companies, are required to make the conversion.[52]

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[46] "How to Participate," California HVIP, March 2020, https://www.californiahvip.org/how-to-participate/
[47] "Ready for Work"; Fleets for the Future, "Electric Vehicle Procurement Best Practices Guide."
[48] Fleets for the Future, "Electric Vehicle Procurement Best Practices Guide"; "Idle Reduction Technology," Idle-Free California, accessed July 17, 2020, http://idlefreecalifornia.org/idle-reduction-technology.html
[49] Tyler Fussner, "Engine Idle Reduction Systems and Solutions," *Vehicle Service Pros* (blog), July 7, 2020, https://www.vehicleservicepros.com/vehicles/powertrain/emissions-fuel-efficiency/engine-idling-devices-idle-control-systems/article/21142636/engine-idle-reduction-systems-and-solutions
[50] Fleets for the Future, "Electric Vehicle Procurement Best Practices Guide."
[51] "Advanced Clean Trucks: Accelerating Zero-Emission Truck Markets" (California Air Resources Board, June 25, 2020), https://ww2.arb.ca.gov/sites/default/files/2020-06/200625factsheet_ADA.pdf
[52] "Ready for Work"; Fleets for the Future, "Electric Vehicle Procurement Best Practices Guide."

Fleet Management and Rightsizing

Rightsizing

The current Evanston fleet includes many vehicles with low annual mileage, even excluding the lowest mileage values, which may not have miles recorded or may be equipment hours of usage—201 vehicles recorded between 1,000 and 10,000 miles in 2018. The median mileage was just 4,233 miles, as compared to the U.S. average of 11,800.[53,54] This presents an opportunity for combining vehicle uses and rightsizing the fleet. For example, the City of Seattle has instituted a policy to eliminate fleet vehicles used less than 2,400 miles per year (200 miles per month).[55]

Hours, days, and purposes of vehicle usage should be tracked to identify cases where one new vehicle could serve the same utility of two or more existing vehicles. The reasons for rightsizing include 1) the higher up-front cost of alternative fuel vehicles make them a more effective investment if they are used more;[56] 2) induced demand has shown when a vehicle is available individuals tend to find reasons to use it instead of seeking alternatives; 3) encouraging only essential vehicle use will reduce fuel consumption and greenhouse gas (GHG) emissions; and 4) freeing up space now used for vehicle parking will support installation of zero carbon infrastructure, green stormwater infrastructure, or other sustainability and resilience actions.

The scenarios for Evanston's carbon neutral fleet include a significant reduction in the number of vehicles—from 467 in 2018 to 342-380 by 2035. The avoided purchase of these vehicles could save $4 to $7 million. These vehicles should be replaced by reduced travel, alternative transportation modes, and more efficient use of vehicles including shared vehicles across departments. Identifying these opportunities will require a survey of vehicle users or travel diary[57] in addition to the existing fleet tracking, but such data would be useful for assessing VMT reduction potential as well.

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[53] This analysis of fuel economy and 2018 mileage excludes vehicles that were indicated as sold, or 2019 and later model years, as well as those with 0 or negative or other significant outlier data points for fuel or mileage. Exclusions are intended to allow for a full-year's analysis of typical fleet activity as of 2018.

[54] "Annual Vehicle Distance Traveled in Miles and Related Data - 2018 (1) by Highway Category and Vehicle Type," Federal Highway Administration, November 2019, https://www.fhwa.dot.gov/policyinformation/statistics/2018/vm1.cfm.

[55] City of Seattle, "Green Fleet Action Plan: An Updated Action Plan for the City of Seattle," 2019. https://www.seattle.gov/Documents/Departments/FAS/FleetManagement/2019-Green-Fleet-Action-Plan.pdf

[56] Best practice is 10,000 to 12,000 miles annually, but that may be an unrealistically high target for Evanston's needs. Fleets for the Future, "Electric Vehicle Procurement Best Practices Guide," Guide (Washington (DC): National Association of Regional Councils, 2016), https://static1.squarespace.com/static/57a0a284d2b857f883096ab0/t/5c3e30734ae237da7d84cf2c/1547579509097/Electric%2BVehicle%2BProcurement%2BBest%2BPractices%2BGuide%2BFinal.pdf

[57] A travel diary can be a physical or virtual "log book", in which every vehicle user fills out their trip purpose, passengers, and other information that is not otherwise in the vehicle tracking system. This level of detailed data collection should only occur for a short time, enough to learn a typical pattern of activity.

