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Whatcom Transit Authority Senior Project Report

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Project Title: Electrifying Public Transportation... How Much Could it Help?

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Electrifying Public Transportation…

How much could it help?

The above photo was taken by Kendall Jouett on May 20, 2023.

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Abstract

The current scenario of greenhouse gas emissions is expected to increase with global warming throughout the end of the twenty-first century. Organizations in the United States are actively working towards mitigation strategies that are beneficial in contributing towards the progress of the Biden Administration's goal to cut back greenhouse gas emissions from the levels recorded in 2005 down by half by 2030. In order to accomplish this goal, counties are developing sustainability plans specialized to the area's lifestyle uses of energy. A major focal point nationally is the transportation sector's environmental impacts, and many are looking toward the development of sustainable vehicles as a potential solution. While there are many up-and-coming alternatives to the current vehicles, electricity may be a more feasible option in public transportation. Plenty of factors play a role in deciding which improvement will prove to have the largest impact on emission reductions at local levels. Financing these changes may be a struggle, but with federal grants, there can be progress in developing environmental resiliency. Whatcom County in Washington State recently established a target to reach zero emissions in their public transportation fleet by 2040 using a multitude of methods to accomplish this. This report will dive into the plans put in place and the decisions behind them to explain why electrical transportation is a beneficial step in creating a specific environmentally friendly system.

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1.0 - Introduction

1.1 - Global Warming

The Intergovernmental Panel on Climate Change (IPCC) released its sixth assessment report throughout 2021 to 2023. This report will be used to acknowledge progress in the Paris Agreement's goal of limiting global warming to 1.5℃ from human-caused climate change. This progress will not occur overnight. Even with several years worth of newly developed policies, the IPCC is not hopeful that global warming will remain within that ideal boundary by the end of the twenty-first century under the current global greenhouse gas emissions (IPCC, 2023). In order to limit the projected impacts and remain within a maximum 2℃ warming, it would require net zero carbon dioxide emissions.

The likelihood of the global achievability in reaching net zero emissions from 2050 to 2070 varies by country given the high disparity between emission levels and financial feasibility globally. As time passes with a lack of significant emission reductions, it is probable that the impacts experienced from global warming will be exceptionally difficult to acclimate (IPCC, 2023). Moving towards active resiliency implementation will provide the greatest opportunity to restrict how significantly global warming will be experienced.

Energy use is a big-time player in greenhouse gas emissions because of the wide range of lifestyles globally. Some countries, like the United States, are the top consumers of unsustainable energy currently. As of 2021, the United States consumed roughly 16% of the total world's energy consumption. Comparing that energy percentage to the country's population of 4% of the global population, it ranks the United States as the tenth largest per capita energy consumption globally (U.S. Energy Information Administration, 2022). It is important to note that the global coronavirus pandemic was ongoing at the time of this data, which may have skewed the total

energy consumption percentages slightly. Nonetheless, this ranking will likely still be similar to the United State's energy consumption pre- and post-pandemic for the sake of this report.

Fully adjusting lifestyle use is impractical given how technologically advanced our society is in the twenty-first century. Regardless, ongoing efforts in reducing greenhouse gas emissions are not deterred by this. Instead, the Biden Administration has used it as a focal point in their campaign of tackling climate change. As of 2021, President Biden established a nationwide goal to reduce emissions to half of the 2005 levels by 2030 (The White House, 2021). Further promises to make substantial movement toward a long-term sustainable and liveable environment, President Biden wants to reach a net zero emissions economy by 2050 (The White House, 2021). These targets put in place may help to accomplish the IPCC's goal of striving to keep global warming under 2℃. President Biden's goals remain within the boundaries of the United States, but it sets the country to be an active partaker in mitigating global warming.

In order to better analyze energy use, it has been split into sectors in order to thoroughly quantify consumption amounts to evaluate places possibly worth investing technological improvements in. This report will not analyze all of the sectors that contribute to energy consumption, but rather just the transportation sector in the United States. It is notable that within the transportation sector, there may be factors unaccounted for, such as the manufacturing of architecture and vehicles that are also partly responsible for the United States' energy consumption.

