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Energy and Cost Savings from Electrified Transit: A Case Study on Electric Bus Performance in Bermuda

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Executive Summary

The Government of Bermuda has successfully deployed 30 electric transit buses in its public bus fleet, with 40 more to follow in late 2023. Preliminary analysis from the first 10 months of operation suggests the electric buses have saved the Government nearly $150,000 in fuel costs alone, already recovering the purchase cost of a single bus. This document explores the performance of these buses over the initial months of operation, evaluating the economic and environmental benefits of electrification. Operating mileage and charging data are analyzed to estimate real-world energy efficiency, fuel cost savings, and emissions avoided from electrified transit as compared to diesel. The sensitivity of charging costs to electricity tariffs is also highlighted, indicating the impact of rate components on electricity costs and in turn on the economics of building high-capacity charging depots. The procurement process undertaken to identify an appropriate vehicle in compliance with the Government's size, cost, and performance criteria is also briefly summarized.

Keywords: bus, charging, deployment, government, public transport.

1 Introduction and Background

1.1 EVs in Bermuda

With just 64,000 residents and over 430 electric vehicles (EVs) on the road [1], the North Atlantic island nation of Bermuda is well-positioned to be a leader in the EV transition. The case for EVs is particularly strong in Bermuda due to its geography and energy landscape. The archipelago consists of seven interconnected islands covering a land area of 21 square miles, dispelling any major EV range concerns. The roads are narrow and hilly, making EVs particularly well-suited for this use case due to the higher power provided by electric motors in relatively smaller vehicles.

Bermuda depends almost completely on oil imports for its transportation energy and electricity needs leading to high liquid fuel and electricity prices. EVs coupled with an increasing amount of locally generated renewable energy can help reduce fossil fuel dependence and lower overall energy prices, further incentivizing transportation electrification and the decarbonization of the broader energy system in Bermuda.

Bermuda's populace is served by 70 public buses daily, with a total fleet of 100. Before the COVID-19 pandemic, the maximum daily range for each diesel bus was estimated to be 200 km – well-under the current advertised 240 mile or 320 km range of an electric transit bus [2]. These promising benefits along with an aging diesel bus fleet drove the Government of Bermuda to pursue electrification of its public transit system.

1.2 Electrifying Bermuda's Public Transport

Bermuda embarked on a journey to transform its energy system in 2014, by focusing on both the electricity and transportation sectors. In 2018, the Government Department of Public Transportation (DPT) collaborated with RMI to launch the electrification of Bermuda's public bus fleet, making its public transport more energy efficient and the island more resistant to the impacts of climate change and geopolitical energy crises [3].

The bus electrification project has involved comprehensive technical research and analysis, a robust proposal selection process, and infrastructure planning to support the nation in pioneering public transport electrification in the region. Bermuda requires new vehicle purchases to meet certain maximum size and weight specifications in each vehicle category to ensure safety on its narrow, hilly roads, limiting the qualification of most widely available transit bus models. The Request for Proposals (RFP) process concluded with Xiamen Golden Dragon as the selected vendor for the initial deployment of 30 8.05 m (26-ft) electric buses (e-buses) [4]. As of April 2022, these buses are operating daily on the island - representing over one-third of the operating public bus fleet. This initial purchase was the first pivotal component in the nation's multiyear EV strategy, as Bermuda plans to fully electrify its public transport bus fleet by 2030.

RMI continues to support the Government of Bermuda in its nation-wide vehicle electrification initiatives, which include analyzing operational data from the buses to understand real-world performance, costs and efficiencies to ensure reliable and low-cost operations.

2 Motivation and Contemporary Work

2.1 Objective

As the e-buses were deployed and put into service, the Government of Bermuda began to assess and verify their operational characteristics. The estimated operational energy and emissions savings data from the e-buses' time in service is valuable to DPT as it seeks to expand fleet electrification and supporting charging infrastructure. This data helps to illustrate the cost savings and impact of electricity tariffs on operating costs as well as make the case for future procurements. Understanding charging cost sensitivities will support the planning process for expansion of charging depots and drive engagement with the utility to develop an electric vehicle tariff.

This study also adds value as a publicly available resource on electric transit performance, serving as a reference point for other fleet operators and entities as they embark on electrifying their fleets. It is unique in that it addresses transit electrification on an island nation with hilly terrain and regular tropical storm concerns, that has, until now, been dependent on imported fossil fuels.

2.2 Contemporary Work

For broader context on contemporary transit electrification, as of 2022, 5,269 full-size battery electric transit buses were registered in the US – a 66% increase from 2021. Additionally, 876 small e-buses, similar to those in Bermuda, also exist in the US. These are used primarily as transit buses, or within private fleets and at airports [5]. E-buses are also making an impact in other markets within the Caribbean and Latin America. In 2020, Barbados led the region by deploying 35 electric 30-foot buses from BYD in its public transport fleet [6], marking an important milestone for the Barbados National Climate Change Plan that targets carbon neutrality for the island by 2030. Increasing to 49 in 2022, this made it the largest e-bus fleet in the Caribbean [7]. Bogota, Colombia, has 889 e-buses in its Transmilenio fleet and plans to add another 596 to constitute the largest electric fleet outside China. Santiago, Chile, also has 776 e-buses in operation [8].