Fuel Economy

The fuel economy of new vehicle purchases should be increased 42%-50% from 2018 levels by 2035. The overall fuel economy of vehicles for sale in the market is improving, so much of this change will occur naturally with fleet turnover, but procurement with a focus on fuel economy should be a priority.[58] Additionally, smaller, lighter vehicles should be chosen when they can meet City needs. The typical passenger vehicle in the current fleet is a sports utility vehicle (SUV) or pickup truck. Replacing some of these vehicles with sedans would save energy, emissions, fuel cost and purchase cost. In the case of electric vehicles, choosing smaller vehicles can reduce charging times and increase driving range. The electronic traction control in electric vehicles can help even smaller models handle snow and ice well.[59]

Staff members should be encouraged and enabled to use vehicles efficiently to support the city's climate goals. There are information tools that can give drivers feedback on the efficiency of their vehicle usage and trainings available on "eco-driving" that can teach best practices for achieving fuel economy.[60] Enforcement of the City's existing anti-idling policy could reduce fuel usage.

Tracking

Improvements in data quality control with Evanston's existing fleet and fuel tracking systems will enable closer management of vehicle activity and emissions. An assessment of fleet data found gaps that should be amended, including mileage data that was not recorded during fueling and lack of differentiation in reports between hours and miles of vehicle activity. A new data management structure will be needed to better represent the fleet's energy and performance data as electric vehicles are adopted. Specifics include, "energy consumed (kWh), vehicle state of charge (SOC) before, during, and after trips, charge times and duration."[61] Additionally, Evanston may consider including real time data collection within zero-emission vehicles to give drivers and fleet managers more insight into usage and performance.[62]

Procurement

Procurement goals can ensure the decarbonization of the fleet happens in a timely manner. The decisions made in the next 5 years will shape Evanston's 2035 fleet. The City of Los Angeles set a goal of 50% electric light duty vehicles by 2017 and now is working toward 100% zero-emissions sedans by 2021. Additionally, their procurement process dictates considering zero-emission vehicles first for all procurement of new equipment.[63] As vehicle technologies are changing rapidly, leasing may be a good

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[58] U.S. Department of Energy, Energy Information Administration, "Annual Energy Outlook," (2018). Light duty vehicles are projected to improve fuel efficiency 40% by 2035, commercial light trucks 21%, and freight trucks 25%. https://www.eia.gov/outlooks/aeo/pdf/appa.pdf

[59] Jukka Kukkonen, Fresh Energy, "Electric vehicles are great winter cars," February 11, 2019. https://fresh-energy.org/electric-vehicles-are-great-winter-cars/#

[60] "Eco Driving Tools," Energypedia, November 7, 2014, https://energypedia.info/wiki/Eco_Driving_Tools

[61] Fleets for the Future, "Electric Vehicle Procurement Best Practices Guide," 13.

[62] "AC Transit Zero-Emissions Bus Rollout Plan: Alameda Contra Cost Transit District Oakland, CA."

[63] Michael Samulon, Update on LA Municipal Fleet Zero Emissions Goals, Phone, August 19, 2020.

option to increase fleet turnover. [64] The Climate Mayors Electric Vehicle Purchasing Collaborative has information on electric vehicle purchasing and leasing.[65] Early decommissioning of fossil fuel fleet vehicles and ending the practice of transferring older vehicles between departments may help Evanston meet its climate targets sooner.