1.2 - The Role of Transportation Sectors

Within the United States, the transportation sector, "...is responsible for 29% of the nation's carbon emissions,..." (Office of Energy Efficiency and Renewable Energy, 2022). This

percentage is larger than any other single sector within the United States economy. As explained in the previous section of this report, the recent global pandemic may have impacted energy consumption data. Pandemics are not regular occurrences, and given many nationwide lockdowns that have occurred, the data may seem more significantly different than it may have been if energy consumption had remained consistent.

I mention this again because three years previous to this data, the United States Department of Transportation stated that, “In 2019, the transportation (sector) accounted for 33% of emissions in the United States…” (U.S. Department of Transportation, 2023). Between these two data statistics, the time frame is a three-year difference with a 4% decrease in carbon emissions. I was unable to clarify if this decline can be fully attributed to the pandemic’s lockdowns that occurred over the course of a year, or if this decline can be fully attributed to improvements in actions taken to reduce greenhouse gas emissions. It is much more probable that a combination of these two components contributed to a 4% decrease over a three-year time frame.

Nevertheless, this is still notable progress in the right direction. If this rate of decreasing greenhouse gas emissions within the transportation sector continues, it would majorly benefit cutting down the total emissions within the United States by 2030. The transportation sector in the United States accounts for all modes of transportation, both private and public, through the land, air, and sea associated with the United States. Figure 1 (U.S. Environmental Protection Agency, 2023), below, uses data that the Environmental Protection Agency (EPA) collected in 2021. It shows where the emissions stem from within the transportation sector based on the categories described above. The ‘Other’ category is used to compile nationwide emissions from

public transit buses, motorcycles, and anything not accounted for by the five remaining categories.

