EVERSOURCE

Electric Bus Overview

January 2019

Executive Summary

- Market for bus electrification is nascent (even more than passenger vehicles)
- Preliminary evaluation of a Transit Authority in our service territory points to positive cost/benefit
- Under most scenarios, electrification should provide a significant savings over diesel fuel costs. Savings are maximized by staggering fleet charging to reduce demand charges
- Fuel savings key, but a host of other considerations need evaluation: Cost of charging infrastructure, need for additional power to garage sites; capital and scheduling

Medium / Heavy Duty: Market Outlook

Most mature → Furthest out

PROTERRA

CT DOT anticipating small-scale pilot program; lead time > 1 year

WORKHORSE

Began producing N-GEN 1000 for 50 UPS truck test fleet in October 2018

TESLA

Production originally slated to begin in 2019; 2020 more likely

Other Manufacturers: BYD, New Flyer, Mitsubishi | Zenith, various Chinese mfgs. | Mercedes, Mitsubishi

- Medium and heavy duty market most developed in Europe, secondarily in China
- Share of truck electrification in Europe and China less than 1%
- Even in Europe, no all-in parity between EV and combustion engine fleets until mid 2020's
- Limited fleet deployment supported by heavy government incentive
  - *e.g.,* 50 UPS trucks in London, $3 million UK govt grant
  - China (govt subsidized) focus on transit bus (150,000 implemented – 2x current US public bus fleet)

Electric Buses – Early Days

In U.S. lots of splashy announcements…

Metro
Los Angeles County Metropolitan Transportation Authority (Metro)

- plans to transition its entire bus fleet (2,200) to electric by 2030

MTA
New York City Transit

- plans to convert its public bus system (5,700) to all-electric fleet by 2040

King County METRO

- implementing 120 electric buses by 2020

Foothill Transit

- plans to fully electrify its bus fleet (350) by 2030.

…but so far, mostly pilots, with mixed results

- production problems and severe range shortfalls hinder Albuquerque pilot
- Long Beach pilot concludes bus range dropped to 108 miles when air conditioning was used in mild weather
- Solano County limits buses to routes of 80 miles or less, and after watching bus crawl slowly up a hill decides to keep it off steep grades

Meanwhile in New England

Planned pilots in MA (5 buses on Silver Line in Boston) and CT (5 buses in Bridgeport) will help determine how these buses fare in New England environment and determine how the technology could be implemented region wide

Bus Electrification Evaluation in CT

We examined the possibility of electrifying a sample transit bus fleet in CT

Eversource Scope

- Review existing electrical infrastructure to ensure sufficient capacity exists on-site
- Install, own and operate the infrastructure (front of and behind the meter) to support electrification of transit bus fleet
- Own up to charging stub (same structure as passenger make-ready)
- Exact infrastructure costs unknown
  - Nascent market limits ability to reference other examples throughout the country
  - Engineering analysis required

Transit Authority Scope

- Procure the electric buses from a vehicle manufacturer
- Purchase, own and operate the charging stations (primarily 120kW – 150kW)
- Pay the associated electric bill