This study takes baseline cues from other transit electrification initiatives undertaken by the US Department of Energy's National Renewable Energy Laboratory (NREL) and transit agencies in California, India, and Barbados. Technical analyses carried out by NREL and RMI India, as mentioned below, serve as examples of similar results observed in other geographies and in fleets of different scales.

Foothill Transit in Southern California collaborated with the California Air Resources Board and NREL to evaluate the performance of their fleet of over 30 battery electric transit buses. NREL collected data for several e-bus models at two different locations beginning in 2017 through 2020, and provided a summary of results for several categories of data. Their results indicate that the 35-to-40-foot buses achieved between 1.90 and 2.15 kwh per mile in fuel economy, equivalent to 1.18 and 1.34 kWh per km [9]. The overall cost per mile to fuel these buses ranged between $0.42 and $0.45 per mile ($0.26 to $0.28 per km). In comparison, the buses in Bermuda cost $0.40 per mile to fuel.

NREL also reported a financial analysis of e-buses using their Vehicle and Infrastructure Cash-Flow Evaluation (VICE) model for battery electric buses, to determine which fleets would yield a positive economic return on electrification given varying parameters. Within this, the baseline e-bus efficiency used was 1.82 kWh per mile (1.13 kWh per km), an average of 40-ft bus Altoona testing results for Proterra, BYD, and Nova models [10]. This is lower than the fuel economy between 0.67 and 0.79 kWh per km observed in the buses in Bermuda as shown later in this document. The buses in Bermuda are smaller than the transit buses referred to in the NREL study at 26-ft, and so can be expected to be more efficient due to their size.

The city of Pune, India, is another leading example of an early adopter of electric public transport. Pune's public transport agency, Pune Mahanagar Parivahan Mahamandal Limited (PMPML), currently operates one of the largest public bus fleets in India. 220 e-buses are currently operational in its fleet of 2,169 buses with another 430 remaining to be procured [11]. RMI India's analysis shows that, with government incentives, the total cost of owning these 12-metre air-conditioned e-buses is 15 percent lower than diesel. The Total Cost of Ownership (TCO) of these buses over a 10-year lifetime is equivalent to $0.68 per km, including capital and maintenance costs as well as the amortized cost of supporting infrastructure. Additionally, the study shows that the planned 650 e-buses in PMPML's fleet would avoid 96,000 tons of CO2 emissions over their lifetime and 1.2 tons of local PM2.5 pollution.

3 Data and Methodology

3.1 Data Collection

This project required data to be collected from multiple locations and sources, pertaining to both the charging infrastructure and vehicles themselves. The following data sources were used in the analysis:

1. Charging instance data from the SSE charging management portal
2. Vehicle odometer data from driver logs at bus depots
3. Utility bills from each of the three charging locations
4. Bus roster and job information from actual runs carried by buses

Of these sources, the charging instance data from the SSE portal and the odometer data from driver logs form the analytical foundation of this study.

Charging Instance Data: The e-buses charge at 3 depot locations using 10 total dual port chargers. The main bus depot is located at DPT headquarters in Devonshire and has 2 60kW chargers, while the other 2 charging stations are located at the two ends of the archipelago at St. George's and the Royal Naval Dockyard, with 4 chargers located at each depot. These locations are mapped in Figure 1. The chargers are connected to a central online data management portal offered by the manufacturer that provides real time status updates as well as detailed charging instance information including time, duration, start and end state of charge (SOC), and total power dispensed. The electric demand at each bus charging depot is obtained from the charging portal to be summarized by time and individual buses, and finally evaluated against the applicable utility tariff.