Funding and financing for low-carbon technology continues to evolve. Large providers of the necessary infrastructure technology may offer financing themselves and service models exist in the sustainable infrastructure realm wherein capital cost is borne by private implementers. Outreach to venders, vehicle manufacturers, and the electric utility may identify additional funding and financing incentives. In 2017, for example, San Francisco Bay Area municipalities partnered with an auto dealership to allow the dealership to receive the federal tax incentive for electric vehicle purchases in place of the non-taxed public agencies and the dealership lowered the vehicle sales prices as a result.[66]

A variety of federal energy and transportation funds have been used for electric vehicles and infrastructure purchases.[67] The U.S. has recommitted to GHG reduction by rejoining the Paris Agreement, which may make federal funds for climate neutral fleets and infrastructure more available in coming years.

Maintenance

Maintenance is another important aspect of fleet management that is crucial to GHG savings. Performance of vehicles depends on regular maintenance.[68] Transitioning the fleet to more electric vehicles is likely to save maintenance costs, as electric vehicles do not have the fluids and moving parts of internal combustion engines and have much fewer manufacturer recommended maintenance tasks.[69] However, the transition will require maintenance staff training and time for learning the new technologies to enable maintenance staff to safely keep the fleet at top performance levels.

An important GHG to track and manage in the future is the purchase of refrigerant gas used in most automobile air conditioning systems, which has a high global warming potential. However, this may be less of an issue going forward as these gases are phased out of vehicles.

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[64] "Electric Vehicles and the City of New Bedford" (Massachusetts Department of Environmental Protection, October 9, 2018), https://www.mass.gov/files/documents/2018/10/09/massevip-newbedford.pdf.

[65] Climate Mayors Electric Vehicle Purchasing Collaborative https://driveevfleets.org/

[66] Georgetown Climate Center, "Capturing the Federal EV Tax Credit for Public Fleets: A Case Study of a Multi-Jurisdictional Electric Vehicle Fleet Procurement in Alameda County, California," April 2017. https://www.georgetownclimate.org/files/report/Capturing-the-Federal-EV-Tax-Credit-for-Public-Fleets%20-%20Case%20Study.pdf

[67] U.S. Department of Energy and U.S. Department of Transportation, Guide to Federal Funding, Financing, and Technical Assistance for Plug-in Electric Vehicles and Charging Stations, July 2016. https://www.energy.gov/sites/prod/files/2016/07/f33/Guide%20to%20Federal%20Funding%20and%20Financing%20for%20PEVs%20and%20PEV%20Charging.pdf

[68] Oak Ridge National Laboratory, "Keeping Your Vehicle in Shape," Fuel Economy.Gov, accessed December 8, 2020, //www.fueleconomy.gov/feg/maintain.jsp.

[69] Harto, Chris, et al "Electric Vehicle Owners Spending Half as Much on Maintenance Compared to Gas-Powered Vehicle Owners, Finds New CR Analysis."

Vehicle Miles Traveled (VMT) Reduction

City of Evanston vehicles logged at least 1.5 million miles in 2018. A balanced portfolio of emissions reduction action requires that the vehicle miles traveled for city business decrease 20-30% by 2035. That is much easier to envision now than it might have been even a year ago, as the COVID-19 pandemic has forced new ways of working. Policies and strategies to achieve VMT reduction can include trip reduction, travel efficiency, and use of alternative modes.

Trip Reduction

Ensuring staff have the tools and resources they need to avoid traveling will be the most cost-effective fleet strategy. Departments should be given clear data on their vehicle use with associated targets for reduction. Additional technology for online meetings and conferences should be provided where needed to reduce travel.

Some of trip reduction is a cultural shift—if leadership shows a preference for virtual meetings or avoiding travel it will set the tone. Trip reduction can also be made fun through a competition between departments. Consider also if the locations of staff and activities can be shifted to reduce travel needs between facilities.

Out of town business travel is not yet recorded in Evanston's municipal operations GHG inventory but tracking of it should begin and targets should be set to limit its use to essential needs.