Cost comparison for 58 bus fleet

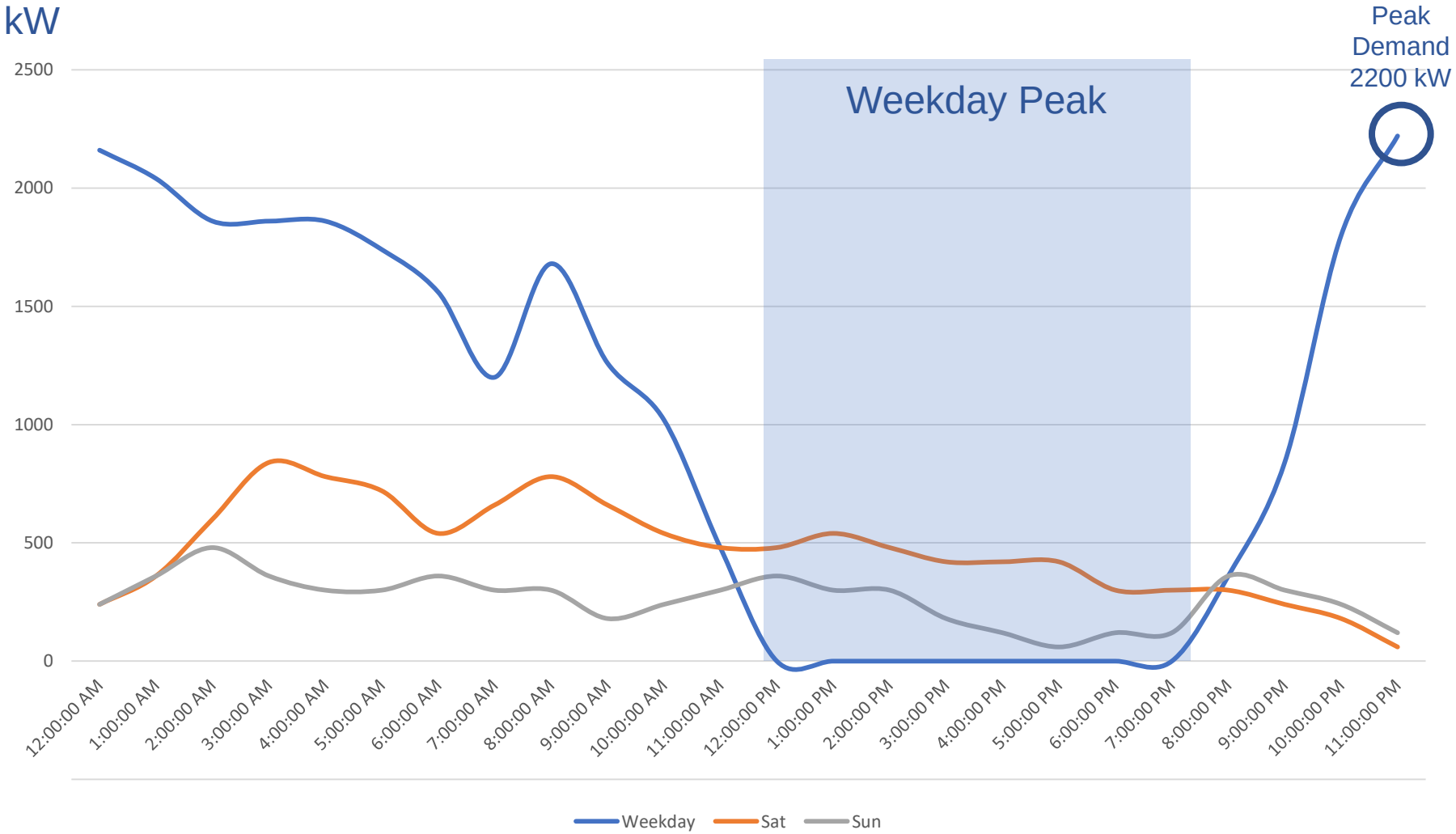
	Diesel	Electric	Electric vs. Diesel
Annual Fuel Cost	$2,784,000	$916,920	**($1,867,080)**
Capital Cost	$26,100,000	$43,500,000	**$17,400,000**

Fuel cost savings from fleet electrification yields **~9 year payback** on upfront capital cost of vehicles

**Note: Analysis only considered capital cost of bus; does not account for electric charging infrastructure*

Sample CT Transit Authority Load Forecast

We modeled a potential charging schedule that would minimize electric bill impacts while also accounting for the routes and utilization of specific buses



Other Considerations

Vehicle
- Resiliency during power outage
- Purchase lead time (1 year from order)
- Cold / hot weather performance

Charging
- Limiting Peak Demand
  - optimized, rolling, charging
  - charging off-peak
- Electric Capacity at Site
- Depot vs. En-route charging

Operations
- Scheduling (routes/times to match charging)
- Capital cost differential
- Vehicle replacement schedule
- Space Constraints
- Impacts to Maintenance, Training

Depot Charging in Germany

En-route Charging in Montreal

Appendix

Vehicle Specs

Proterra Catalyst 40 Foot Bus				
Series	**Model**	**Drivetrain**	Source: Proterra Data Sheet	
E2	E2 Max	Prodrive		
Specs				
Total Energy			660	kWh
Projected Efficiency			1.89	kWH/mile
Nominal Range			350	Miles
Charging				
Max Plug-in Charge Rate (KW)			120	kW
Plug-in Charging (Miles per 5 Min.)			5	Miles
Plug-in Charge Time			4.5	Hours

- Average Miles per Bus/ per Day Based on Sample Route Data

  Average Miles per day/ per bus: 220

  Average Miles per day/Nominal Range: 63%

  Average Charge of Bus Returning: 37%

  Average Charging Efficiency*: 88%

  kWh required to Recharge: 415

  Charge Time per Bus Based on Miles (in Hours): 3.7

  Charge Time per Bus Based on kWh (in Hours): 3.5

* NREL Technical Report - NREL/ TP-5400-67698 June 2017 - Foothill Transit Battery Electric Bus Demonstration Results: Second Report page 19