Vermont Electric School and Transit Bus Pilot Program Report

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Waypoints

- Project Background
- Evaluation Goals and Methods
- School Bus Performance Results
- Key Takeaways

VW Settlement Background

- The unlawful actions by Volkswagen (VW) resulted in drastic increases in NOx emissions from their light duty diesel engines, of up to 40 times the EPA standard
- VW – EPA Partial Settlements: $2.9 billion Environmental Mitigation Trust
- Vermont is a ***beneficiary*** of the Trust - **$18.7 million** allocation

VW Settlement Background

- Consent decree requires that the goal of each Eligible Mitigation Action authorized by the Trust shall be to achieve reductions of NOx emissions in the United States.
- Vermont had access to 1/3 of funding in the first year, 2/3 in the second year, and total allocation in third year. We have 10 years to obligate 80% of the allocation or the money reverts back to Trust.
- Other relief provided to Vermonters: Consumer buy-back program for affected vehicle owners; $4.2M State Environmental Settlement.

Program Goals

- Engage partners across the state, maximize the use of available EMT funds in an effective way and meet specific criteria and priorities. These include:
  - **Testing and evaluating the viability of electric buses in Vermont** as replacements for diesel-powered buses, across a range of route conditions, geographical areas, and types of weather.
  - **Maximizing air quality benefits** by considering the engine model year and remaining vehicle life for the buses that are replaced, as well as by prioritizing areas that are disproportionately impacted by air contaminants in the state.
  - **Familiarizing Vermonters** from different communities, demographic profiles, and geographic regions to electric bus technologies.


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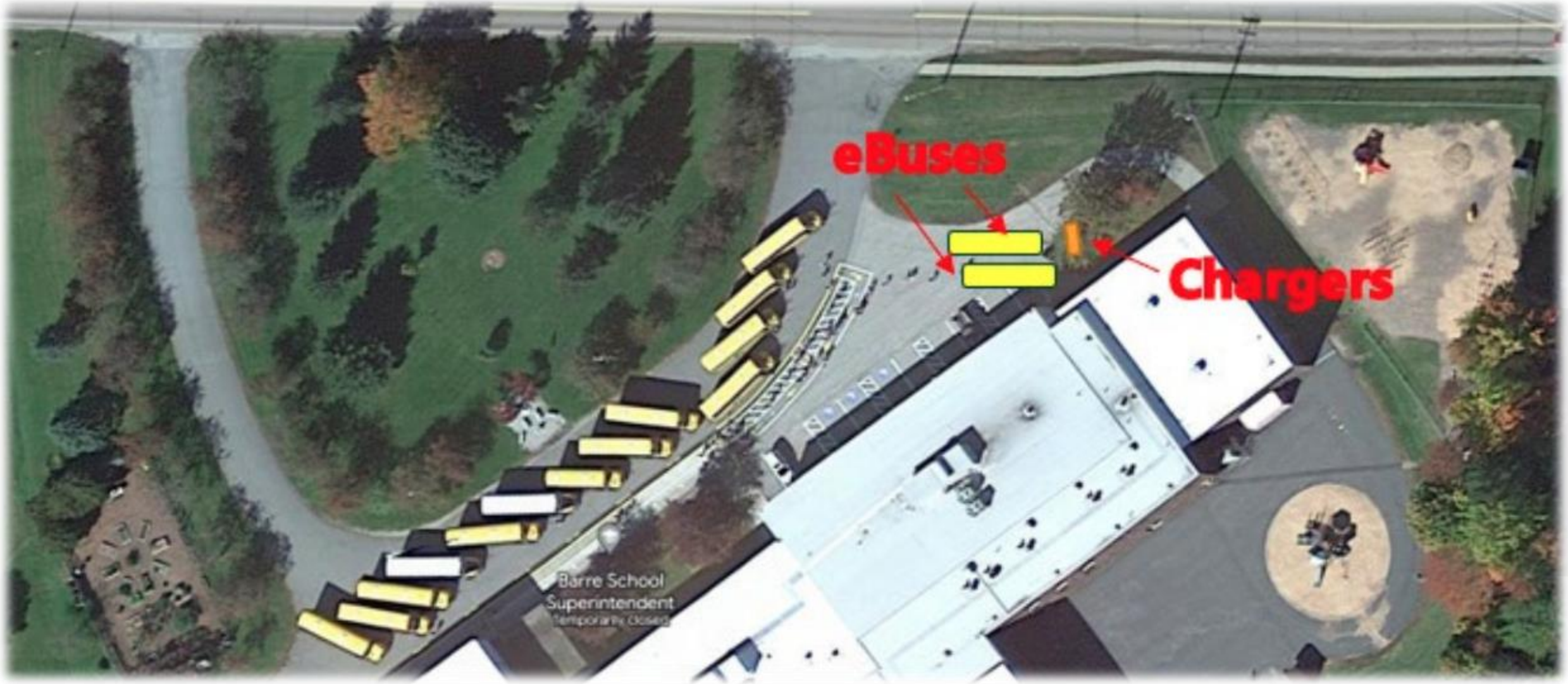
CHAMPLAIN VALLEY SCHOOL DISTRICT