Travel Efficiency

When travel in Evanston fleet vehicles is necessary it should be done efficiently. Routes for vehicles such as garbage trucks should be analyzed for efficiency—fuel savings may be possible by changing routes or adjusting vehicle overnight parking locations. Carpooling among all staff for City business should be expected and rewarded. A staff survey or travel diary may identify ways in which trips for multiple purposes can be combined to save mileage, as well.

Alternative Modes

Evanston is a multi-modal city and City operations should take advantage of that. Staff should be encouraged, expected, and rewarded for traveling to meetings virtually, by bicycle, on foot, or by public transit. Current vehicle uses should be analyzed to determine use purposes that could be replaced by other modes. The City conducting its operations on foot, by bicycle, or on transit makes its commitment to carbon-neutrality visually present in the community. Some of these alternative modes may be weather-dependent, so the city may want to provide a limited number of taxi vouchers or other back up transportation options to staff (these should be carefully tracked as they would be part of the city's operational carbon footprint).

Staff Commutes

Staff commutes are outside of the scope of Evanston's municipal operations GHG inventory, however best practice for climate action would encourage staff to reduce the GHG emissions associated with their commute. The strategies listed in this VMT Reduction section can be applied to commutes as well. Policies such as parking cash out, subsidized transit passes, or payments for staff who walk, bike or carpool are all also supportive of reducing staff commute emissions. The location of City facilities should be prioritized for location efficiency and access by transit and other non-auto transportation modes. Electric charging stations could be made available to staff who commute or carpool by personal vehicle to encourage clean vehicle use.

Cost Impacts

A high-level cost estimate was created for each of the scenarios as shown in Table 4. Implementation and operational choices made in the process of decarbonizing the fleet can greatly impact costs, so these values should be considered as indicators of the scale of cost involved rather than as forecasts.

Scenario 1 creates total savings over the period from 2021-2035 of $12 million. This scenario has the highest costs for infrastructure and vehicle purchases over business as usual, but it also generates the most savings in annual fuel and maintenance costs. Scenario 1 includes a large reduction in the number of fleet vehicles and vehicle miles traveled, which both generate cost savings against business as usual.

Scenario 2 has the lowest total savings at $5 million from 2021-2035. Both Scenarios 2 and 3 have lower investment needs as less of the fleet is transformed to zero carbon fuels, but both achieve lower annual fuel and maintenance savings as a result.

The bulk of the infrastructure investment in each scenario needs to occur in the early to mid-point of the scenario period to support the fleet as it transforms. In 2021 and 2022 investment needed will include electric vehicle charging stations for smaller fleet vehicles. As charging needs grow in future years a significant electrical system upgrade is likely required and those costs are estimated in the scenarios. The on-site solar investment could be spread out over time, but earlier installation is encouraged to capture the electricity cost savings it will generate and its GHG benefits.

Table 4. Estimated Cost Impacts by Scenario

2035	Scenario 1	Scenario 2	Scenario 3
Annual Fuel Cost Reduction from Business as Usual in 2035[70]	$(400,000)	$(300,000)	$(220,000)
Annual Maintenance Cost Reduction from Business as Usual in 2035[71]	$(3,200,000)	$(1,700,000)	$(1,500,000)
Estimated Change in Fleet Vehicle Purchase Costs (Total 2021-2035)[72]	$670,000	$(600,000)	$(1,300,000)
Estimated Infrastructure Cost (Total 2021-2035)[73]	$16 million	$12 million	$8.2 million
Total Estimated Savings from 2021-2035[74]	$(12,000,000)	$(5,400,000)	$(6,800,000)

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[70] Fuel savings include increased fuel economy, reduced vehicle miles traveled, cost savings from self-generating electricity with on-site solar and the cost savings of grid electricity over other transportation fuels. Annual value. All cost values in today's dollars.

[71] Maintenance savings is an estimate based on Evanston's reported 2018 fleet maintenance costs per mile, maintenance cost differentials reported for New York City's electric fleet, and reductions in vehicle miles traveled in each scenario. Annual value.

[72] Net fleet purchase costs include the added cost of electric vehicles over business as usual and the savings from fewer vehicle purchases with rightsizing.