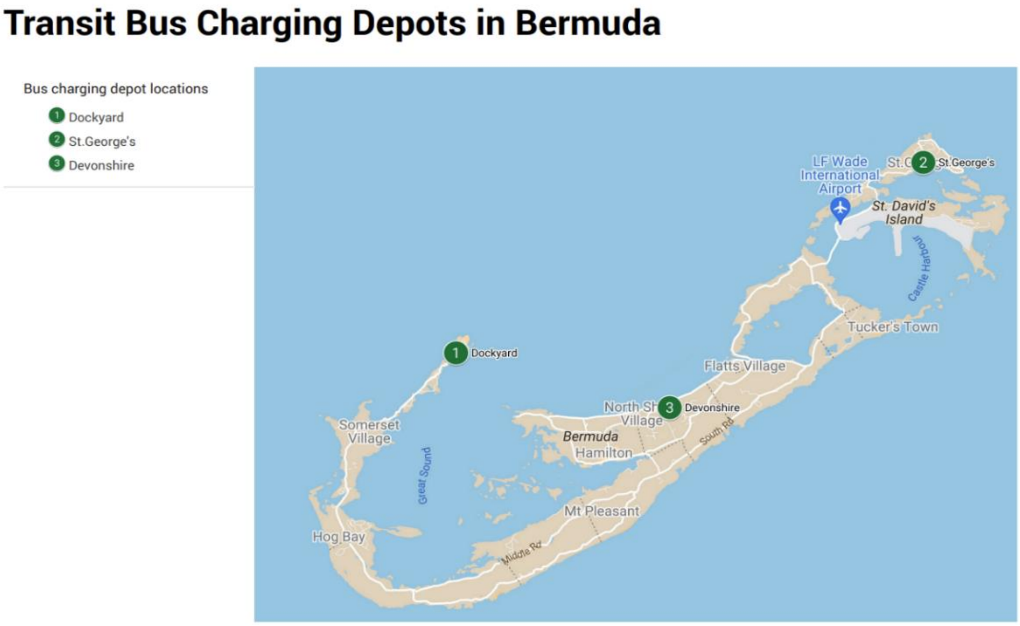

Figure 1: Transit bus charging depot locations in Bermuda.

Vehicle Odometer Logs: Operating mileage is logged as odometer readings by operators at the central bus depots at the end or beginning of trips for individual buses. These readings contain time stamps and, occasionally, include detail on the associated time the bus is put on and taken off a charger and the start and end SOC. This data is used to calculate monthly mileage for individual buses. The time stamps are further matched with the charging instance data to calculate bus charging demand over specified time periods. The mileage and charging demand are ultimately used to derive real-world kWh per km fuel efficiency and monthly fuel cost savings from electrified transit, as explored later in this document.

Figure 2: The CCS2 DC charging stations by SSE International at a bus depot in Bermuda.

3.2 Methodology

This study is structured into an exploratory analysis followed by four estimation models. The two foundational data sources are explored and evaluated to calculate mileage and electric charging demand for specified time periods and individual buses. These metrics are then used within estimation models to calculate fuel economy, electricity cost, fuel cost savings, and avoided emissions.

3.2.1 Vehicle Mileage

As previously mentioned, the vehicle mileage logs are used to calculate the distance traveled for each bus in the fleet. This data is summarized into monthly and total mileage for individual buses as well as the 30-bus fleet. Fleet level totals are used more widely in the analysis as they are more accurate representations of bus utilization than individual buses due to possible discrepancies in manual data logging. The average single bus mileage from fleet level totals is corroborated by comparison to odometer data for the most frequently logged buses to identify any discrepancies.

The 30 e-buses were known to run a full schedule daily for the first 10 months (April 2022 to February 2023). Odometer data logs suggest an average bus traveled 4100 km monthly over these first 10 months of operation. 70 percent of the buses traveled over 4000 km every month, resulting in an estimated typical daily mileage at 130 to 160 km per bus.

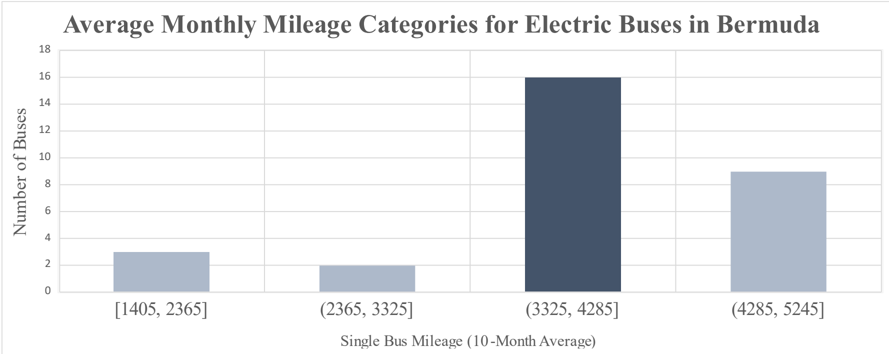

Figure 3: Frequency Distribution of Average Monthly Transit Bus Mileage in Bermuda

3.2.2 Charging Demand and Electricity Cost Estimation

The charging instance data as previously outlined is used to estimate the monthly cost of charging from the total electric load at each depot subjected to the applicable utility tariff in the Small Commercial rate class. The load and effective electricity cost at each depot is then compared with actual utility bills from these locations to corroborate and identify any discrepancies. The impact of tariff structure on charging cost is evaluated by applying a demand rate-based tariff to the same charging load to explore the sensitivity of these costs to demand charges. Given DPT's plans to scale its fleet and charging infrastructure, an expanded charging scenario for a larger capacity depot is explored. This helps identify the optimal charging tariff for high-capacity charging depots, as well as when managed charging can play a bigger role in lowering costs.

3.2.3 Fuel Economy

Xiamen Golden Dragon provided a guaranteed fuel efficiency of 1 kWh per km on average, annually. The TCO analysis carried out to support the procurement included 0.8 kWh per km for tractive power alone in the winter months with an additional 0.3 kWh per km air conditioning load in the summer months. The following approaches were used with real-world operational data from the buses to estimate and compare the experienced fuel economy in diverse time frames and trip distances.

1. Monthly mileage from odometer logs along with total monthly electric demand at charging depots was used to calculate kWh per km fuel efficiency. This was summarized across individual buses as well as monthly fleet totals to increase sample size for the analysis.
2. Odometer logs were matched with relevant charging instances from the portal data to calculate the fuel economy from km traveled and kWh consumed during those time periods.
3. Operators were requested to evaluate a set of trips in real time, logging data on start and end SOC associated with specific jobs or bus trips. This data was used to calculate the kWh per km fuel economy on these trips of varying distances and durations.