Project partner	Selected bus vendor and type	Selected EVSE vendor and type
FWSU	(2) 2021 Blue Bird 77 passenger Type C 120-mile range	Nuvve charging station: Level 2, 16.6 KW (2 units)
CVSD	2021 77-passenger Lion C 100-mile range 2021 77-passenger Lion C 125-mile range	ABB Terra Wallbox: DC, 22.5 KW (2 units)
BUUSD/STA	(2) 2021 77-passenger Lion C 100-mile range	ABB Terra Wallbox: DC, 24 KW (2 units) (Temporary installation of (2) Delta wall-mounted DC 24 KW chargers which remained in place for the duration of the project due to issues with the ABBs)

Site Layout - BUUSD



Site Layout - CVSD

Site Layout - FWSU

Performance Evaluation Methodology

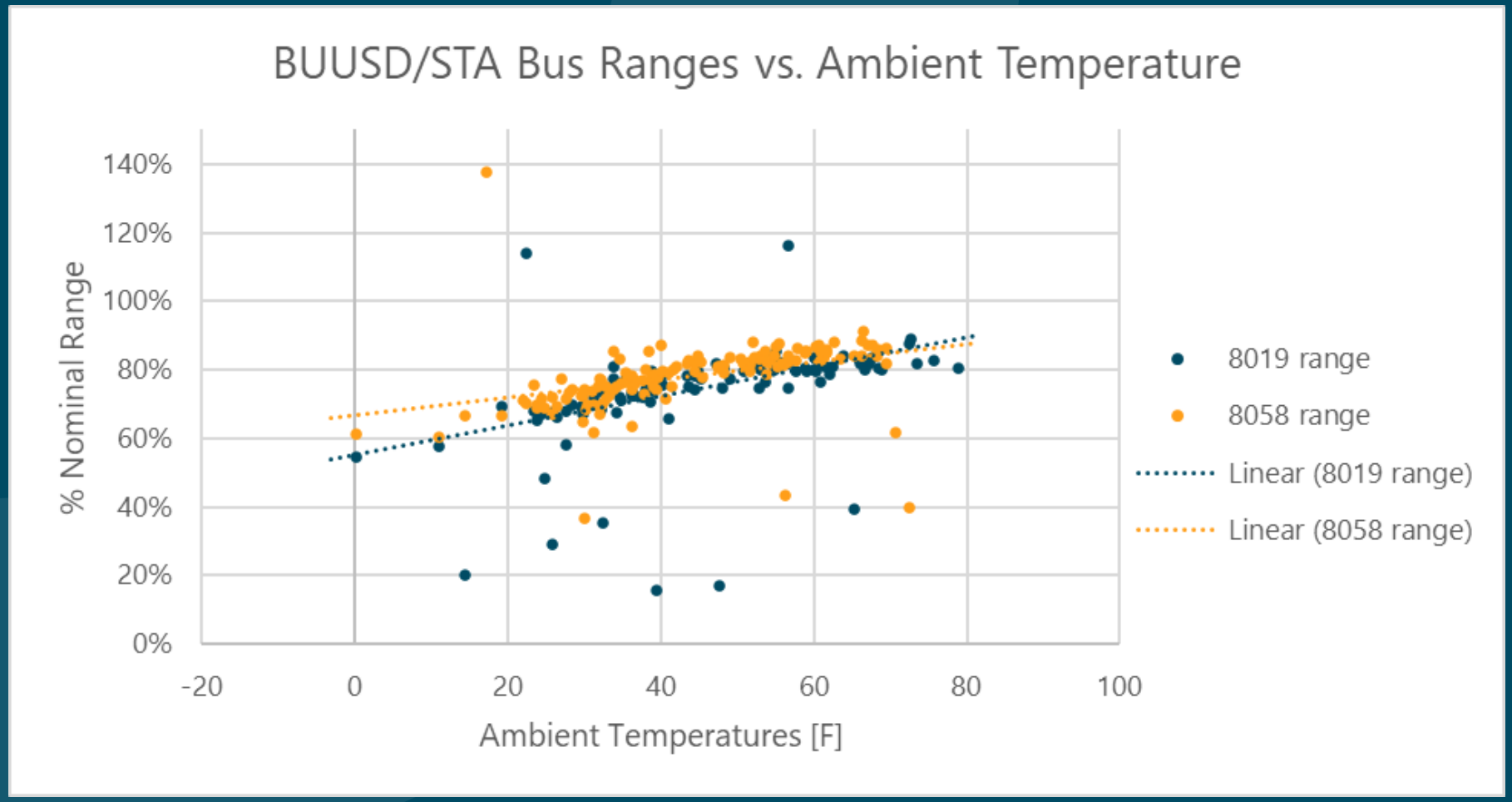
Sources

- A full year of data capture
- Data sources include:
  - Driver Logs
  - Maintenance Logs
  - Telematics
  - AMI data
  - Submeter data
  - Vehicle Telematics
  - NOAA weather
  - VTrans fuel price history

Parameters

- Mileage
- kWh and kW (1-minute intervals)
- State of Charge (SOC)
- Diesel used (for aux. heater)
- In-service rate
- Maintenance issues
- Ambient Temperatures

Impacts of Temperature on Range



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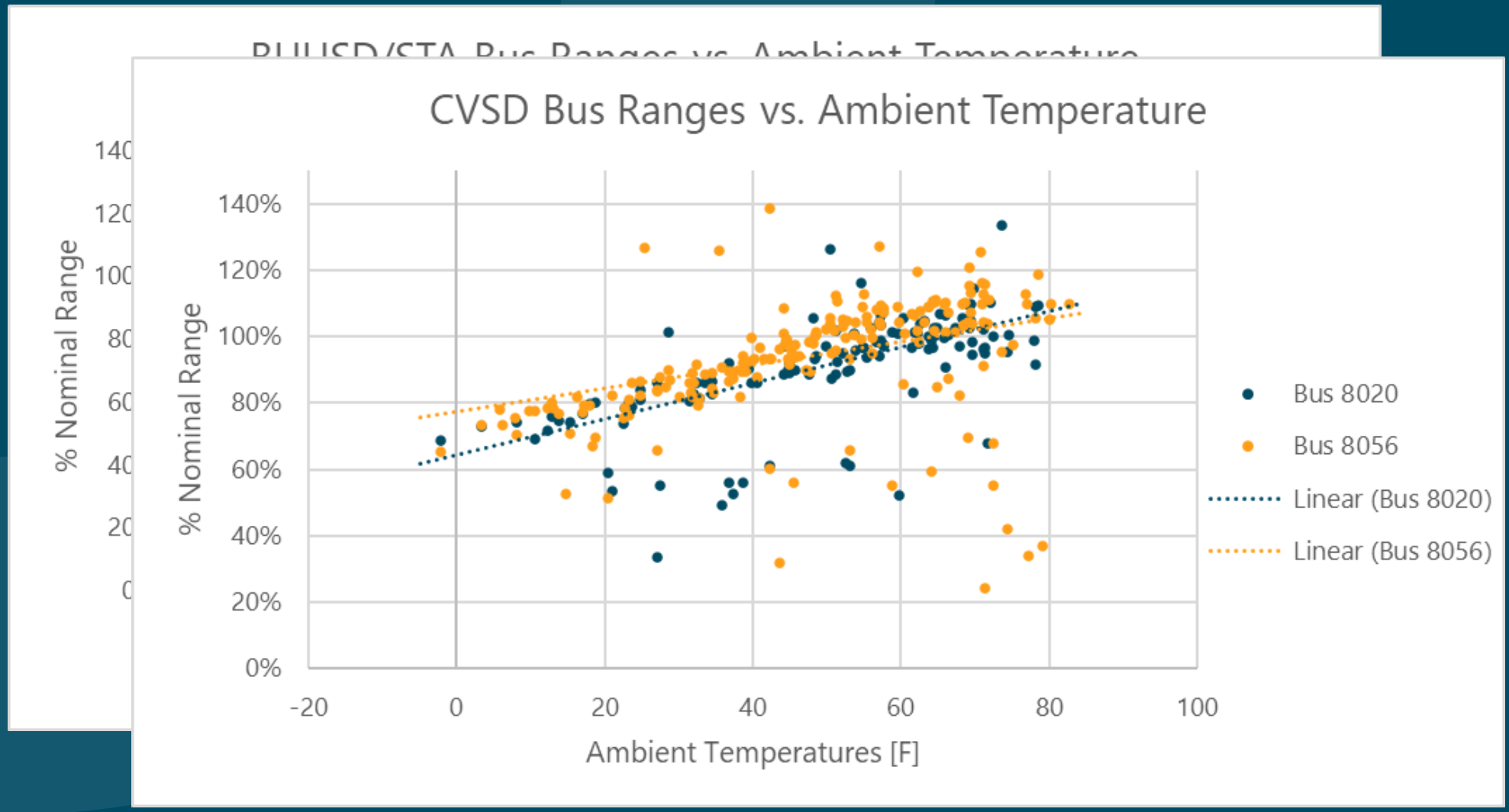