[73] Infrastructure costs include the total estimated costs for electric vehicle chargers, on-site solar installation, and electrical system upgrades. These costs may vary significantly with infrastructure system design.

[74] Total estimated savings are infrastructure costs + change in fleet costs + annual fuel and maintenance savings assuming an adoption rate of new vehicles and technology of 7% of the fleet per year + offset purchases in 2035 to achieve carbon neutrality.

Appendix 1: Fuel Lifecycle Emissions Comparison[75]

While Evanston's municipal operations GHG inventory does not include lifecycle emissions, Evanston should take these into consideration when making choices about fuels or infrastructure investments. Argonne National Laboratory's GREET calculator provides in-depth information on fuel and vehicle lifecycle impacts. The fuel module estimates GHG emissions from "Pump to Wheels" (PTW, the direct emissions in the GHG inventory), as well as "Well to Pump" (WTP, indirect Scope 2 and upstream Scope 3 emissions). The figure below provides these values in terms of grams of CO_2e per gallon of gasoline equivalent (GGE).

The GREET model shows two zero carbon fuels on the current market—renewable electricity and hydrogen from distributed solar. This is indicated by the black dot, which is the sum of WTP and PTW impacts, including negative carbon values from fuel sources that take carbon out of the atmosphere, such as when soybeans are growing.

Biofuels, such as biodiesel, ethanol and renewable diesel, produce carbon emissions upon combustion, but those emissions are considered biogenic carbon that are part of the existing carbon cycle, which is tracked separately and considered a lower impact than anthropogenic carbon. Thus, they can be considered nearly carbon neutral fuels, despite showing significant tailpipe carbon emissions, if they are sustainably produced and their upstream emission are not large.

[75] Energy Systems, "GREET 2019 WTW Calculator," Argonne National Laboratory, 2019, https://public.tableau.com/views/GREET2019_WTWCalculator/GHG_Dashboard?:embed=y&:showVizHome=no&:host_url=https%3A%2F%2Fpublic.tableau.com%2F&:embed_code_version=3&:tabs=no&:toolbar=yes&:animate_transition=yes&:display_static_image=no&:display_spinner=no&:display_overlay=yes&:display_count=yes&publish=yes&:loadOrderID=0.