3.2.4 Fuel Costs and Savings

Fuel costs were calculated for the e-buses using the estimated mileage, average fuel economy, and electricity costs from the models mentioned above. Charging load was not used for this calculation due to incomplete data availability in some winter months (November, December, January) due to tropical storms and technical connectivity disruptions to the charging portal. The total monthly electric demand (kWh) and associated representative diesel usage were calculated for the estimated mileage. This along with the unit costs of diesel and electricity, as displayed in Table 1, were used to calculate fuel cost savings from the e-buses.

Table 1: Input values used to calculate electricity and diesel fuel costs.

	Fuel Economy		Fuel Cost		Operational Fuel Cost	
Diesel	0.33	L/km	1.59	$/L	0.5	$/km
Electricity	0.79	kWh/km	0.5	$/kWh	0.4	$/km

The average diesel bus fuel economy as observed in the MAN buses in Bermuda's fleet was used for this calculation. An updated average electric bus fuel economy as estimated from the findings in the next section was used in place of the manufacturer estimated 1 kWh per km to calculate these results. Diesel fuel costs as experienced in 2022 were used, reflecting market conditions and any discounts relevant to the government. Bermuda has some of the highest electricity rates observed globally. A typical local commercial electricity cost of $0.50 per kWh was used, reflecting the actual experienced average cost at all three charging locations. These numbers are also used to calculate fossil fuel usage avoided in liters of diesel, not including the fuel oil used by BELCO to generate electricity, realized through the electrification of public transport.

3.2.5 Emissions Savings and Air Quality Benefits

Emission factors for diesel fuel and the local electric grid in Bermuda were used to calculate the emissions saved by electrification of the public bus fleet. These values are outlined in Table 2. All emission factors are per unit of energy consumed. A standard kgCO2 per L emission factor was used for transportation diesel fuel, and the grid factor for oil-based electricity generation was used for electric fuel. These factors are applied to the electric and diesel fuel demand as calculated in the previous step to estimate roadside emissions avoided. The magnitude of these avoided emissions is further illustrated by comparison with the annual emissions of a typical passenger car in Bermuda.

Table 2: Emission factors used to calculate emissions and air quality benefits of electric buses in Bermuda.

Emission Factors and Metrics		
Diesel fuel emission factor	2.68	kgCO2/L [12]
Bermuda grid emission factor	0.71	kgCO2/kWh
Average annual emissions of an average car in Bermuda	1824	kgCO2
Diesel exhaust NOx emission factor	1.45	g/km [13]
Diesel exhaust PM2.5 emission factor	0.016	g/km [13]

The air quality benefits of electric transport go beyond carbon emissions. To illustrate this, two significant local air pollutants were quantified – Nitrous Oxides (NOx) and fine Particulate Matter (PM2.5, or soot). These emission factors, as shown in the table, were used to estimate the amount of local air pollution from diesel exhaust avoided by the e-buses.

4 Results and Observations

The data sources and calculation models described above were used to arrive at the following four categories of results.

4.1 Fuel Efficiency

The average monthly fuel efficiency over the initial months of operation as calculated from the bus odometer logs and total charging demand at the charging stations is shown in Figure 4. In months with high utilization of buses (i.e., high recorded mileage), the efficiency was observed to be high as well, as can be expected. The linear trend puts the typical efficiency across six months at 0.80 kWh per km in the summer months and closer to 0.60 kWh per km in the winter months. The utilization and recorded mileage of the buses increased gradually as they were incrementally put into service over the summer after introduction in April. In late August and September, the buses were switched over to serve the winter roster which increased the number of runs in a day due to added utilization such as for school runs, explaining the increase in recorded mileage.

It is important to note that the charging portal data experienced interruptions in connectivity in September due to tropical storms, and again in November due to a technical fault. This explains the significant increase in efficiency in September as the total charging demand reported in the data portal underestimates the actual energy used in that month.

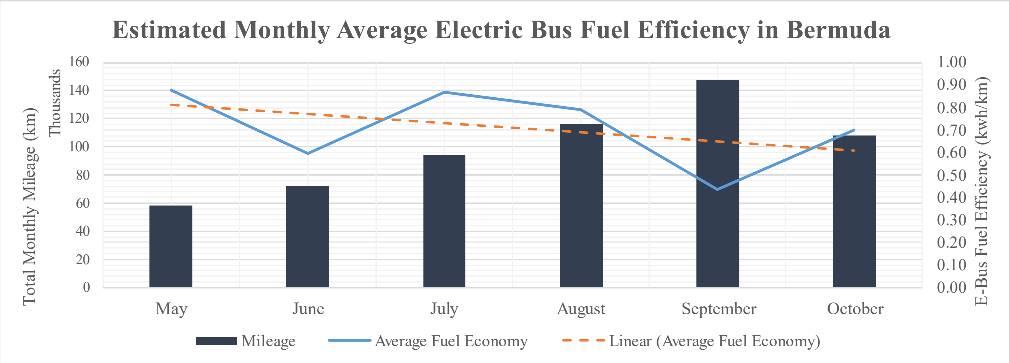

Figure 4: Estimated monthly average electric bus fuel efficiency in Bermuda.