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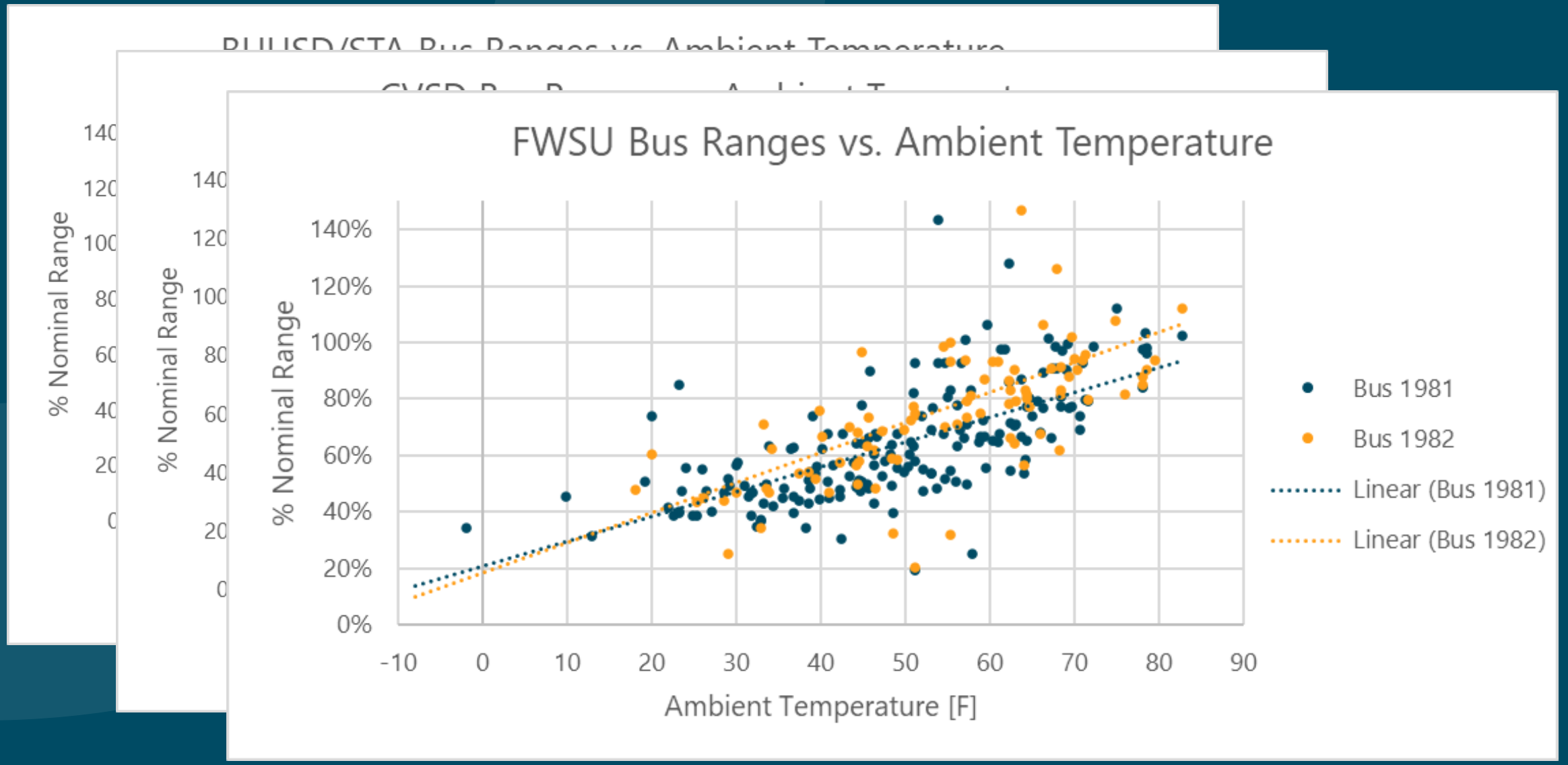