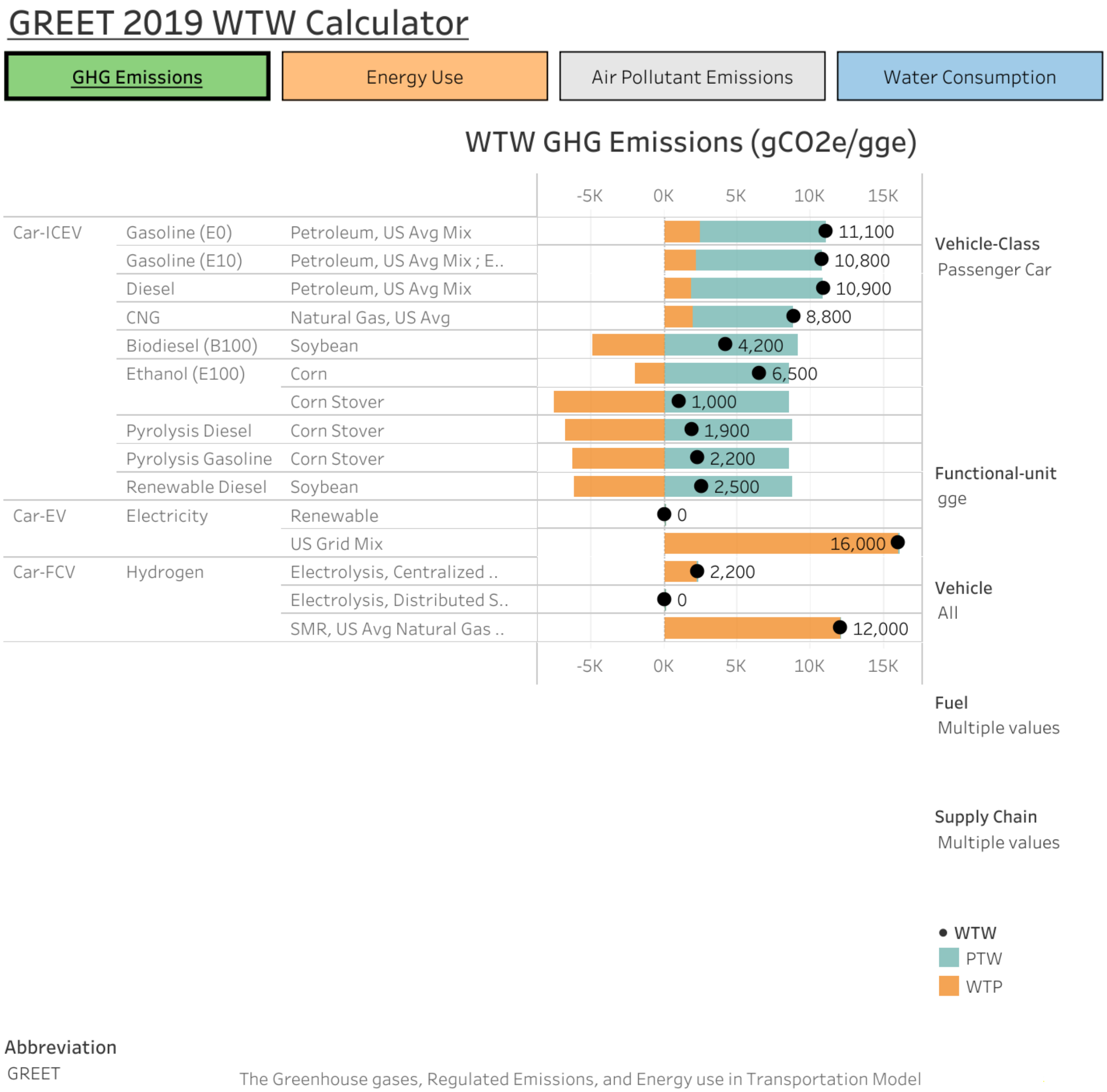

Figure A- 1 Lifecycle Emissions of Transportation Fuels (gCO2e/gallons of gasoline equivalent) (Pump-to-Wheels and Well-to-Pump) [76]

[76] Energy Systems, "GREET 2019 WTW Calculator," Argonne National Laboratory, 2019, https://public.tableau.com/views/GREET2019_WTWCalculator/GHG_Dashboard?:embed=y&:showVizHome=no&:host_url=https%3A%2F%2Fpublic.tableau.com%2F&:embed_code_version=3&:tabs=no&:toolbar=yes&:animate_transition=yes&:display_static_image=no&:display_spinner=no&:display_overlay=yes&:display_count=yes&publish=yes&:loadOrderID=0.

The following figure models the same data on a per mile basis, which considers typical vehicle efficiencies. In this approach, the efficiency gains and greater carbon emissions advantages of electric and fuel cell vehicles is more apparent than in the figure above.