The impact of seasonal air-conditioning load on the efficiency of the buses was studied in two parts. For the summer, operational samples from a set of buses in July were evaluated. These data points use odometer logs and the corresponding charging instances between those log dates. Some samples were collected from actual runs completed by the buses as part of their roster, using the length of the trips completed and the start and end battery percentages. The resultant sampled fuel efficiencies are displayed in Table 3.

Table 3: Sampled electric transit bus summer fuel efficiencies in Bermuda.

Bus No.	Sampled Distance (km)	Electricity Demand (kWh)	Fuel Efficiency (kWh/km)
2204	3189	2632	0.83
2222	1501	1088	0.72
2221	4337	3604	0.83
2210	3286	2255	0.69
2215	585	507	0.87
2210	103	79	0.77
2203	84	65	0.77
2202	108	86	0.80
2206	92	72	0.78
2207	94	77	0.82
		Average Bus Efficiency (kWh/km)	0.79

The average summer fuel efficiency as calculated from these samples is 0.79 kWh per km, which is aligned with the trend observed in the monthly averages. In the winter months, a directed effort was made to log start and end battery percentages associated with bus trips according to the roster schedule over three days in February. These data points were used to calculate the associated fuel efficiency similar to that for the summer months. The distribution of the resultant efficiencies is displayed in Figure 5. The typical calculated efficiency ranges from 0.67 to 0.74 kWh per km, with the average being 0.67 kWh per km.

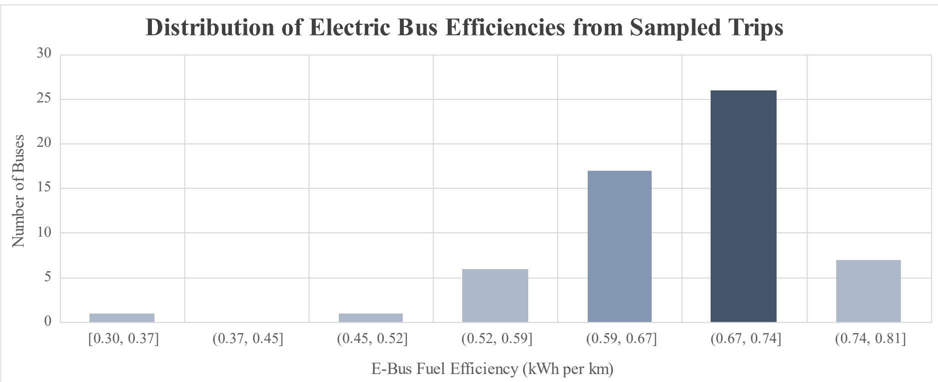

Figure 5: Frequency distribution of electric transit bus winter fuel efficiencies from sampled trips in Bermuda.

These results also indicate that up to 0.12 kWh per km can be attributed to air-conditioning load. In comparison, a 0.30 kWh per km A/C load was used in the TCO analysis to support the procurement decision.

In conclusion, the buses are estimated to be outperforming the manufacturer estimated efficiency. The buses are estimated to be 28% more efficient than expected in the summer months and 16% more in the winter. The reasons behind this could be multifold. The average daytime temperatures in Bermuda are fairly mild, ranging from the high 60s Fahrenheit in the winter in February to the low 80s in the summer in July and August. Given this range, the buses may be using A/C at a lower intensity and for shorter durations than was earlier expected, as indicated by the 0.18 kWh per km lower observed air-conditioning load. They may also be carrying less payload than was assumed by the manufacturer. Additionally, driving patterns in Bermuda may also have contributed to better performance of the electric motors, such as lower speeds and shorter trips.

As Bermuda must frequently plan for electricity service disruptions due to tropical storms, DPT is also considering resilience strategies for back up and distributed power generation such as battery storage and onsite solar power. This is also expected to reduce the cost of charging as well as increase overall emissions avoided by the e-bus fleet by increasing the share of low-cost and low-carbon electricity.

4.2 Electricity Cost

The buses charge at three spatially separate locations on the island, namely the St. George's, Dockyard, and Devonshire bus depots, as depicted in Figure 1. These charging sites are subject to the local utility, Bermuda Electric Light Company's (BELCO) Small Commercial rate class tariff. These chargers are connected to a central data management portal that provides real time status updates as well as detailed charging instance information including time, duration, start and end battery level, and total power dispensed. The electric demand at each bus charging depot as obtained from this charging portal was summarized and evaluated against BELCO's Small Commercial tariff to arrive at a $ per kWh effective electricity cost. These monthly costs are summarized in Figure 6.

The average cost of electricity in Bermuda ranges between $0.40 and $0.50 per kWh. Across the three depots, the effective cost of charging ranges between $0.49 and $0.52 per kWh across the first eight months of operation. The cost for months wherein stations experience a very low billed demand (such as at St. George's since the chargers came online only in mid-June) is higher due to less kWh being consumed for the same facilities charge. Additionally, months with high billed demand can lead to a higher effective cost as the energy rates within the Small Commercial rate class increase progressively with every 1000 and 5000 kWh of billed electric demand.