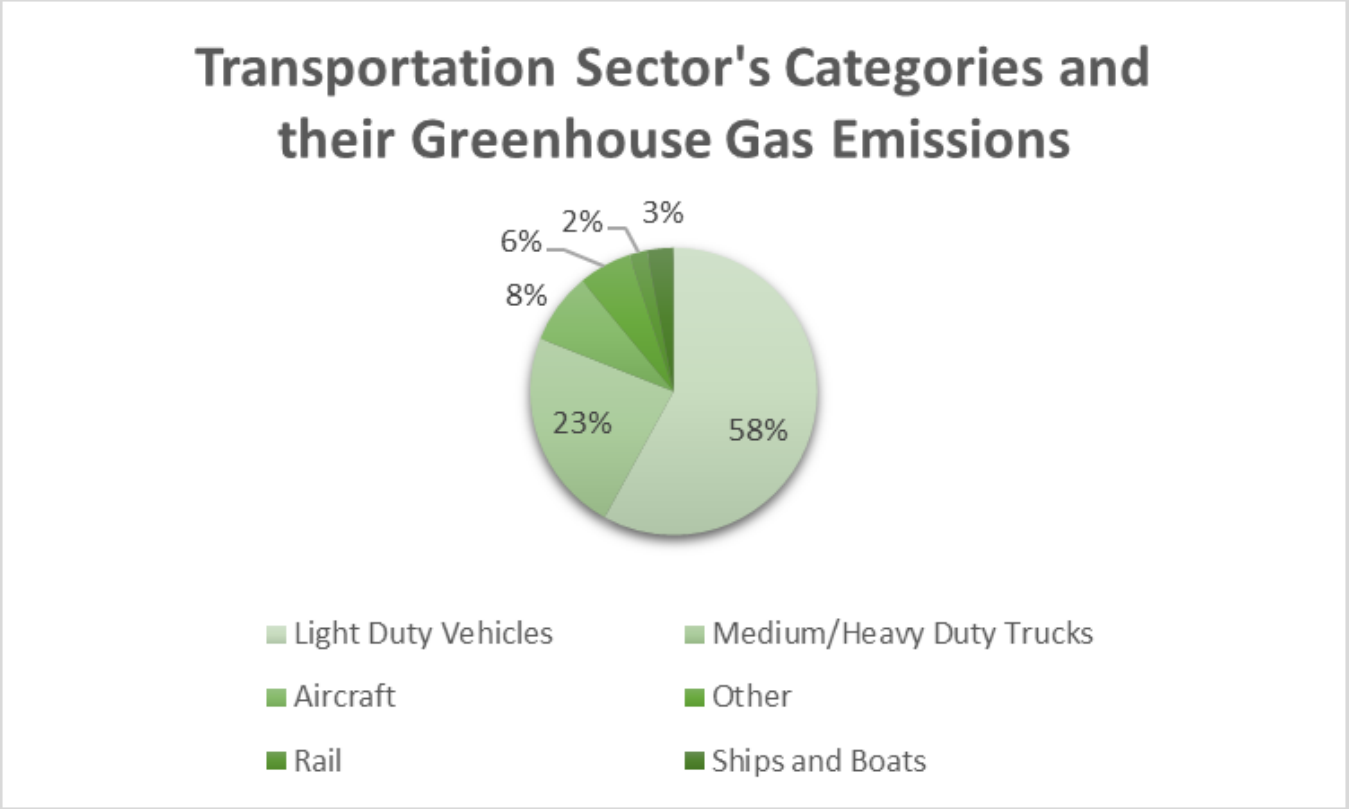

Figure 1: *Transportation Sector's Categories and their Greenhouse Gas Emissions*. This data has been collected by the U.S. Environmental Protection Agency in 2023. This represents the emissions in the transportation sector in the year 2021. These values were rounded to the nearest whole number in order to total one hundred percent, so note that these values may not be exact.

The largest category in Figure 1 with the greatest emissions is the light-duty vehicles. This includes mostly private individual cars that millions of Americans own for day-to-day use. Private and public usage are not differentiated within the EPA's data specifically, but this category likely consists of a majority of private individual transportation. This 58% is over half

of the transportation emissions, which helps to explain the recent technological push for vehicles run on alternative fuels. Some of the fuels that are being tested for long-term usage and efficiencies include electricity, biodiesel, ethanol, hydrogen, natural gas, and propane (Office of Energy Efficiency and Renewable Energy, n.d.). Out of all of these options, electric vehicles have been the primary focus due to their increasing accessibility. Industrial and federal movements have centered around electric vehicles, and in fact, many of the action plans in place are incorporating the implementation of electric vehicle charging stations along major roadways. It is a work in progress, but electricity seems to be the go-to move for an alternatively fueled private vehicle.

As for public transportation, electricity-powered transit will have the greatest economic and environmental pay-offs. An electric bus does cost significantly more upfront; however, the overall maintenance and fuel costs over the bus's entire lifetime negate it. These buses will emit lesser amounts of carbon dioxide. Multiple cities are working toward the incorporation of electric public transit into their current systems such as Los Angeles, Denver, Seattle, and this report will specifically focus on the city of Bellingham. Each city listed here, and any other city in the United States will vary in the capability of carrying out the transition to electrical-powered transit or any other alternative fuel.

1.3 - Addressing Current Emissions

In order to reduce carbon emissions in the transportation sector, the Department of Transportation has developed a Carbon Reduction Program (CRP) for each state to fund projects that will reduce emissions (U.S. Department of Transportation, April 26, 2023) across any of the subcategories listed in Figure 1. One of the programs is the Low or No Emission Vehicle

program that specifically provides funding for the, "...purchase or lease of zero-emission and low-emission transit buses as well as acquisition, construction, and leasing of required supporting facilities," (Federal Transit Administration, 2023). These funds are not guaranteed to any singular state governmental authorities, and the programs are quite competitive.

Washington state's greenhouse gas emission measurements have been recorded up to the year 2019. I was unable to find any data that may showcase the emissions post-pandemic. Washington emitted roughly 102.1 million metric tons of carbon dioxide equivalents (Department of Ecology, 2020) and within that, 39% of the emissions came from the transportation sector. Nationally and in Washington state, the transportation sector continues to remain the sole largest contributor to carbon dioxide emissions. In response to these data, Washington has established a target goal of reducing their emissions by 95% before the year 2050 using a variety of methods including zero-emission vehicles, clean fuel standards, and a permanent halt in the use of hydrofluorocarbons (Department of Ecology, n.d.).

The city of Bellingham in Washington state has taken on an active stance in combating climate change on a local level. The city has initiated a Climate Protection Action Plan that states their local goal is to cut emissions within city limits by 40% before 2030 (City of Bellingham, 2018). Numerous approaches will be taken in order to achieve this such as promoting modes of transportation other than private singular vehicle rides. Doing so would include increasing the accessibility to public transit and possibly expanding the routes provided by public transit. Advertising the effectiveness of carpooling, biking, and walking to the general public in the city may also prove to be beneficial in spreading awareness of one's options in choosing sustainable transportation.

2.0 - Implementation of Mitigation Plans

2.1 - Whatcom Transportation Authority

The leading public transportation system within Bellingham and Whatcom County is the Whatcom Transportation Authority (WTA). The WTA provides multiple modes of transportation in order to better suit the public needs. They have arranged several different services including fixed route buses, paratransit, zone, vanpool, and hop (WTA, 2023). Fixed routes are a total of twenty-eight different routes that buses provide service to seven days a week from early mornings to late evenings. Paratransit is available for disabled passengers who are unable to rely on the fixed routes for service, but the passages and time availability match the fixed routes. Zone is a service that will allow travel for anyone to rural locations outside of the serviced areas within the boundaries of Whatcom County. Vanpool acts essentially as a carpooling service for small groups of passengers, but this service allows them to lease a van for a duration of time for the sole purpose of commuting. The last remaining service provided by the WTA is Hop, which essentially provides rides only within the boundaries of Lynden Hop.

As some services are more readily available for the public to use, they are larger in size. According to a WTA *Sustainability Plan*, the WTA's current fleet consists of sixty-two fixed route buses, forty-seven paratransit vehicles, seventeen vanpool vehicles, thirty-seven non-revenue vehicles, and two on-demand vehicles (WTA, 2023). It totals one hundred and sixty-five vehicles, and there is a wide distribution of the fuel used within each category. The fuel types used by the WTA include electric, hybrid, diesel, unleaded, and propane (WTA, 2023). This report will only focus on the fixed route vehicles used in the WTA. Of the sixty-two fixed route buses, there are two electric, eight hybrid, and fifty-two diesel vehicles (WTA, 2023).

The most recently available data of all services provided by the WTA are from the full calendar year of 2021. There have been recent upgrades in some services within the last year and a half that are not specifically stated within the 2021 data. The WTA is working toward a zero-emission fleet by 2040 (WTA, 2022), which will allow them to complete the goals of emission reductions set by Washington State and the Department of Transportation. Thirteen new electric-powered buses are in the process of being incorporated into the fixed routes from 2023 through 2025 (WTA, n.d.). After this timeframe, 25% of WTA's active fleet will be battery electric-powered transit buses. This work-in-progress will be discussed in a further section.

As for the current fleet of fixed route buses, there are multiple factors that play a role in the current distribution of fuel efficiency types. One bus, regardless of its fuel type, has an average lifespan of twelve years (WTA, n.d.) before needing replacement. Of the sixty-two buses, the age distribution is not equivalent. Some will need replacing relatively soon, but any diesel or hybrid buses bought within a few years before 2021, will likely have another decade of use. While this may be beneficial from the long-term financial viewpoint, it does prohibit immediate greenhouse gas emission reduction. The remaining factors discussing the efficiency of the different fuel-powered transit buses in use will be incorporated into a further section.

In 2021, the fixed route transit buses saw 1.7 million boardings (WTA, 2023). I am unclear as to which of the twenty-eight routes received the highest traffic. The WTA collected data on the annual average of the passenger miles per boarding, which was 3.2 passenger miles per boarding (WTA, 2023). Using these data, I calculated the passenger miles traveled (PMT) in 2021 by multiplying the two data to get 5.4 million PMT. This calculation matched the WTA's measure of passenger miles; however, my answer is slightly higher than the WTA's data.

This calculation allowed me to get an estimate on the ‘pollution avoided’. Pollution avoided is the term used to estimate how much carbon emissions were not emitted through the use of public transportation over personal, private vehicles. The WTA calculated this as the annual PMT multiplied by the percentage of people recorded using the fixed route buses in favor of not driving their personal vehicle; they estimated this percentage to be 38% (WTA, 2023). Calculating this led to an estimated one thousand metric tons of carbon dioxide emissions avoided solely through the usage of the WTA’s twenty-eight fixed routes in 2021 (WTA, 2023). This result does not factor in any fuel type used by the current fleet.

If the fleet remains as is with the current fuel type distribution, it is still extremely effective in limiting some greenhouse gas emissions. This proves why public transportation is useful for cities to invest in for long-term sustainability. The pollution avoided can be increased as well with alternatively-fueled vehicles other than diesel.

Table 1: *Data on the Fixed Route Buses in WTA’s Service for 2021.* This data came from WTA’s *Sustainability Plan* (WTA, 2023).

Total Boardings	1,714,220
Passenger Miles per Boarding	3.2
Passenger Miles Traveled	5,485,504
Pollution Avoided (Metric tons CO2)	1,168

2.2 - Efficiency of the WTA's Sustainability Plan and 2040 Plan

The WTA has developed plans that are in correspondence with the city of Bellingham's plans for emission levels in the upcoming decades. The WTA and the city of Bellingham have developed a *2040 Long-Range Transit Plan.* This plan acknowledges several goals that do not only focus on investing in alternative-fueled vehicles. By the year 2040, the WTA is striving to increase its service by 25%, provide 35% more jobs and transit availability, ensure that 50% of people are within manageable walking distance to a service location, increase riders per hour by 35%, and avoid 7,500 of carbon dioxide equivalent metric tons through public transit annually (WTA, 2022). These goals sum up to what the WTA describes as the "Three E's": equity, efficiency, and environmental progress (WTA, 2022). The purpose of the plan's publication is to spread awareness and ensure that the public has access to the action steps that are being taken to accomplish the Three E's. The plan dives in-depth into many different projects that are being discussed or are actively taking place in improving the WTA's accessibility, services, and environmental leadership for other communities and organizations to look to for possible guidance in similar situations.

Accomplishing these goals may seem as difficult, but the *2040 Long-Range Transit Plan* acknowledges current issues and failings in the WTA's system as is before any improvements take place. This allows the WTA to throw primary focus into those issues. A major one is the financial funding of the many projects described in the plan. It discusses local funding that may occur for the support of transit projects in the city of Bellingham, as well as additional state and federal grants, fares, taxes, and possible partnerships that may provide sufficient funding for the goals stated (WTA, 2022). The pandemic has impacted the planning process and while this plan mentions it, the WTA gathered public input through online means. This has allowed some

feedback on the *2040 Long-Range Transit Plan*, and the WTA has incorporated it into the planning process. There is some leeway for improvements within the plan as funding or technological developments occur as well. This *2040 Long-Range Transit Plan* presents itself as extremely sufficient in accomplishing the Three E's goals it describes.

Another plan that the WTA has more recently developed is its *Sustainability Plan*. This plan is much more specialized to the WTA's current fleet and the room for possible improvement. This plan also acknowledges any and all faults within the WTA's system as is before any improvements occur. This allows for the WTA to primarily focus on the aspects that show the most potential in becoming a more sustainable practice. The goals that this *Sustainability Plan* strives to accomplish include increasing sustainable transportation mode-share, reducing environmental impacts, transitioning to a zero-emission fleet and facilities, and preparing for climate change resiliency (WTA, 2023). The data presented in this plan are used to support the goals listed here and the goals described in the *2040 Long-Range Transit Plan*.

A majority of this *Sustainability Plan* dives into the statistical collection of the data for the usage of the WTA's current fleet, facilities, and employees. This information is crucial in setting ideal levels for emitted pollution from the fuels used by the fleet and facilities. This plan is not specific to any service that WTA provides or any exact location. There is sufficient data on all five service options: fixed route, paratransit, vanpool, zone, and hop. As for the facilities that the WTA owns, there are data presented on each of the seven locations: Maintenance, Operations, Administrative, Base (MOAB), Midway Lot, North Lot, Bellingham Station, Cordata Station, Ferndale Station, Lynden Station. The *Sustainability Plan* also incorporates the

emissions within each facility station. This regards the electricity, natural gas, water, and waste usage between all sites.

There is such a wide variety between the WTA's services and facilities that the plans made in this *Sustainability Plan* are not set-in-stone and remain flexible. This is ideal given that the future is unpredictable in terms of customer usage, financial budgets, and the ideal timeline completion for each of the goals mentioned above. As a whole, this plan presents itself as extremely sufficient in accomplishing the WTA's goals.

2.3 - Comparison of Electrical and Diesel Buses

There are stark differences between electrical and diesel buses in both finances and emissions. This section will cover both topics.

The electric buses that the WTA uses in their fleet run on batteries. A brand new battery electric powered bus costs roughly $1.1 million (WTA, n.d.) as of 2023. In addition to that price point is the estimated $20 million needed for the required charging infrastructure (WTA, n.d.). These electric buses, while costing significantly more upfront for production, are predicted to decrease in price in the coming decades. With increasing technological advances, it is extremely likely that the batteries will become more readily available in the industry allowing for lower-price production. On the other hand, diesel buses are quite literally half of the cost of a battery electric-powered bus ringing in at just $500,000 upfront. This significant difference would make diesel buses much more financially feasible for any city's public transportation organization.

Governments, on the state and the federal level, are creating and funding plentiful programs dedicated to helping cities and organizations to offset the costs of purchasing or leasing

an electric bus (WTA, n.d.). The WTA received $8.86 million from the Low or No Emission Vehicle program for the purchase of eight new electric buses and charging stations from 2023 to 2024. The WTA likely would not have been able to proceed with a zero-emission fleet without this support from grants. Many other cities and organizations are also benefiting from this program and others similar to it.

Analyzing the costs long-term, the electric buses will have significantly lower operation and maintenance costs in comparison to the diesel buses used. I was unable to get exact price amounts for the operation and maintenance costs of a bus over the course of its lifetime due to many unpredictable factors. However, electricity is less expensive in comparison to diesel. An electric bus will also not have many operating pieces running as a diesel bus that is en route does. Due to this, there is less opportunity and risk of a bus breaking down and being out of service while waiting for repairs. I do not know how often a typical diesel bus needs maintenance, or the average costs of repairs when it does occur, because everything is a different scenario. A bus may need a repair on a cheaper part only once during its entire lifetime, while another needs yearly maintenance. I did not want to estimate given this wide disparity in possible maintenance costs. It is likely that given the operating parts on a battery electric-powered bus are fewer, it stands to reason that it would not need as many repairs, therefore reducing the costs long-term.

As for the greenhouse gas emissions from an electric bus, there is an average of 1,100 fewer metric tons of carbon dioxide emitted in comparison to a diesel bus (WTA, n.d.). Electric buses also emit fewer levels of various other greenhouse gasses like nitrogen oxide and carbon monoxide. There is one, smaller benefit to an electric-powered bus that the diesel bus lacks. The

quieter noise levels from the lack of an engine in an electric bus make for a more peaceful ride and surrounding areas of the fixed routes.

Finally, it is also important to note that under the current twenty-eight fixed routes that both of these buses service, the battery electric-powered buses are unable to complete a full range of the routes (WTA, n.d.). This is due to their limited battery lifetime under one singular charge. Diesel buses do not experience this issue because they are not run on batteries at all. As the demand for electric buses increases, it is highly likely that the industry will work to make them more efficient per charge per battery. It is a matter of time until this occurs, but until it does, it could be a major issue for any city or organization depending on the length of the routes and the daily operation timeframe. The batteries used in the electric buses will also take a designated amount of time to charge, and this could vary depending on the manufacturer and how long a battery goes between charges. This could also present issues for a public transportation system.

There are advantages and disadvantages of both electric and diesel buses in their current states today. With improving technological advances and the need for sustainable transportation long-term, it is likely that the battery electric-powered transit buses will become more probable for cities to invest in purchasing or leasing given the significant difference in carbon dioxide emissions avoided.

3.0 - Discussion

3.1 - The Importance of Improving Transportation

Given the IPCC's predictions through the end of the twenty-first century under the four different global greenhouse gas emission rates are extremely daunting to discuss, it does put

emphasis on the need to take action. As this realization begins to hit home for many people within recent years, more communities are striving for possible mitigation strategies that benefit their local area. With state and federal governments, both in the United States and elsewhere, developing and putting policies in place creates a hopeful outlook for many people that individual actions may have a larger impact than they are aware of.

A previous section of this report provided examples of greenhouse gas emissions that many people partake in, which is the transportation sector within the United States. Statistics on these emissions at federal and state levels put this sector as the largest contributor to our nation's greenhouse gas emissions. Transportation is unavoidable due to our society's structure, but this does not mean that it is a lost cause. Private and public transportation has room for improvement as our society advances technologically with every passing year. Our ever-gaining knowledge of our planet's climates and its interacting systems should be applicable to protecting it. Not only could these new and improving developments be beneficial for our planet, but they could benefit our society as well.

While investing in electrical transportation, or any other alternatively fueled transportation for that matter, may have an expensive cost associated with them, it does not nullify the environmental resiliency it builds. The steps that are being taken toward making progress in environmental matters may be boosting our nation's economy through additional employment opportunities for example.

We have made substantial steps in protecting our planet's climates and its systems for decades now through the creation of endless programs, such as the EPA for example. The creation of these programs does not equate to 'taking a break' in taking action, if anything we as

a society should strive for better results and actions. Our capabilities are constantly improving, and our advancements in the largest sectors of our lives should reflect that.

3.2 - Case by Case Analysis

While the previous sections have gone in depth as to the effectiveness of Bellingham's public transportation transition toward sustainable vehicles in the fixed route service, this scenario will not reflect exact results for any other city within the state and outside of the state. A city's lifestyle varies considerably given the population size, the convenience and ease of accessing different necessities within the city, and the financial cost of public transportation usage. A city may recommend various other methods to improve their carbon emissions in their transportation sector with plentiful options in investing in sustainable, alternative fuels. A transportation system may favor different services within a particular city due to financial costs and infrastructure. Each service may have different options available to it.

Therefore, a thorough case-by-case analytical study done in a city interested in converting toward a sustainable future is recommended. This will allow for finer predictions of the cost-effectiveness of that particular city, given that federal and state grants are extremely competitive and not guaranteed. Personalized action plans will be the most beneficial when accounting for local greenhouse gas emissions, financial funding, passenger usage, and other crucial factors.

3.3 - Future Recommendations for Further Study

I was not able to run a complete analysis of the entirety of the WTA's current fleet of fixed route buses. I lacked information on the hybrid buses regarding their costs, operation,

maintenance, emissions, and how they run. I could not find sufficient, reliable information on these topics, so I opted to omit the hybrid buses within this analysis. I would like to note the importance of hybrid buses regardless. Hybrid buses are likely somewhere between the upfront, operation, and maintenance costs of the electric and diesel buses described in a previous section. Hybrid buses may act as a transitory step towards a sustainable future for public transportation systems that are waiting to receive state or federal funding because they will likely emit lesser amounts of greenhouse gasses than a diesel bus and will likely not be twice the cost of a diesel bus. Looking into this option when considering a more sustainable and healthier future is crucial.

This report also did not analyze the emission efficiency or costs of any service that the WTA provides outside of the fixed routes. Paratransit, zone, vanpool, and hop are also actively emitting greenhouse gasses. Any opportunity that the WTA has to possibly transition the vehicles used for these four services to battery electrical power may also help to reduce emissions locally. Any step taken towards emission reduction, whether locally, federally, or nationally, will help to combat global climate change and its likely long-term lasting impacts.

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