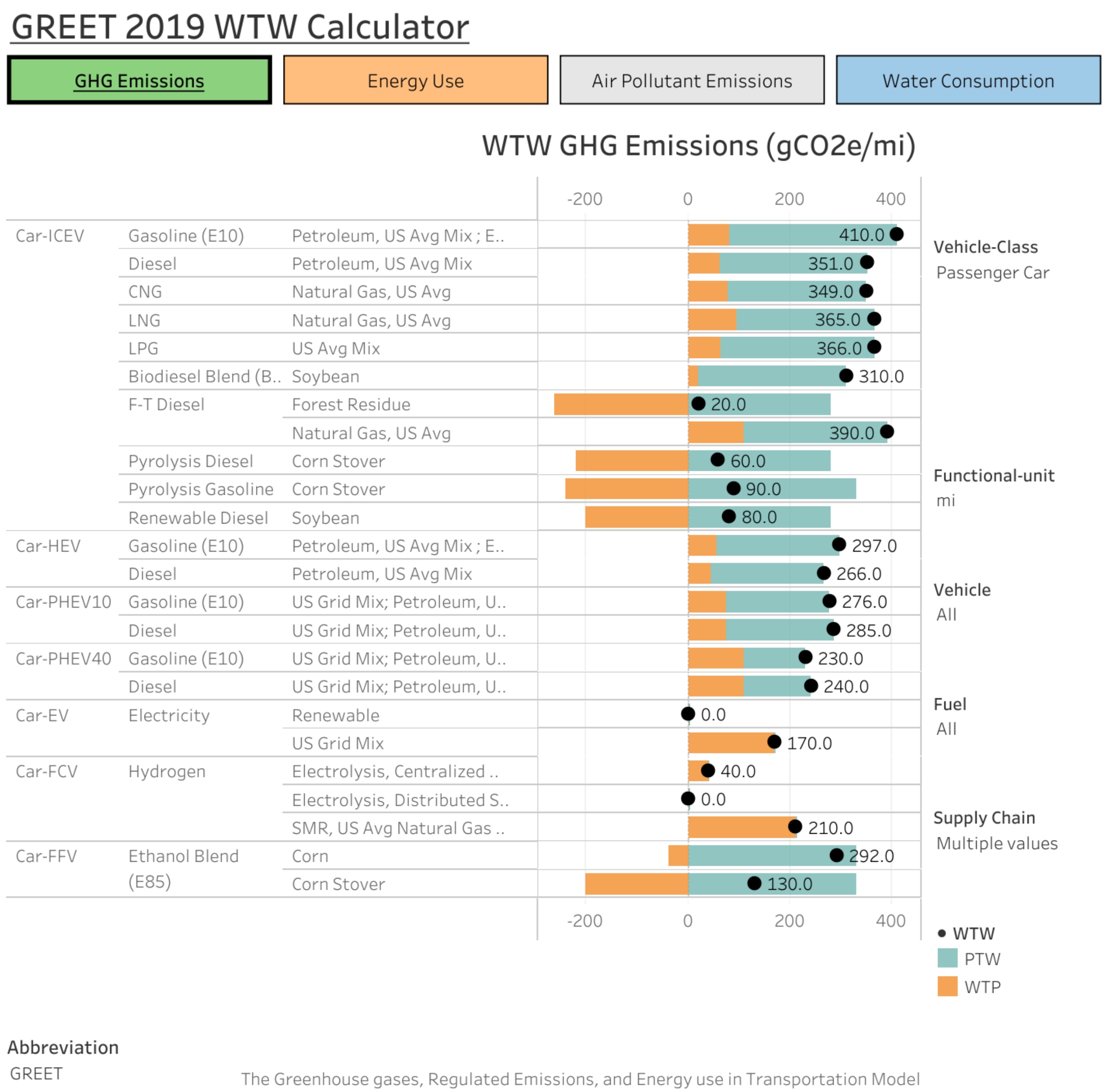

Figure A- 2. Lifecycle Emissions of Transportation Fuels per Mile in a Passenger Car (gCO2e/mile) (Pump-to-Wheels and Well-to-Pump) [77]

[77] Energy Systems, "GREET 2019 WTW Calculator," Argonne National Laboratory, 2019.