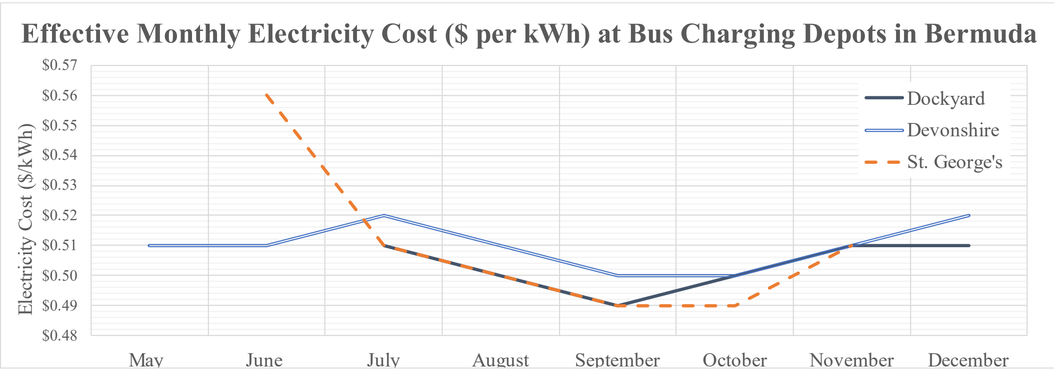

Figure 6: Effective monthly charging cost ($ per kWh) at bus charging depot locations in Bermuda.

As the Small Commercial rate class is an energy rate-based tariff, it would be expected that the overall cost of charging would be lower than a comparable demand rate tariff as this avoids the demand charges commonly considered notorious for increasing the cost of electric vehicle charging. However, as depicted in Figure 7, this is not always the case. Energy rate-based tariffs are favorable only when the hourly peak demand (kW) of a load is relatively high and the total consumed energy (kWh) is not. As these charging stations only have two to four 60 kW chargers installed leading to a 240 kW peak demand at the most, compared to over 40,000 kWh in total demand, this benefit is not realized. In the example of the Devonshire bus depot in Bermuda, switching from the Small Commercial rate class to the Demand A tariff would save anywhere between 3 to 9 cents per kWh (~10-20%), leading up to $4000 in monthly electricity cost savings.

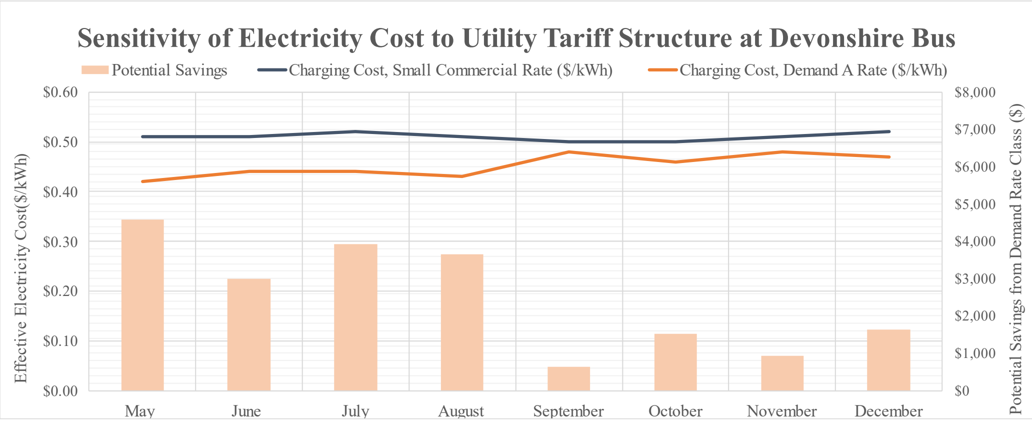

Figure 7: Electricity cost savings potential due to different utility tariff structures at bus charging depot.

This result, however, changes as the scale of charging capacity at the depot increases. As Bermuda plans to increase the size of its charging depots to serve a growing e-bus fleet, it is important to understand how an increase in both total charging demand and hourly peak demand will affect charging costs. Charging costs scenarios for 20 60 kW two-port chargers serving 70 buses at Devonshire in the future are explored in Figure 8. The Small Commercial rate class would incur a cost of $0.52 per kWh, similar to what was noted above. If all 20 chargers are used by 40 buses plugged in at the same time, the hourly peak demand would lead to a higher cost of $0.56 per kWh. This, however, does not simply indicate that the small commercial class would be more economical; rather, it points to a need for managed or optimized charging. If the same buses were charged at varying times staggered over a period of 8 hours through the day to limit the number of chargers in use in the same hour, the peak demand would be reduced, leading to a 10% decrease in charging costs. Furthermore, if charging was staggered over 12 hours in a day, planned around service schedules, the effective charging cost would decrease to $0.45 per kWh – 14% or $13,000 in potential monthly savings.

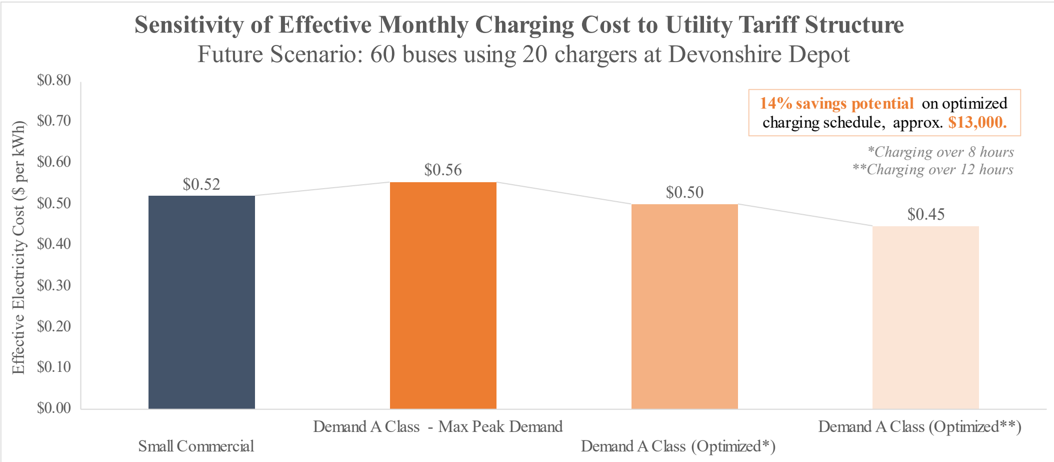

Figure 8: Effect of different utility tariff structures and managed charging on effective charging cost.

The charging cost of e-buses can be reduced by switching to the most appropriate utility tariff which may not necessarily be the energy rate-based tariff, as commonly expected. Further, as charging depots scale in capacity and size of fleet served, savings can be maximized through optimized and managed charging.

4.3 Fuel Cost Savings

Having established the fuel economy and effective charging cost of these buses, the next step is estimating and understanding the economic benefits of e-buses compared to their diesel counterparts. Over the first 10 months of operation, the 30 e-buses have saved $147,000 in fuel costs alone. This does not include any avoided maintenance, repair, or parts costs, though those would certainly add to the cost savings experienced with e-buses. As indicated in Figure 9, on average, the current electric models in the fleet save DPT about

$15,000 every month, with an individual bus savings of about $500. These fuel cost savings from the initial fleet of 30 buses have already covered the entire purchase cost of a single bus, with the landed cost of $132,000, in less than a year of operation. As the next round of 40 buses is added to the fleet this year, by 2024, the 70-bus fleet will be recovering the capital cost of more than 3 buses every year. It is important to note that the capital cost of these buses was less than that of the comparable MAN diesel buses in operation in Bermuda, and so there is no capital premium to be recovered as is often typical of electrification projects.

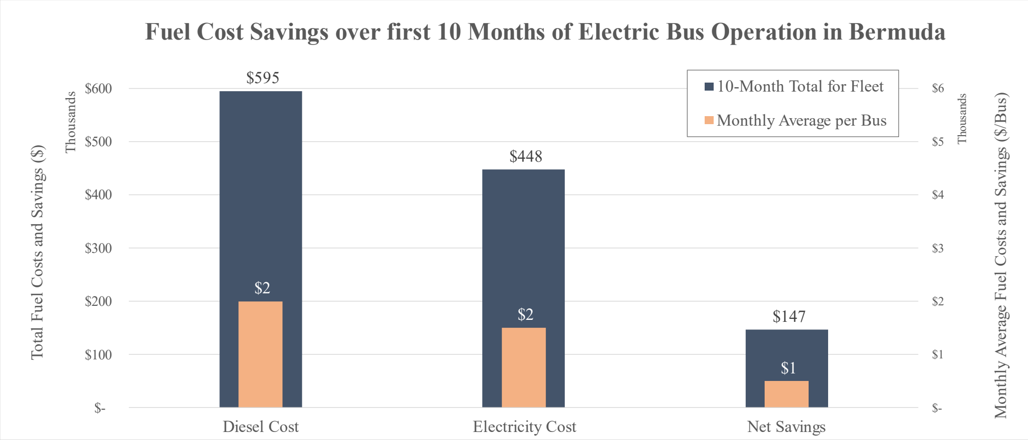

Figure 9: Fuel cost savings over first 10 months of electric bus operation in Bermuda.

These savings vary by month due to operational and seasonal differences. The highest cost savings are estimated in September due to high utilization of the buses. Even from conservative estimates, these calculations suggest that the current 30-bus electric fleet can save more than $10,000 in any given month.

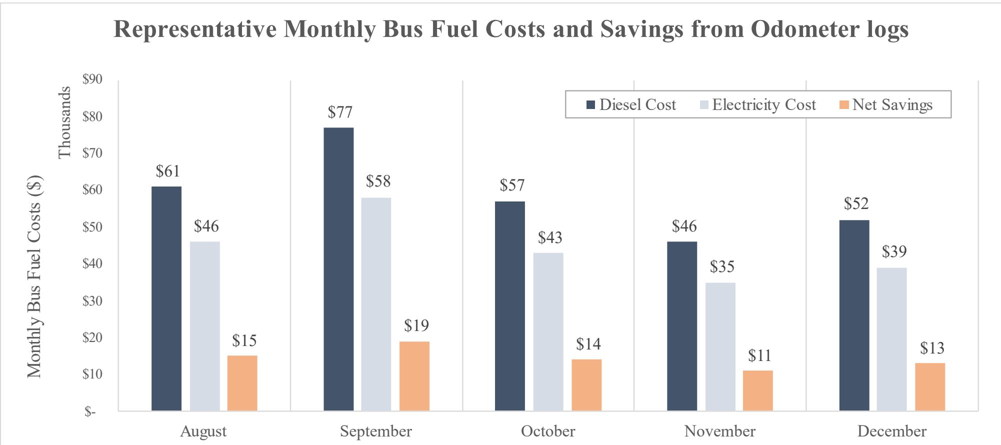

Figure 10: Monthly fuel costs and savings for electric buses in Bermuda.

It is important to note that these estimates include static diesel and electricity unit costs. The cost of diesel fuel on the island as of summer 2022 was used to calculate fuel costs for the first 10 months of analogous ICE bus operations, while a representative $0.50 per kWh electricity cost was used to calculate charging costs. Additionally, the previously mentioned 0.79 kWh per km average fuel economy as experience in the first four summer months was used for these estimates. The real winter fuel economy, as noted previously, is considerably greater at closer to 0.67 kWh per km.

4.4 Emissions Savings

Perhaps the most important case to be made for e-buses, aside from their proven favorable economics, lies in emissions savings and avoided fossil fuel usage. Diesel exhaust has been classified as carcinogenic by the World Health Organization, and research has demonstrated that its constituent Particulate Matter (PM2.5) and Nitrous Oxides (NOx) emissions are harmful to humans even at low concentrations [14]. PM2.5

contributes to respiratory and cardiovascular illnesses, and it can result in premature death. NOx exposure is particularly harmful as it has been directly linked to the development of asthma, and it aids the creation of ground-level ozone. While everyone is susceptible to the harmful effects of air pollution, children, elderly, and individuals with preexisting respiratory conditions are disproportionately affected. E-buses avoid roadside exhaust completely, providing health benefits to the immediate community they operate in. In Bermuda, these 30 buses are estimated to avoid 164 kg of NOx and 2 kg of PM2.5 every month. As the fleet grows, these air quality benefits can be expected to more than double by the end of 2023.

The e-buses emit 37% less carbon dioxide emissions per km traveled than comparable diesel buses. This is due to the greater efficiency of electric motors than ICE engines, which provide considerable environmental benefit despite Bermuda's oil-fueled electric grid. Over the first 10 months, the 30 buses have saved approximately 367 Tons of CO_2 – equivalent to the annual emissions from 200 personal cars in Bermuda. Over the course of a year, with the 30 e-buses currently in operation, this fleet will have avoided 440 Tons of CO_2, offsetting annual CO2 emissions from 240 typical private cars in Bermuda. As the fleet grows with the imminent arrival of the next 40 buses later in 2023, the emissions savings will scale higher as well. An operational fleet of 70 e-buses in Bermuda will save the island over 1000 Tons in CO_2 emissions, comparable to the annual emissions from over 560 cars which make up 3% of all private road vehicles on the island.

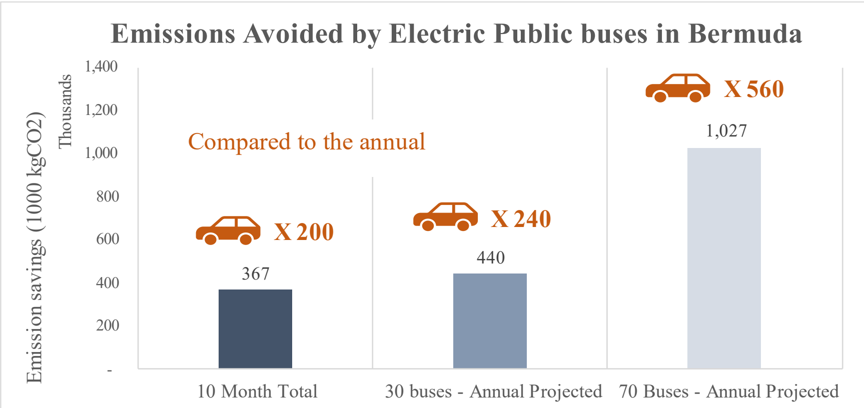

Figure 11: Emissions savings from electric public buses in Bermuda.

In addition to emissions reductions, the buses have helped reduce the consumption of imported liquid fossil fuels. Through February 2023, the fleet has avoided the consumption of 375,000 liters of diesel fuel – equivalent to the jet fuel burned in three-and-half seven-hour transatlantic flights. As BELCO's local generation capacity still utilizes fuel oil as the primary generation source, the energy used to power these buses is not completely free from fossil fuels. As more renewable generation comes online, electric transportation will help reduce Bermuda's dependence on imported fossil fuels for energy and reduce associated emissions even further.

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