Performance Results – School Buses

	In-service rate [%]	Annual miles [mi]	Average daily trip total [mi]	Average real-world range between charges [mi]	Average efficiency [kWh/mi]	Average efficiency - MPG diesel equivalent [MPGe] ***
BUUSD/STA - Lion Bus 8019	60%	3991	37	74	2.1	16.3
BUUSD/STA - Lion Bus 8058	86%	5443	32	78	2.0	17.1
CVSD - Lion Bus 8020	73%	9988	75	101**	1.7	20.2
CVSD - Lion Bus 8056	100%	9998	51	94	1.8	19.1
FWSU - Blue Bird Bus 1981*	57%	5468	49	77	2.4	14.4
FWSU - Blue Bird Bus 1982*	29%	2507	44	89	2.5	13.7

* FWSU's Blue Bird buses range and efficiency values are likely overestimated. The buses had very few cold-weather data points, as they were mostly out of service during the months of January, February, and March.

** CVSD's Bus 8020 received a battery upgrade 7 months into deployment. Prior to the upgrade the real-world range was 81 miles, and after it was 132 miles. However, much of the first value's drive time included winter driving, while the latter did not.

*** Typical Type C diesel buses get a national average of 8.2 MPG according to the Argonne National Lab. Argonne National Lab Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool – https://greet.es.anl.gov/afleet_tool

Performance Results – Fuel Savings

	Average electricity costs [$/mi]***	Auxiliary heater diesel costs [$/mi]	New diesel type C bus fuel costs [$/mi]****	Savings [$/mi]
BUUSD/STA - Lion Bus 8019*	$0.36	$0.06	$0.66	$0.24
BUUSD/STA - Lion Bus 8058*	$0.34	$0.07	$0.66	$0.25
CVSD - Lion Bus 8020	$0.29	$0.05	$0.66	$0.33
CVSD - Lion Bus 8056	$0.31	$0.04	$0.66	$0.32
FWSU - Blue Bird Bus 1981**	$0.40	$0.02	$0.66	$0.24
FWSU - Blue Bird Bus 1982**	$0.43	$0.00	$0.66	$0.23

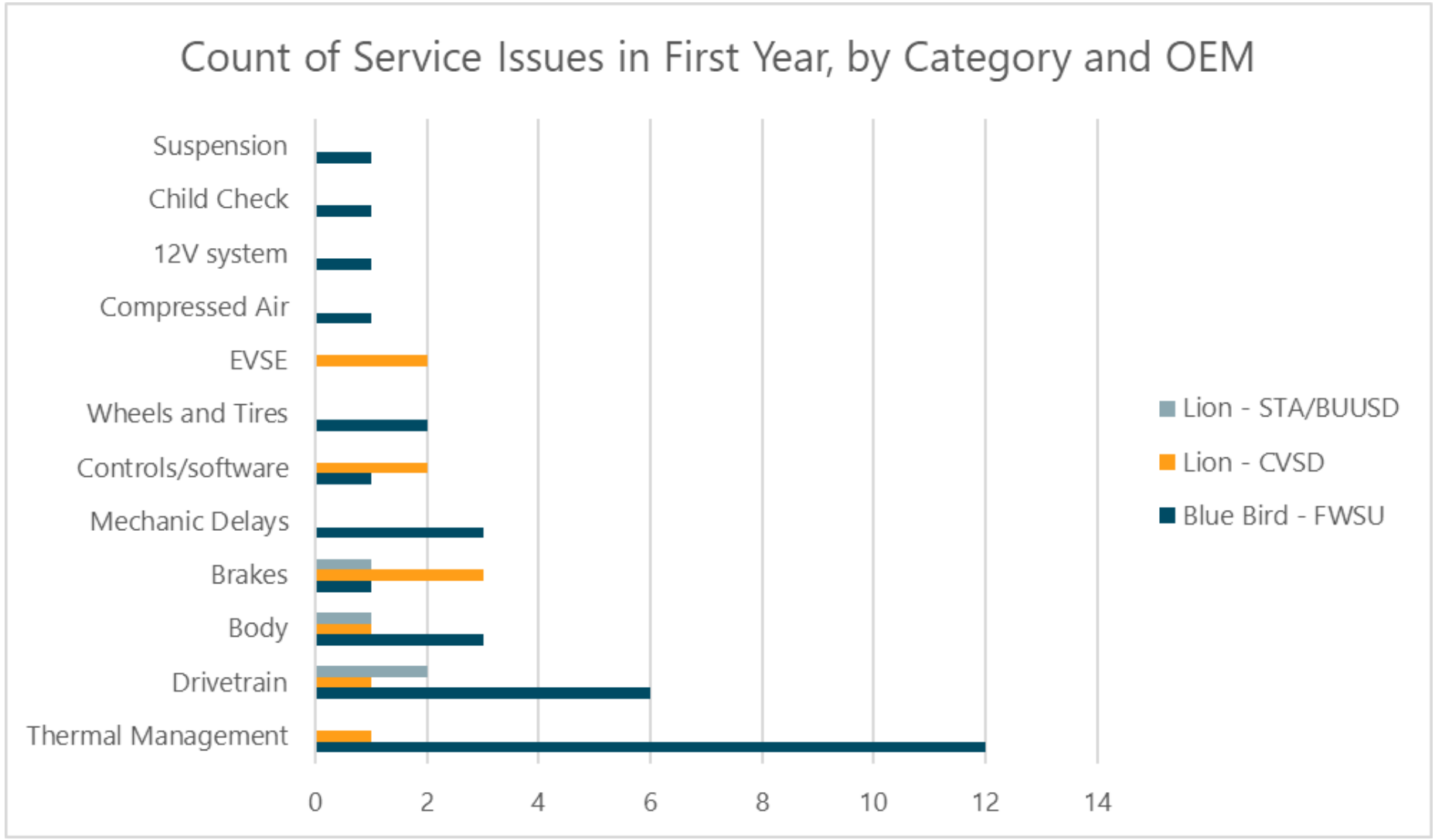
* BUUSD/STA's Lion buses were discovered to be drawing power at a 1kWh rate even after the vehicle was done charging, to govern thermal management and keep the link with the charger open. CVSD's Lion buses had the same issue, but to a lesser extent due to charger faults. Those additional loses are included in the figures above.

** FWSU's Blue Bird buses' true energy and diesel costs were significantly higher than shown here. The buses were generally in-service only during the most efficient periods of the year. Also, the auxiliary heaters on those buses were not functioning properly for the first winter they were deployed.

*** Electricity costs are based on GMP's 2021-2022 commercial Rate 6 tariff price of $0.17141/kWh - **https://greenmountainpower.com/rates/**

**** Diesel fuel costs are based on federally reported average area fuel prices seen over the evaluation period and an assumed MPG rating of 8.2 miles per gallon for a conventional diesel school bus, a figure gleaned from the Argonne National Lab AFLEET tool - **Argonne National Lab Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool - https://greet.es.anl.gov/afleet_tool**

Performance Results – Reliability

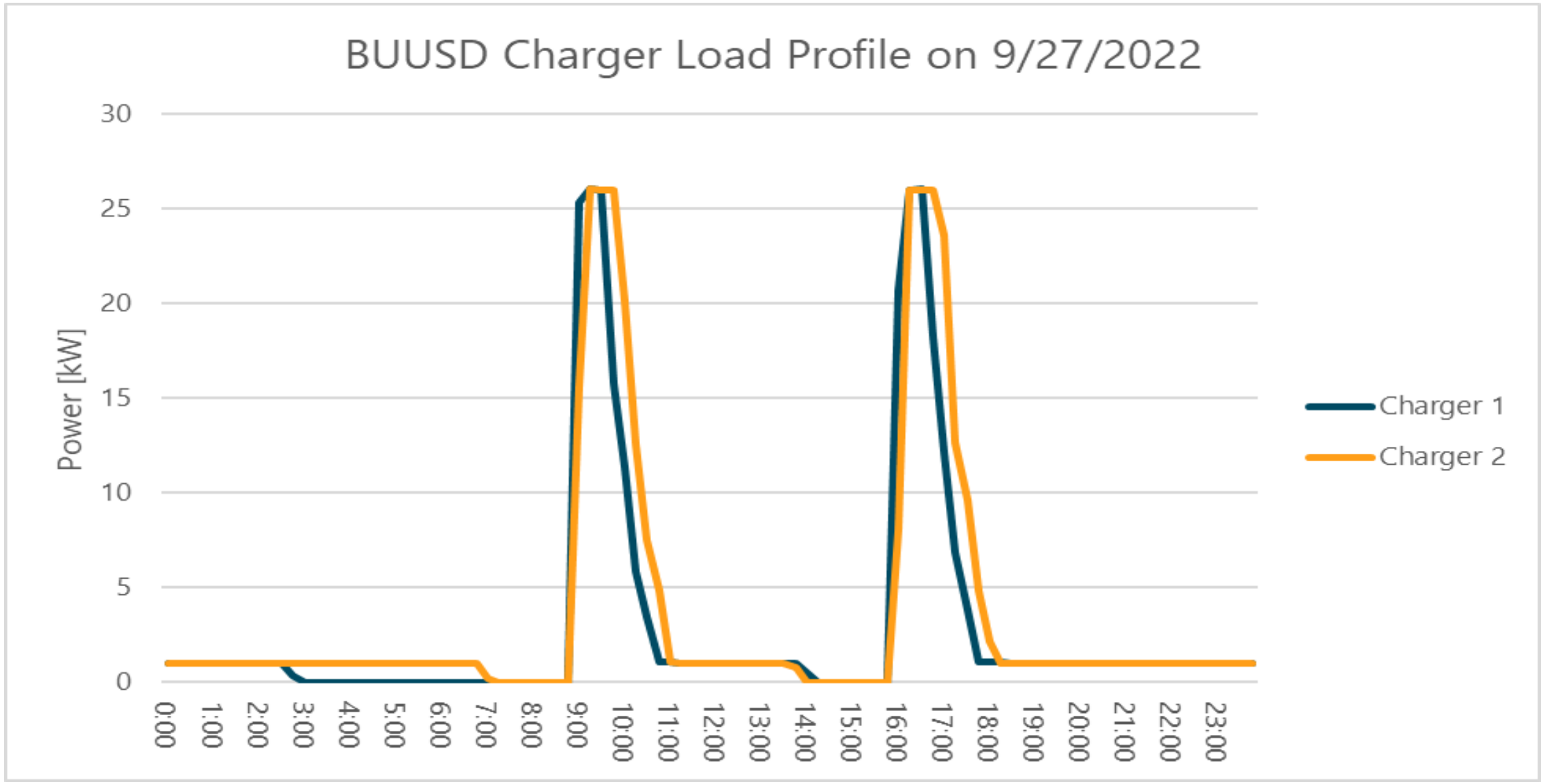


Emissions Reductions Compared to Scrapped/New Buses

ESB vs. Scrapped Bus	Normalized NOx reductions [lbs]	Normalized PM2.5 reductions [lbs]	Normalized PM10 reductions [lbs]	Normalized GHG reductions [short ton]
BUUSD/STA - Lion Bus 8019	79.5	0.3	19.9	8.3
BUUSD/STA - Lion Bus 8058	79.4	0.3	19.9	9.1
CVSD - Lion Bus 8020	153.7	9.9	11.0	11.3
CVSD - Lion Bus 8056	154.2	9.9	11.0	11.5
FWSU - Blue Bird Bus 1981	153.8	9.9	11.0	10.1
FWSU - Blue Bird Bus 1982	154.3	9.9	11.0	10.4

ESB vs. New Diesel Bus	Normalized NOx reductions [lbs]	Normalized PM2.5 reductions [lbs]	Normalized PM10 reductions [lbs]	Normalized GHG reductions [short ton]
BUUSD/STA - Lion Bus 8019	18.2	0.1	0.1	8.3
BUUSD/STA - Lion Bus 8058	18.2	0.1	0.1	9.1
CVSD - Lion Bus 8020	18.2	0.1	0.1	11.3
CVSD - Lion Bus 8056	18.3	0.1	0.1	11.5
FWSU - Blue Bird Bus 1981	18.3	0.1	0.1	10.1
FWSU - Blue Bird Bus 1982	18.4	0.1	0.2	10.4

Charging issues



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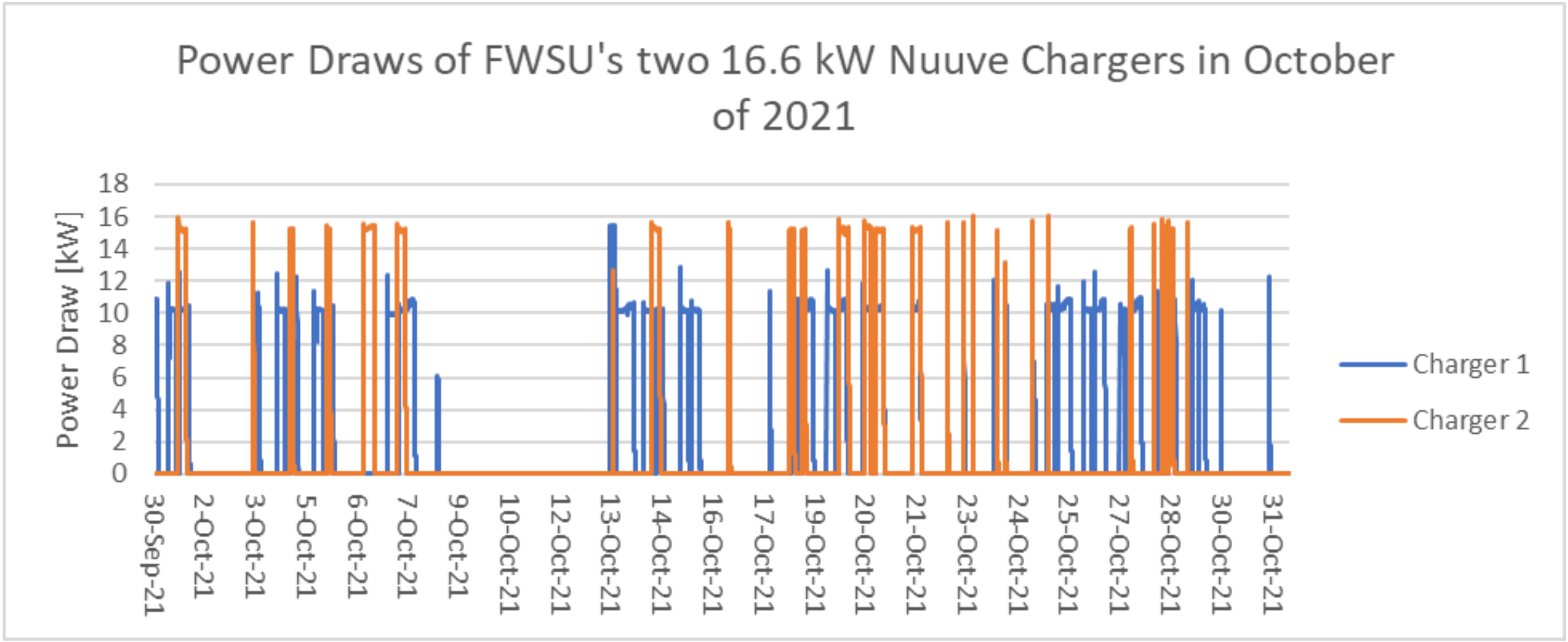

Key Takeaways

- Though OEMs have stumbled some on adjusting to the new technology, today's electric school buses are clearly viable for use in Vermont.
- The ranges that the school buses were able to achieve sufficiently exceeded the miles the buses needed to travel.
- Schools need a lot of support to plan for, pay for, procure, and monitor electric buses in their fleet.

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Key Takeaways

- Charger maintenance has been a constant issue.
- High-power Level 2 or low-powered Level 3 chargers are sufficient for most school operations.
- Having multiple chargers provides redundancy, if one charge
- Access to submeter and telematics data can help find issues before they become problems.

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Thank you