Table B- 1. Model Year 2020 & 2021 Vehicle Examples

Vehicle Make & Model	Model Year	Fuel	Efficiency	Efficiency Units	Range (miles on one full tank / battery)	MSRP Cost Low	MSRP Cost High	Time to Charge Battery	Car and Driver Rating	Cost Analysis Annual Miles	Annual Fuel Use	Fuel Units	Annual Fuel Cost	Annual Maintenance Cost	Total 10-Year Annualized Cost	Annual GHG MTCO2e
Sedans																
Hyundai Ioniq	2020	Electric	25	kWh/100 mi	170	$33,045	$38,615	5.8 hrs at 240V	8	10,000	2,500	kWh	$181	$200	$3,964	1.3
Chevrolet Bolt EV	2020	Electric	29	kWh/100 mi	259	$37,495	$41,895	10 hrs at 240V	8	10,000	2,900	kWh	$209	$200	$4,379	1.5
Nissan Leaf	2020	Electric	30	kWh/100 mi	226	$31,600	$38,200	8 or 11 hrs at 240V	6.5	10,000	3,000	kWh	$217	$200	$3,907	1.6
Chevrolet Malibu	2021	Gasoline	32	mpg	506	$23,065	$34,295	N/A	7	10,000	313	Gallons	$691	$440	$3,999	2.7
Ford Fusion Hybrid FWD	2020	Gasoline	42	mpg	588	$28,000	$34,595	N/A	6	10,000	238	Gallons	$526	$440	$4,096	2.1
Ford Fusion Energi Plug-in Hybrid	2020	Gasoline	42	mpg	610	$37,000	$37,000	2.6 hrs at 240V		10,000	238	Gallons	$526	$440	$4,666	2.1
SUVs																
Hyundai Kona	2020	Electric	27	kWh/100 mi	258	$37,190	$45,400	9 hrs at 240V	9	10,000	2,700	kWh	$195	$200	$4,524	1.4
Kia Niro	2020	Electric	30	kWh/100 mi	239	$39,090	$44,590	9.5 hrs at 240V	8.5	10,000	3,000	kWh	$217	$200	$4,601	1.6
Volvo XC40 AWD BEV	2021	Electric	43	kWh/100 mi	208	$54,985	$54,985	8 hrs at 240V		10,000	4,300	kWh	$310	$200	$6,009	2.3
Ford Explorer AWD HEV	2021	Gasoline	25	mpg	465	$49,855	$51,855	N/A	7.5	10,000	400	Gallons	$884	$440	$6,410	3.5
Ford Explorer RWD	2021	Gasoline	24	mpg	446	$32,225	$44,710	N/A	7.5	10,000	417	Gallons	$921	$440	$5,208	3.7
Ford Explorer RWD HEV	2020	Gasoline	28	mpg	540	$52,280	$52,280	N/A	7.5	10,000	357	Gallons	$789	$440	$6,457	3.1
Ford Explorer RWD	2020	Gasoline	24	mpg	461	$36,675	$48,310	N/A	7.5	10,000	417	Gallons	$921	$440	$5,610	3.7
Vans																
Ford E-Transit Connect	2022	Electric	unknown		126	$24,285	$45,000	10 miles / hr @240V, or 15 miles / hr @240V-48A	8.5	10,000						

Ford Transit Connect	2021	Gasoline	26	mpg	411	$24,665	$28,795	N/A		10,000	385	Gallons	$850	$440	$3,963	3.4
Ford Transit Connect	2021	Ethanol	19	mpg	300	$24,665	$28,795	N/A		10,000	526	Gallons	$1,316	$440	$4,429	0.0
Pickup Trucks																
Ford F-150	2023	Electric	unknown		Hoping 300	$70,000	$70,000			10,000						
Ford PowerBoost Hybrid F-150	2021	Gasoline	23	mpg						10,000	435	Gallons	$961	$440		3.8
Ford F-150	2020	Ethanol	16	mpg	368	$28,745	$55,820	N/A	9	10,000	625	Gallons	$1,563	$440	$6,231	0.0
Ford F450 4x4	2021	Gasoline	15	mpg	435	$55,415	$55,415			10,000	667	Gallons	$1,473	$440	$7,455	5.9

Ethanol vehicles would also emit 3.0-3.6 $MTCO_2$(b) biogenic emissions.
Sources: U.S. DOE and U.S. EPA "Fuel Economy.gov" https://www.fueleconomy.gov/
Car and Driver https://www.caranddriver.com
City of Evanston Fuel Cost Data
U.S. EPA GHG Emissions Factors
Consumer Reports, "Electric Vehicle Ownership Costs," October 2020. https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf