ANALYZING ELECTRIFICATION OF PUBLIC VEHICLE FLEETS IN WASHINGTON STATE

Results from Draft-Final Report

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ATLAS PUBLIC POLICY

OVERVIEW

- Project Team
- Project Goals and Deliverables
- Background and EV Market Recap
- Review of Results from Draft-Final Report
- Q&A

STUDY TEAM

ATLAS PUBLIC POLICY

Key Personnel

- **Nick Nigro**: Project Director
- **Charles Satterfield**: Project Manager
- **Nicole Lepre**: Lead Analyst
- **Conner Smith**: Project Analyst
- **Josh Rosenberg**: Project Analyst

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Key Personnel

- **Eric Wood**: NREL Team Lead
- **Stephen Lommele**: Lead Analyst
- **Ranjit Desai:** Technical Associate
- **Fan Yang:** Technical Associate
- **Yanbo Ge:** Technical Associate

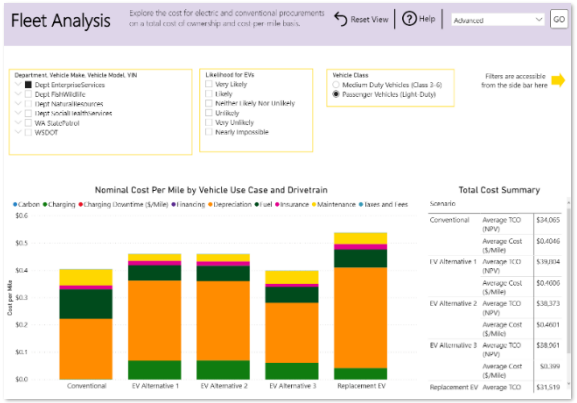
Energy Program
WASHINGTON STATE UNIVERSITY

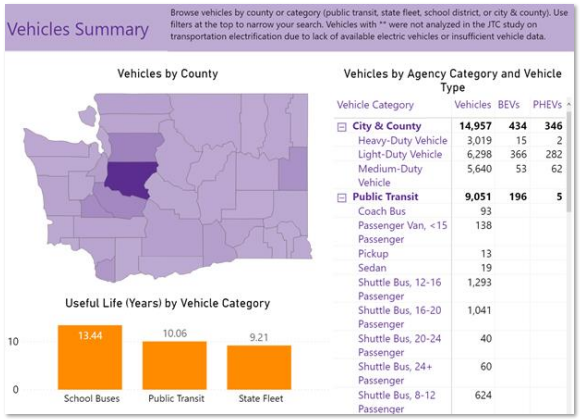
Key Personnel

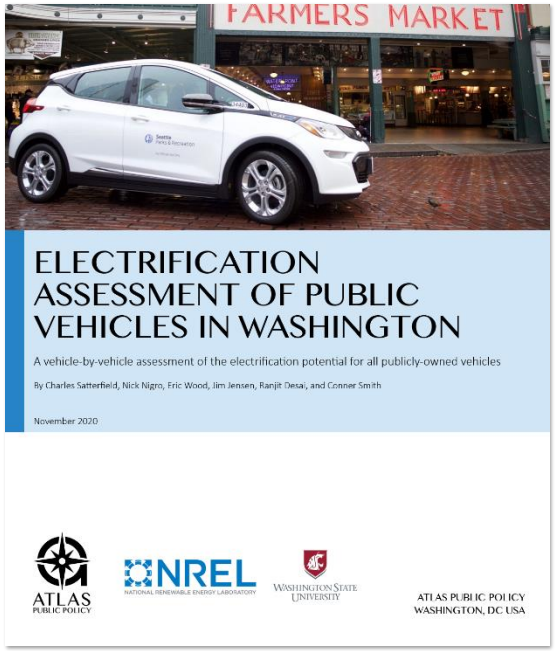
- **Jim Jensen**: WSU Team Lead
- **Gary Kaufman**: Project Analyst
- **Nels Christianson:** Senior Software Engineer

PROJECT GOALS AND DELIVERABLES

- **Deliverables:**
  - Develop inventory of existing state fleet
  - Compare total cost of ownership of available alternative electric vehicles
  - Project costs of electrification for 2025, 2030, and 2035
  - Determine required statewide charging network
  - Quantify emissions abatement from electrification
  - Explore financing strategies and mechanisms to accelerate electrification
- **Goal**: Provide Washington with comprehensive, vehicle-specific electrification cost estimates both today and in future and deliver actionable information on how to efficiently move forward with fleet electrification







VEHICLE BACKGROUND

- Vehicles divided into light-, medium-, and heavy-duty based on weight
- Vehicle electrification in varying stages of competitiveness today
  - Heavy and light-duty vehicles have more mature EV markets
  - Passenger vehicles have the most cost-competitive options
  - Medium-duty EVs primarily aftermarket conversions

Study Class	Vehicle Class (GVWR)	Example Vehicles
Light-duty 	Class 1 (0–6,000 pounds)	• Passenger Sedans and SUVs
	Class 2a (6,001–8,500 pounds)	• Light pickup trucks such as an F-150, small cargo vans
Medium-duty 	Class 2b (8,501–10,000 pounds)	• Full-size trucks and cargo vans such as an F-250 or Mercedes Sprinter
	Class 3 (10,001–14,000 pounds)	• Walk-in vans, small box trucks and full-size picks such as an F-350
	Class 4 (14,001–16,000 pounds)	• Shuttle buses, small freight trucks
	Class 5 (16,001–19,500 pounds)	• Large Shuttle buses and specialty vehicles such as bucket trucks
	Class 6 (19,501–26,000 pounds)	• Large freight trucks, dump trucks, small buses
Heavy-duty 	Class 7 (26,001–33,000 pounds)	• School and transit buses, large dump trucks
	Class 8 (33,001+ pounds)	• Semi-tractors, school and transit buses, road construction vehicles, refuse vehicles

CHARGING INFRASTRUCTURE BACKGROUND

- Key component of any EV procurement
- Options for fast (DC) and slow (Level 2) charging
  - Level 2 up to 19.2 kW
  - DC up to 350 kW
- More powerful chargers require more expensive equipment, additional infrastructure upgrades

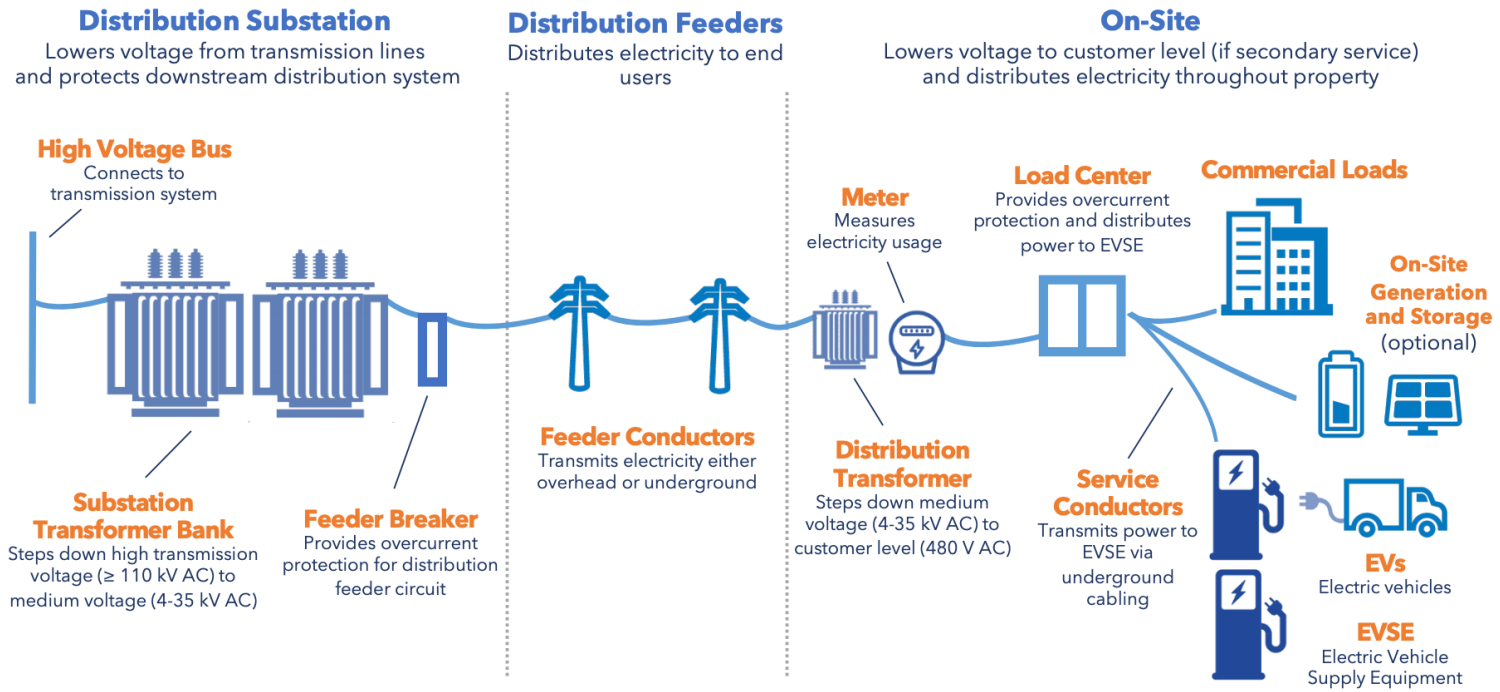


Figure 2. Diagram of typical electricity distribution system components serving EV charging loads divided into three categories – distribution substation, distribution feeders, and on-site equipment.

EV MARKET: QUICK RECAP

- >$400 billion in announced investments in transportation electrification
  - $20 billion in 2020
- >1.6m cumulative passenger EV sales in United States
  - 60+ new passenger EV models expected by 2025
- Medium- and heavy-duty EV market growing
  - >2,200 electric transit buses on road (↑37% from 2018-2019) *(Source: CALSTART)*
  - Ford unveiled e-Transit delivery van on November 13th
- Government & utility funding exceeded $4 billion as of August 2020*
- Approaching 100,000 charging ports nationwide (Level 2 and DC fast charging)

** Not including any federal tax credits*

All sources are Atlas EV Hub unless noted

"We're committed to an all-electric future, and what's possible today is just the beginning. The cost of developing, owning and operating electric vehicles is decreasing as battery technology advances."

GM

Source:

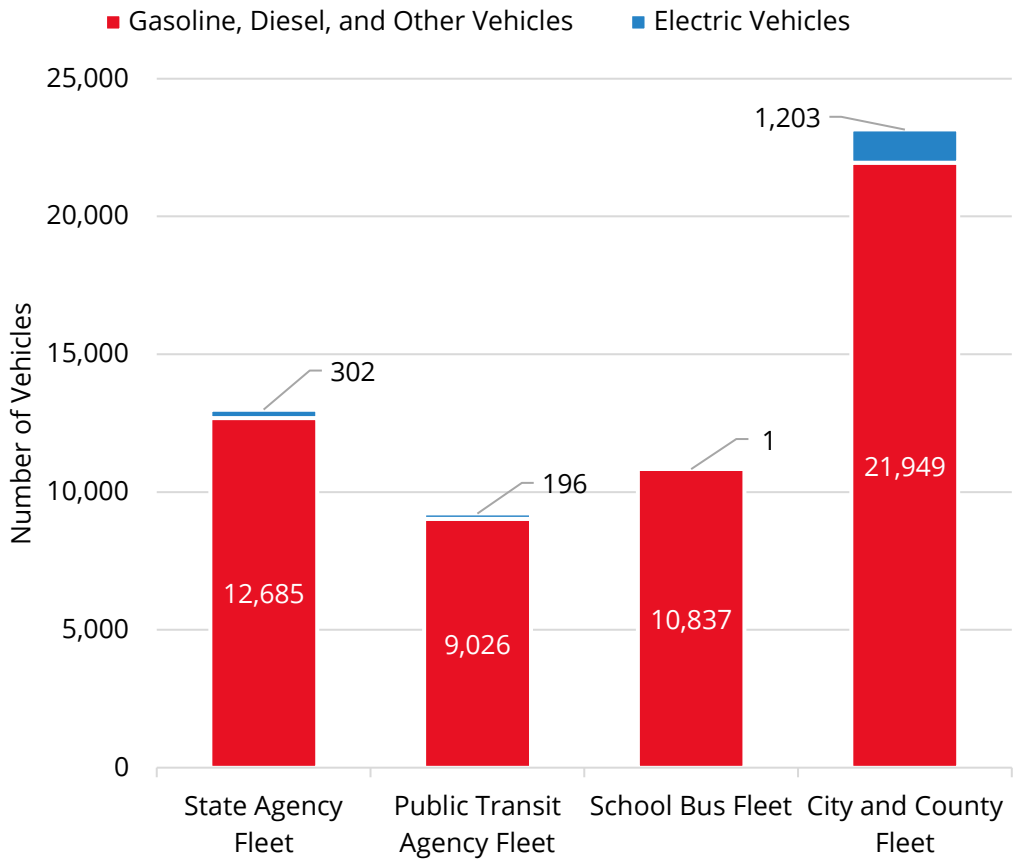
DRAFT-FINAL REPORT

- Fleet Inventory Results
- Present-day Total Cost of Ownership Results
- Future Total Cost of Ownership Results (2025-2035)
- Statewide Required Charging Network
- Emissions Abatement From Electrification
- Financing Mechanisms and Public Policies

PUBLIC FLEET INVENTORY RESULTS

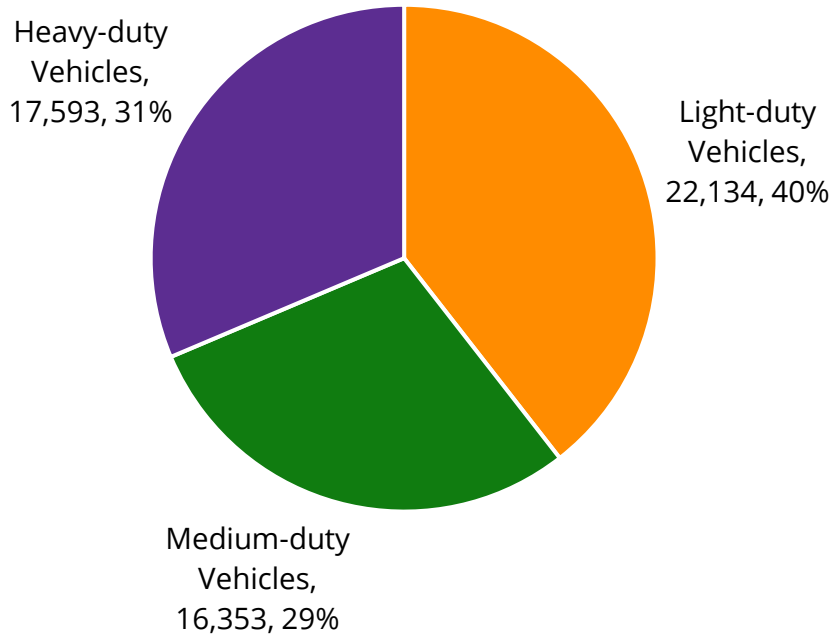
Size and Current Electrification Status of State Agency, Transit Agency, School Bus, and City and County Fleets

SIZE AND ELECTRIFICATION STATUS OF THE FLEET



- > 56,000 vehicles in total fleet, >50% included in analysis
- ~3% electrification as of January 2020; mostly light-duty vehicles

FLEET BREAKDOWN BY VEHICLE CLASS



- Medium- and heavy-duty vehicles highly prevalent (~2/3 of total fleet)
- Light-duty vehicles are primary vehicle class for state agencies and cities & counties

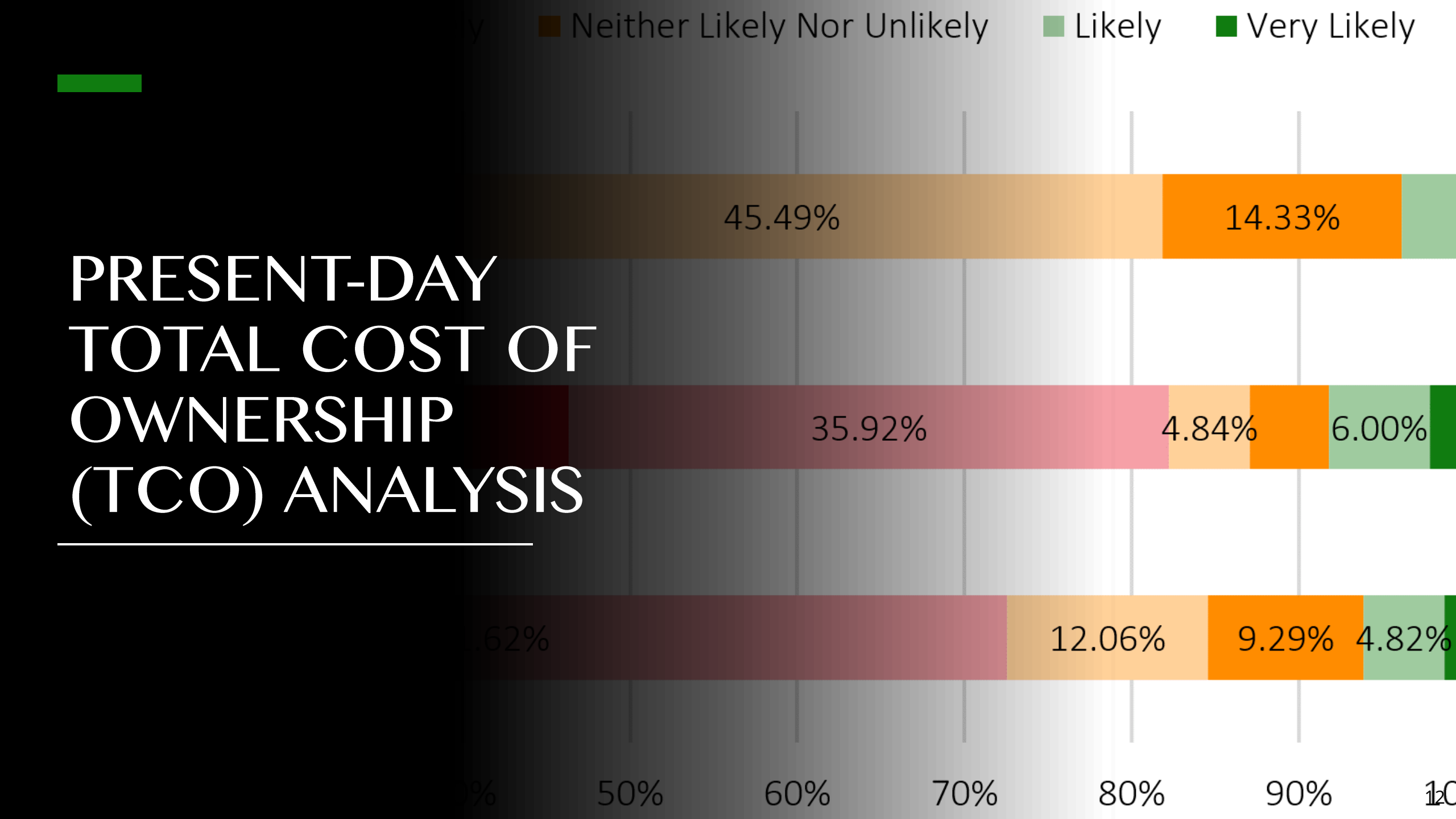
FLEET INVENTORY CHALLENGES

Low Data Availability	No centralized database; reliant on survey responses
Delays in Data Sharing	Delays in data sharing agreements; responsiveness of city and county fleet managers
Data Discrepancies	Inconsistencies in vehicle class or fuel type data
Differences in data conventions across entities	Varying definitions for vehicle class or make/model naming conventions or level of detail being recorded

RECOMMENDATIONS TO THE STATE

- Support standardized tracking of key data fields across state and/or local government entities
- Capture fleet information for tracking through data sharing agreements
- Coordinate definitions for vehicle attributes like weight class or mileage tracking
- Share the results of this project with recommendations for improved data tracking

PRESENT-DAY TOTAL COST OF OWNERSHIP (TCO) ANALYSIS



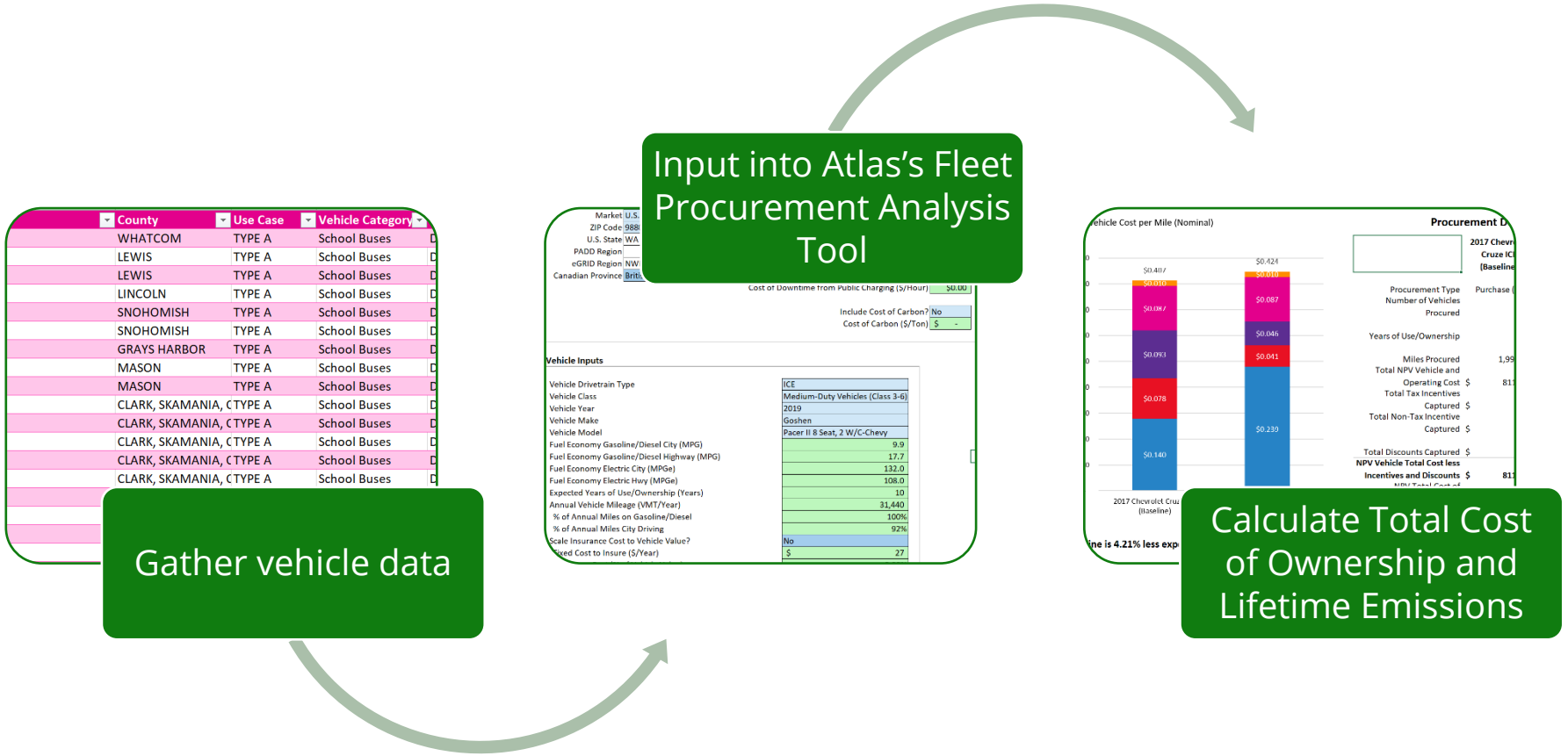
BACKGROUND ON TCO ANALYSIS

- TCO analysis of nearly 29,000 vehicles across 4.2 million scenarios
  - Fleet inventory data used for state agencies, transit agencies, and school districts
  - Electricity prices, EV models, charging configurations, and public policies varied
  - Localized emissions estimates for all vehicles
- TCO estimates calculated for present day and 2025-2035
- EVs within 5% of TCO for conventional counterpart met threshold (WAC 194-28)
- Results categorized by Likelihood (average difference in TCO from conventional counterpart)
- Results calculated for initial and subsequent deployment of EVs
  - Subsequent deployment discounts charging installation costs to reflect long-term savings potential of electrification

Likelihood Category	TCO Percentage Difference from Internal Combustion Equivalent
Very Likely	At least 10% lower
Likely	Between 10% lower and 5% higher
Neither Likely nor Unlikely	Between 5% and 20% higher
Unlikely	Between 20% and 35% higher
Very Unlikely	Between 35% and 100% higher
Nearly Impossible	More than 100% higher

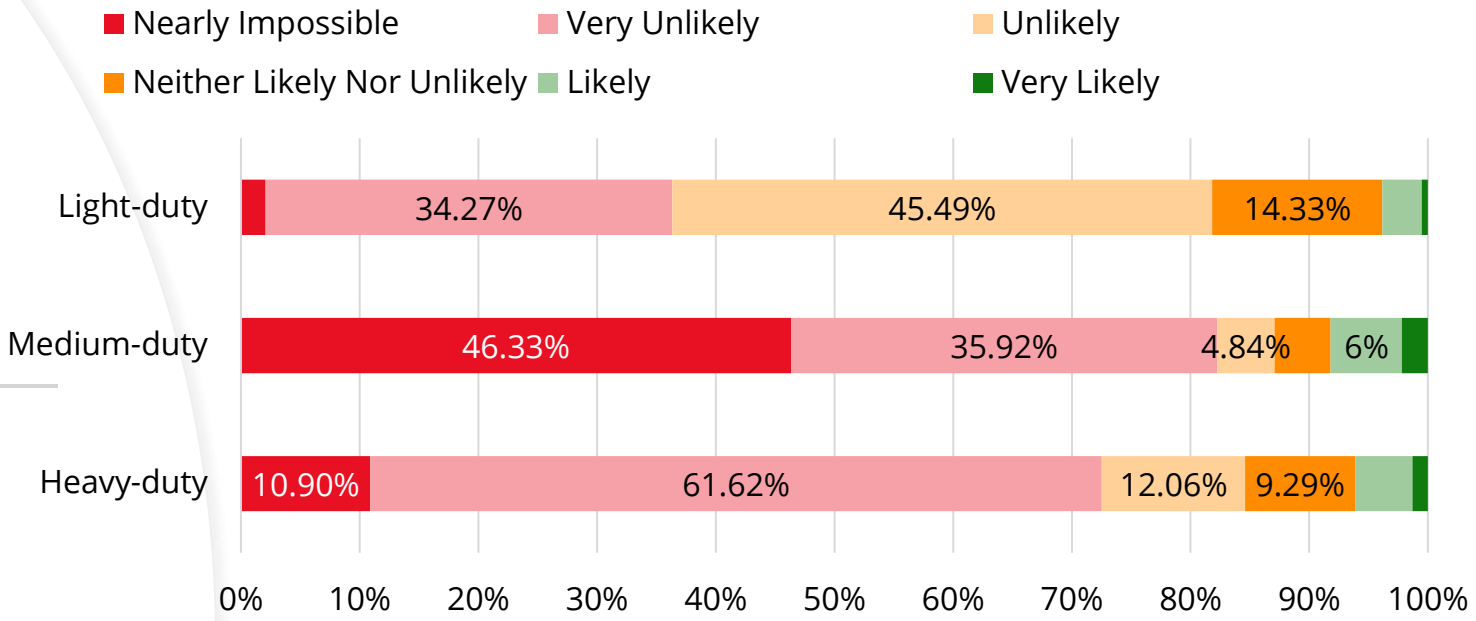
SAMPLE TCO ANALYSIS

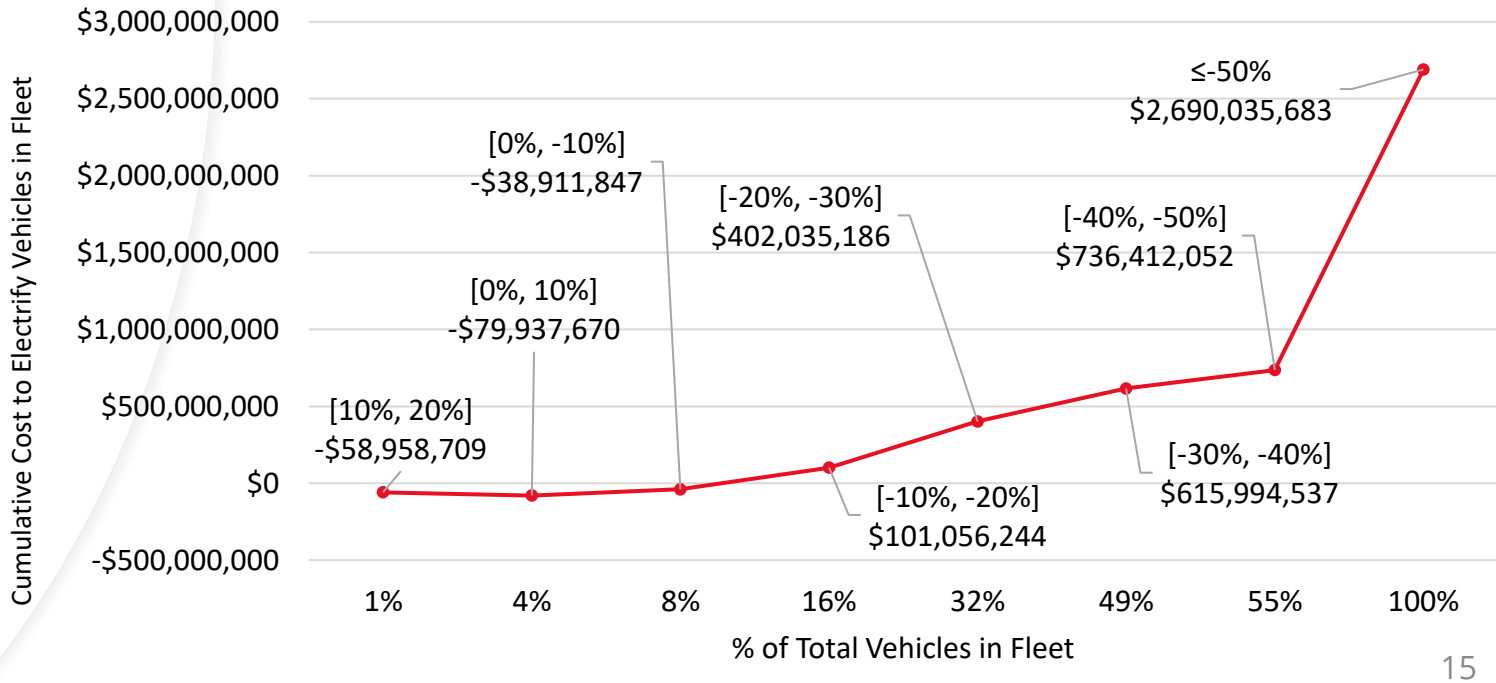
- For each vehicle, gather 40+ data points including
  - Make/model
  - Fuel price
  - Years of ownership
  - Fuel economy
  - Price
  - Charging Infrastructure
- Use detailed financial and environmental model to calculate TCO and emissions



AT LEAST 1,650 VEHICLES CAN BE ELECTRIFIED COST EFFECTIVELY TODAY

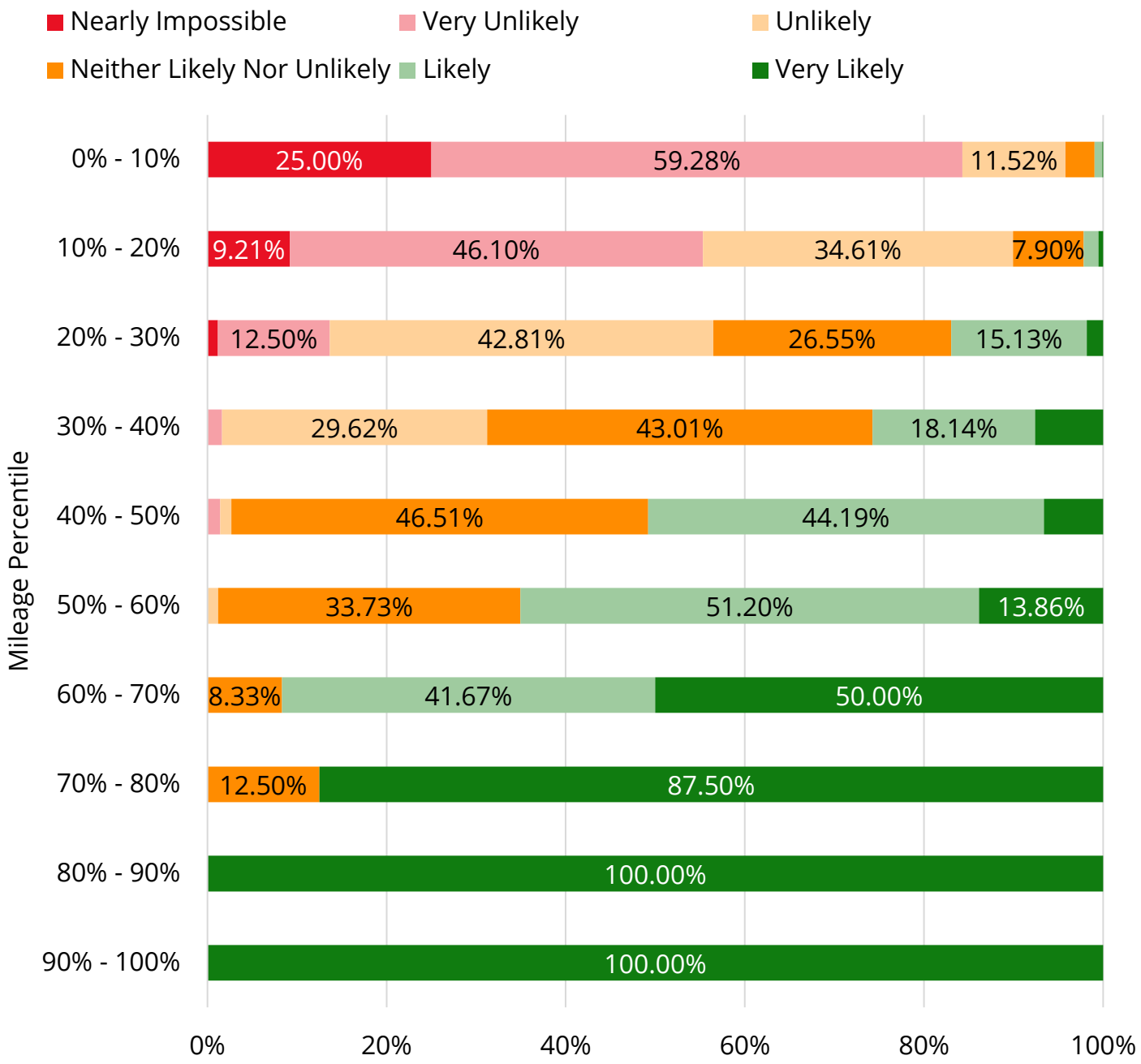
- Low overall share of fleet met 5% TCO threshold
  - Light-duty vehicles near threshold for wide-scale electrification
  - Medium- and heavy-duty transit agency vehicles had best results for electrification
- EVs provide cumulative savings of $72 million at 5% threshold
  - Primarily from transit buses
- Electrification cost-effective for between 2% and 21% of fleet depending on scenario



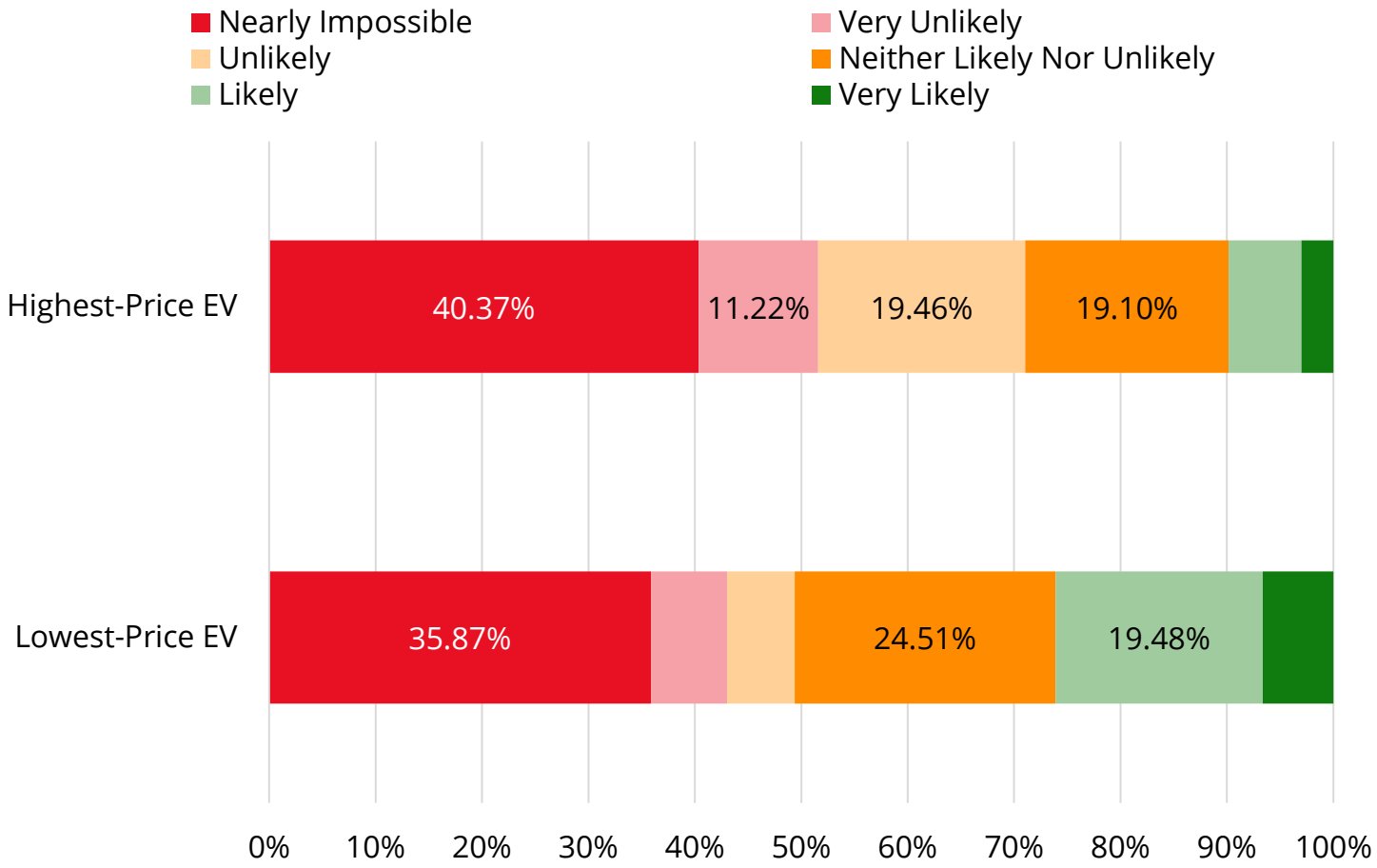


PRIORITIZING VEHICLES WITH HIGH ANNUAL MILEAGE CAN SAVE THOUSANDS

- Other than vehicle price, most important factor annual mileage had greatest effect on EV cost-competitiveness
- Average savings for electrifying vehicles in 90th percentile ~600x greater than vehicles in 10th percentile
- Per-vehicle savings increased by ~130% for each 10th percentile

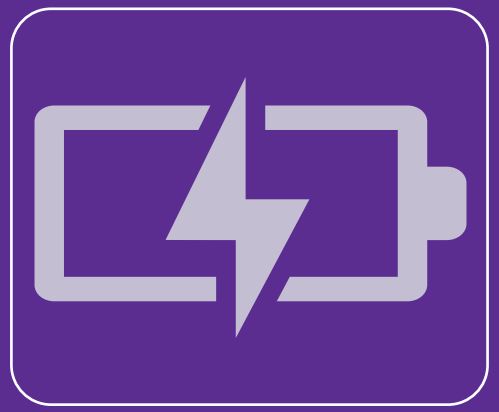


SELECTING RIGHT EV CAN DOUBLE VEHICLES ELIGIBLE FOR ELECTRIFICATION



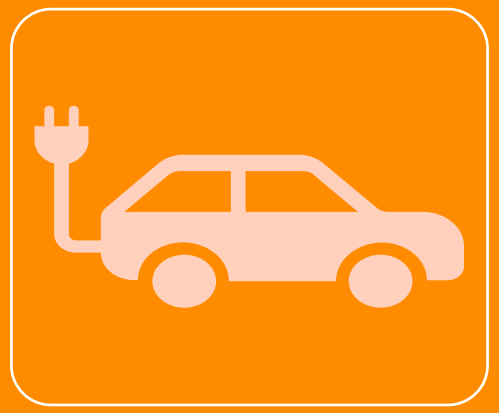
- Low-cost EV model selection the most important factor for determining cost-effective electrification
  - Could double fleet share that meet electrification threshold and increase total savings by 60%
- Choosing lower-range EV alternative for school buses resulted in average upfront savings of ~$50,000
- Requires no change in state policy or allocation of additional funds

ADDITIONAL FINDINGS



Unmanaged Charging Had Significant Negative Effect on Electrification Potential

- Reduced number of vehicles meeting threshold by 50 percent
- Mitigated by smart charging systems



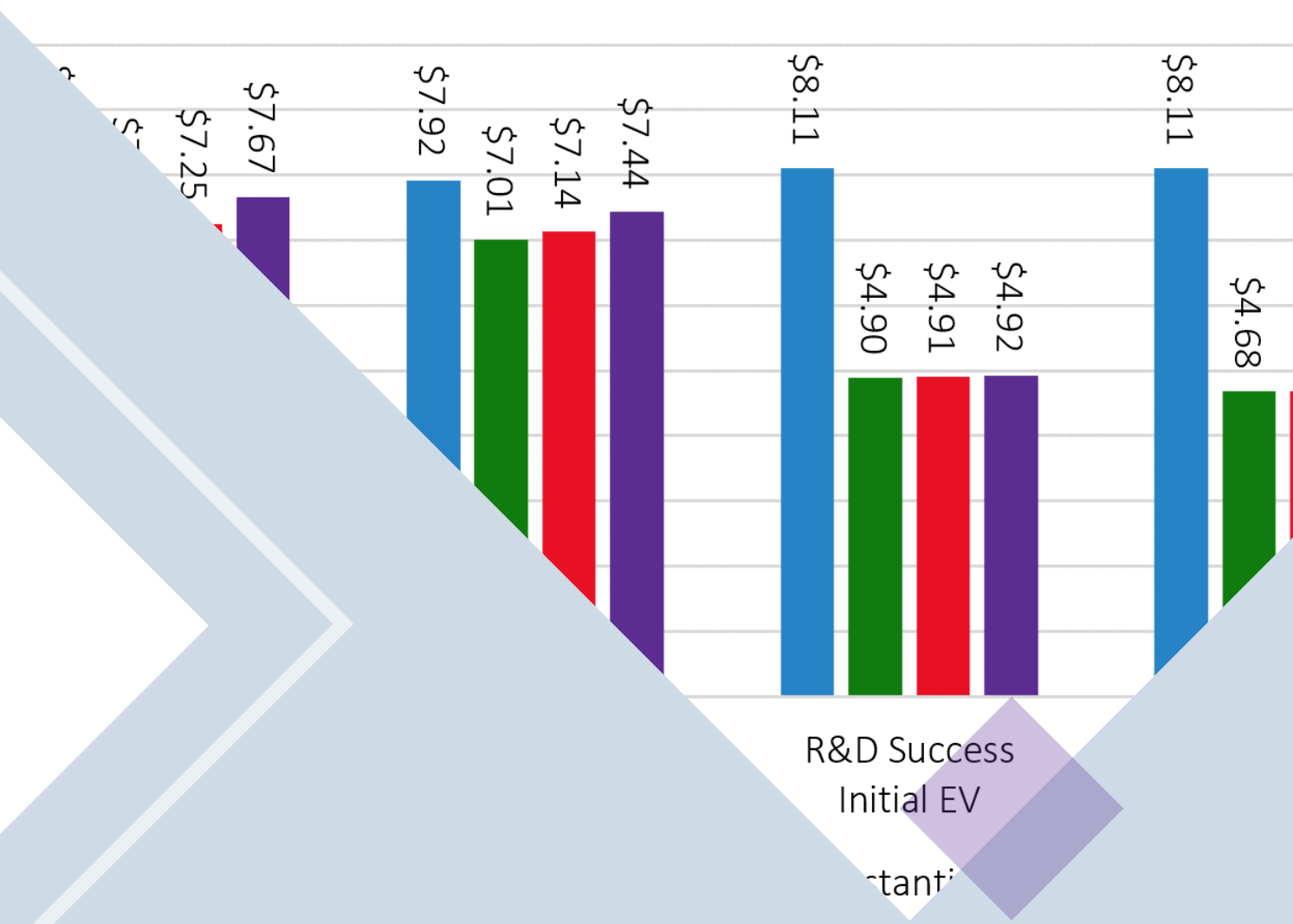
Low-cost charging configurations had greatest influence on light-duty electrification potential

- Tripled number of light-duty vehicles meeting electrification threshold
- Limited impact on medium- and heavy-duty vehicles

RECOMMENDATIONS

- Prioritize medium- and heavy- duty transit bus electrification for greatest savings
- Focus on light-duty electrification for state agencies to electrify vehicles cost-effectively
- Select lowest-cost EV option to substantially increase vehicles to electrify and savings
- Electrify vehicles with high annual mileage first
- Plan for smart charging systems or other means to avoid high electricity costs
- Focus on low-cost Level 2 charging solutions for light-duty vehicles

FUTURE TCO PROJECTIONS & SUBSTANTIAL ELECTRIFICATION (2020-2035)



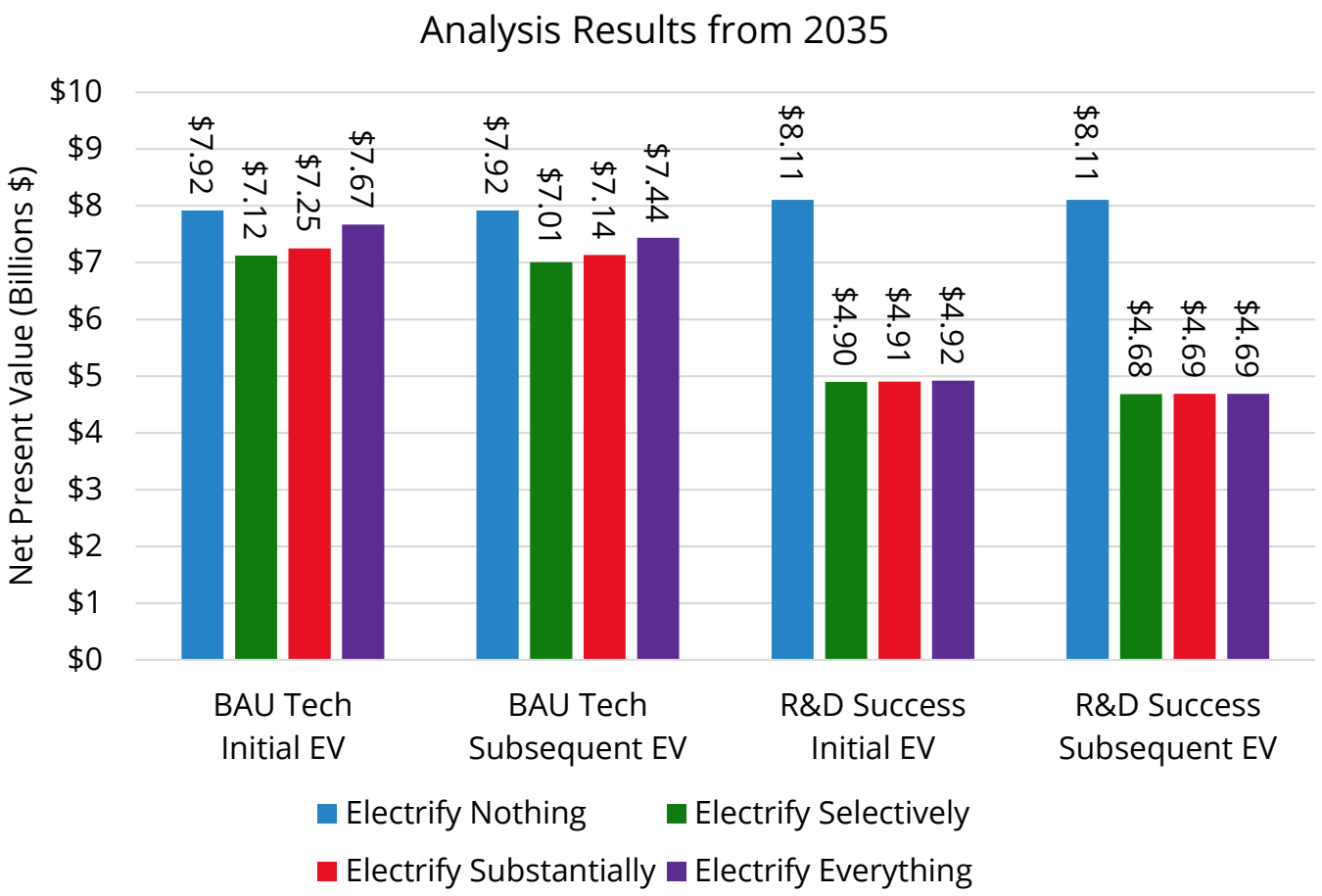
BACKGROUND ON FUTURE TCO PROJECTIONS

- Analysis calculated for 2025, 2030, and 2035
- Considers two technology scenarios
  - Business-as-usual (BAU) Tech
  - R&D Success
- Considers two EV deployment scenarios
  - Initial EV Deployment
  - Subsequent EV Deployment
- Four electrification scenarios
  - Electrify Nothing
  - Electrify Selectively (5% TCO threshold)
  - Electrify Substantially (20% TCO threshold)
  - Electrify Everything

Scenario Name	Electrification Criteria
Electrify Nothing	None of the vehicles in the public fleet are electrified.
Electrify Selectively	Vehicles that meet the "Likely" or "Very Likely" TCO criteria are electrified.
Electrify Substantially	Vehicles that meet the "Neither Likely nor Unlikely", "Likely", or "Very Likely" TCO criteria are electrified.
Electrify Everything	All the vehicles in the public fleet are electrified.

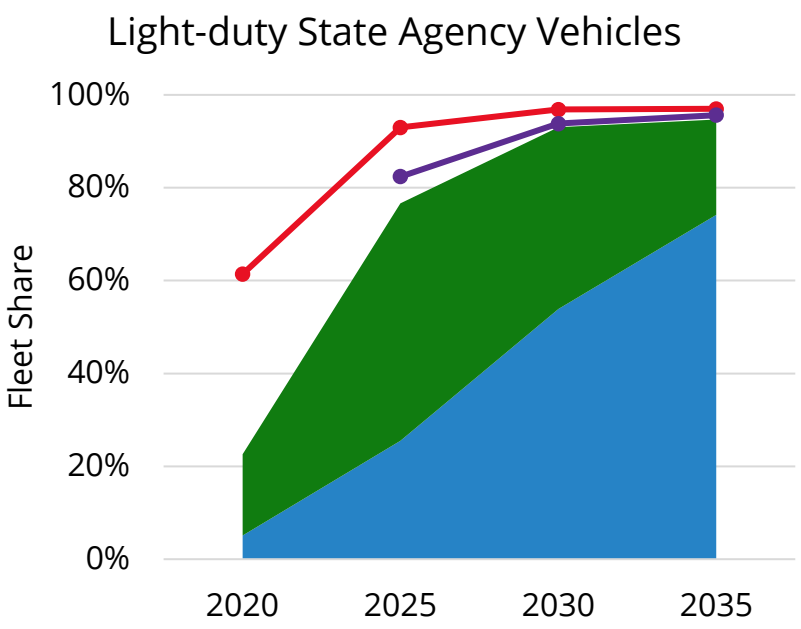
		Technology Scenario	
		Business as Usual Technology	R&D Success
Deployment Scenario	Initial EV	BAU Tech + Initial EV	R&D Success + Initial EV
	Subsequent EV	BAU Tech + Subsequent EV	R&D Success + Subsequent EV

FULL FLEET ELECTRIFICATION PRODUCES SAVINGS IN ALL FUTURE SCENARIOS

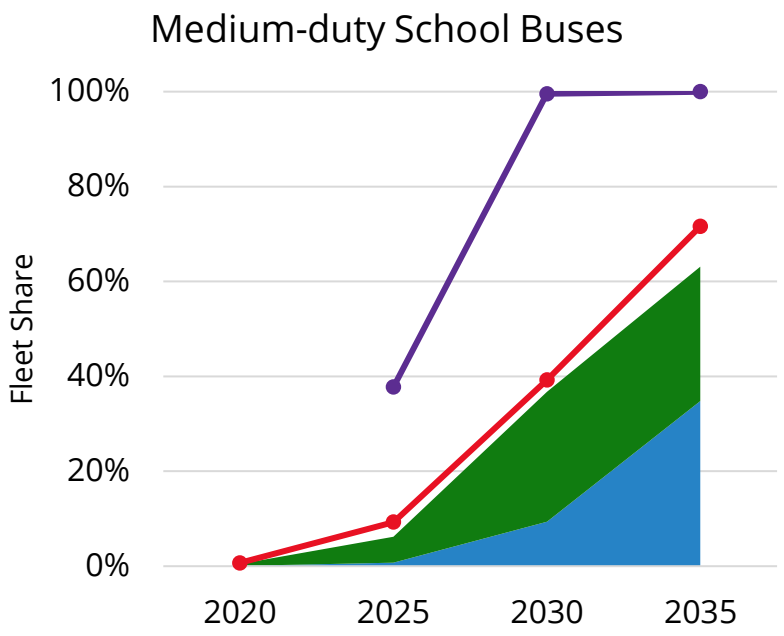


- 100% electrification still resulted in savings even under the worst-case assumptions
- Savings ranged between $250 million to more than $3.4 billion
  - Dependent on R&D success in EV market over next 15 years
- Assumes current policy landscape in WA unchanged

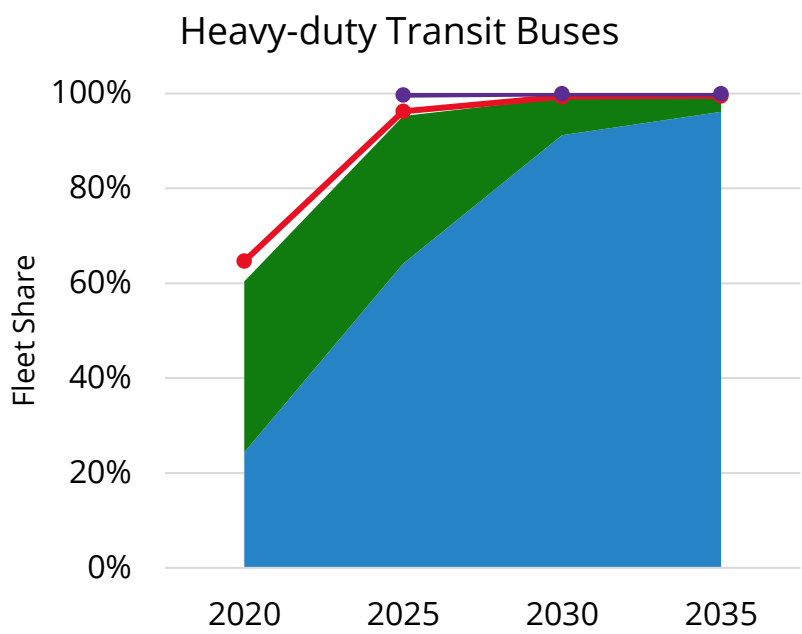
FUTURE FLEET RESULTS



- At least 70% of light-duty EVs cost competitive in 2035
- R&D Success less relevant for light-duty electrification compared to other weight classes



- Almost entirely reliant on R&D success for large-scale electrification
- Manufacturing costs expected to decrease substantially over the next decade



- Nearly all light-, medium- and heavy-duty transit vehicles will have EVs within 20% of TCO by 2035
- 95% of heavy-duty transit buses meet the 5% threshold by 2035

RECOMMENDATION

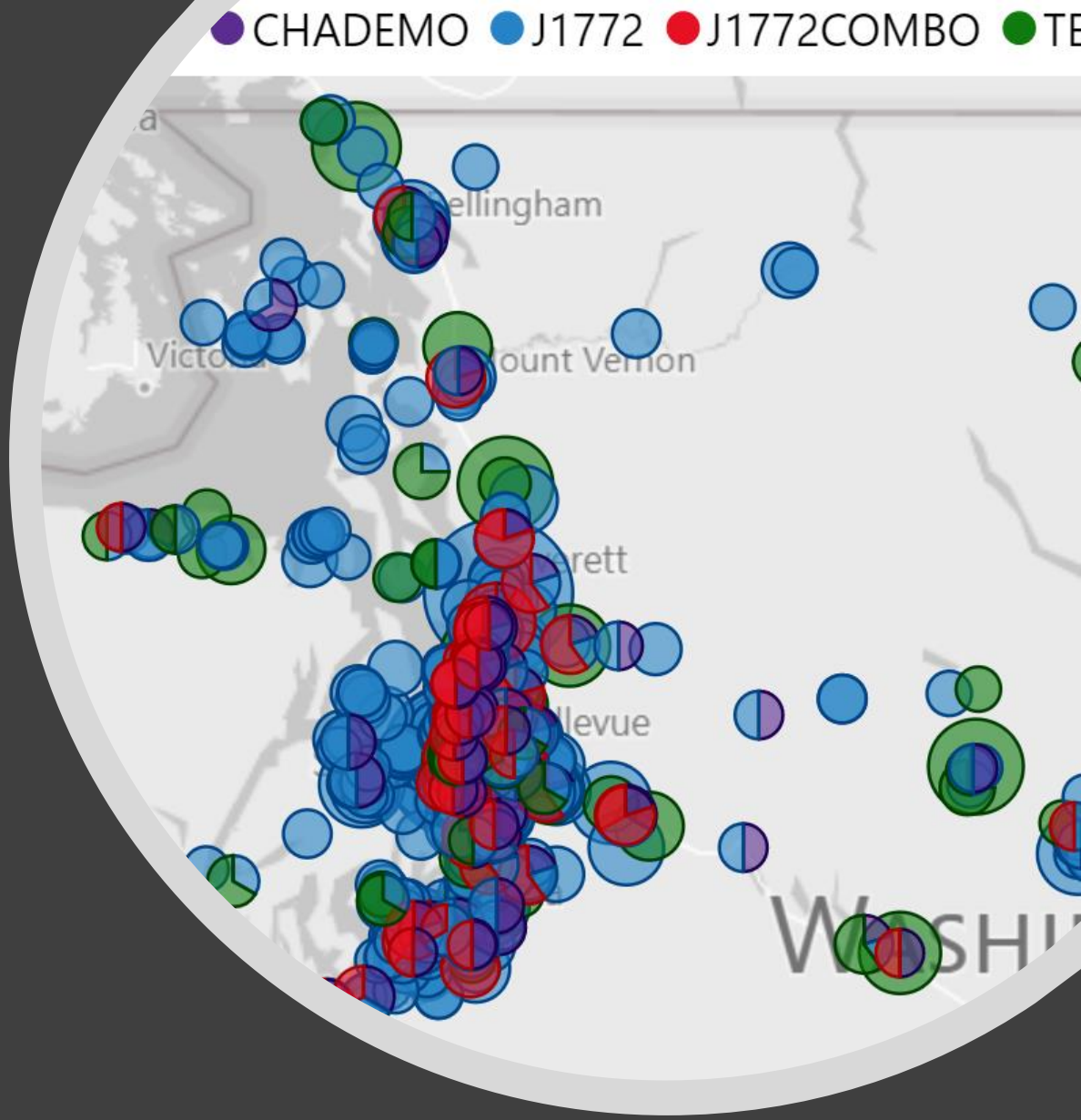
State should consider developing a roadmap to swiftly increase share of EVs in public fleet between 2020 and 2035 to achieve billions in fleet cost savings

- Savings range from $250 million to $3.4 billion depending on technological progress and timing of fleet purchases
- Analysis shows all vehicle purchasing by 2035 could be electric

REQUIRED STATEWIDE CHARGING NETWORK

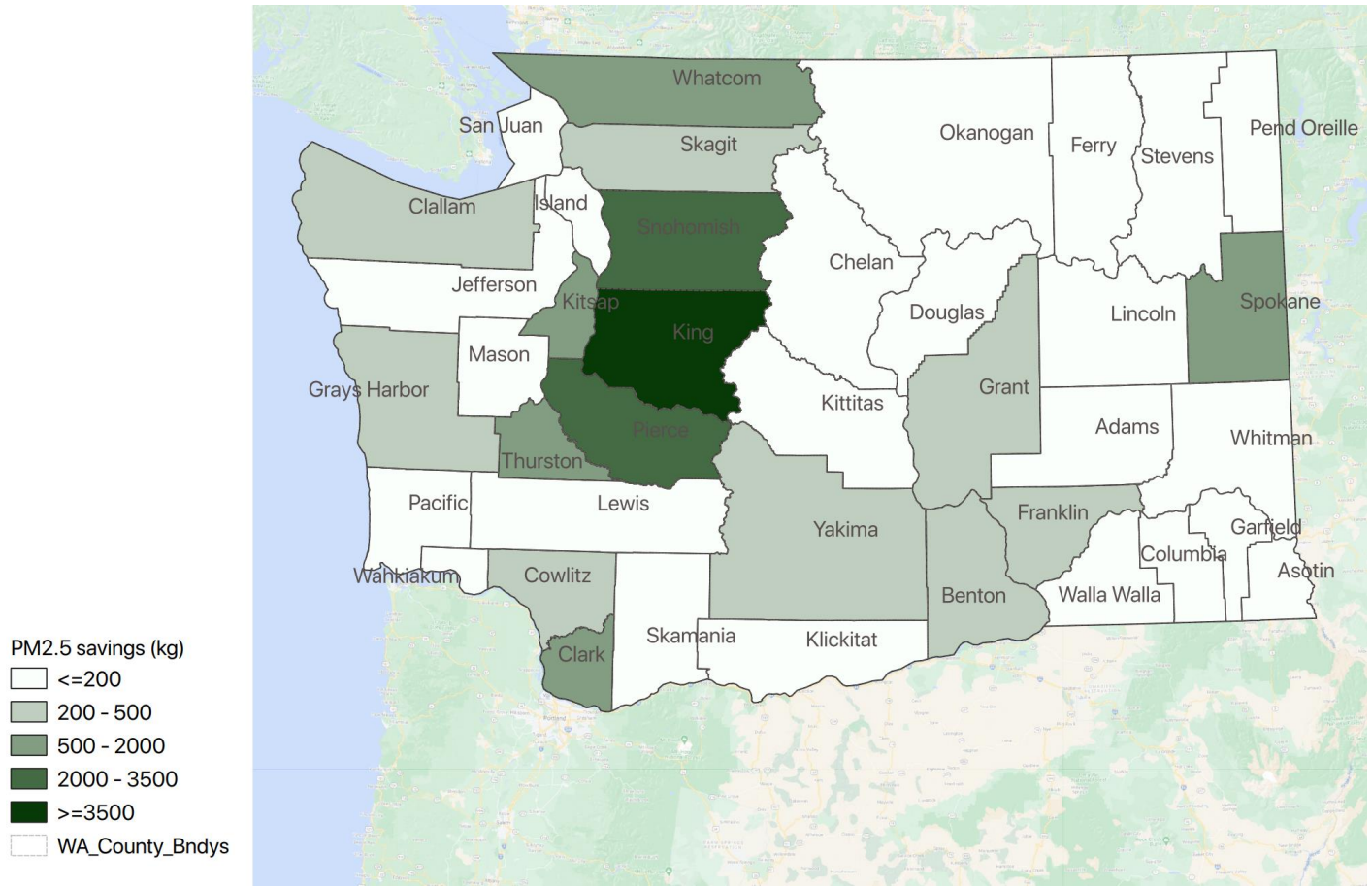
CHARGING INFRASTRUCTURE REPRESENTS A SMALL BUT CRITICAL PORTION OF TOTAL ELECTRIFICATION COSTS

- < 5% of total fleet cost needed for infrastructure under all future scenarios
- About equal share of DC and Level 2 charging solutions with a single DC station supporting multiple light- or medium-duty vehicles
  - ~9,600 stations needed to support nearly 28,000 vehicles in 2035 research and development success scenario
- Fleet managers, budget analysts, and local and state officials should proactively plan for necessary upgrades to support a substantially electrified fleet
  - May be necessary to take advantage of scale discounts



EMISSIONS ABATEMENT

HEAVY-DUTY ELECTRIFICATION ACCOUNTED FOR OVER 75% OF EMISSIONS SAVINGS



- Only accounted for 40% of vehicles analyzed
- 77% of CO_2 emissions savings
- 80% of particulate matter savings
  - Primary determinant of local air quality
- Emissions savings primarily concentrated in dense urban areas and highway corridors

FINANCING MECHANISMS AND PUBLIC POLICIES

Summary of Major Findings

SUMMARY OF MODELED POLICY EFFECTS

- Only modeled for present-day
- Bundled procurements and utility infrastructure grants highly effective at no or low cost to Washington
  - Resulted in over 1,000 additional vehicles electrified
- Policies targeting medium- and heavy-duty electrified fewer vehicles, but at greater operational savings
- Truck and bus grant funding was single most effective policy for advancing fleet electrification in present day
  - Likely most costly as well – subsidizes incremental upfront cost of EVs

Policy Modeled	Number of Additional Vehicles to Electrify	Percent of Fleet Analyzed	Additional Operational Cost Savings from Electrification
Vehicle-grid Integration	468	2%	$17,326,753
Carbon Price	1,725	6%	$84,032,302
Level 2 Utility Infrastructure Grant	1,828	6%	$1,114,852
Utility DC Charging Grant	813	3%	$18,707,575
Truck and Bus Grant Funding Program	12,065	42%	$510,153,977
Bundled Procurements	1,149	4%	$671,420

SUMMARY OF NON-MODELED POLICY EFFECTS

Revolving Loan Funds

- Can bridge gap between capital and operating funds
- Target a zero-percent interest rate and expand to state agencies; savings from electrification enabled by funding are substantial

Right-to-Charge Legislation

- Allows for installation of charging stations at leased properties without costly renegotiation of the lease terms
- Addresses a major administrative hurdle cited by fleet managers at no additional cost to the state

Energy Performance Contracting

- Funds energy efficiency upgrades in states like Washington and Colorado
- Upgrades financed by private companies, reduces savings captured by the state
- Likely use case is for building projects to subsidize EVs

Fleet Management

- Proper fleet management is effective tool for accelerating electrification and maximizing savings
- Target high annual VMT vehicles for substantial savings
- Selecting least expensive EV alternative is effective strategy to increase vehicles electrified

RECOMMENDATIONS

- Prioritize no-cost policies of bundled procurements, right-to-charge legislation, and proper fleet management
- Expand existing grant funding programs to accelerate medium- and heavy-duty electrification in the near term
- Encourage utilities to enact or expand charging infrastructure programs

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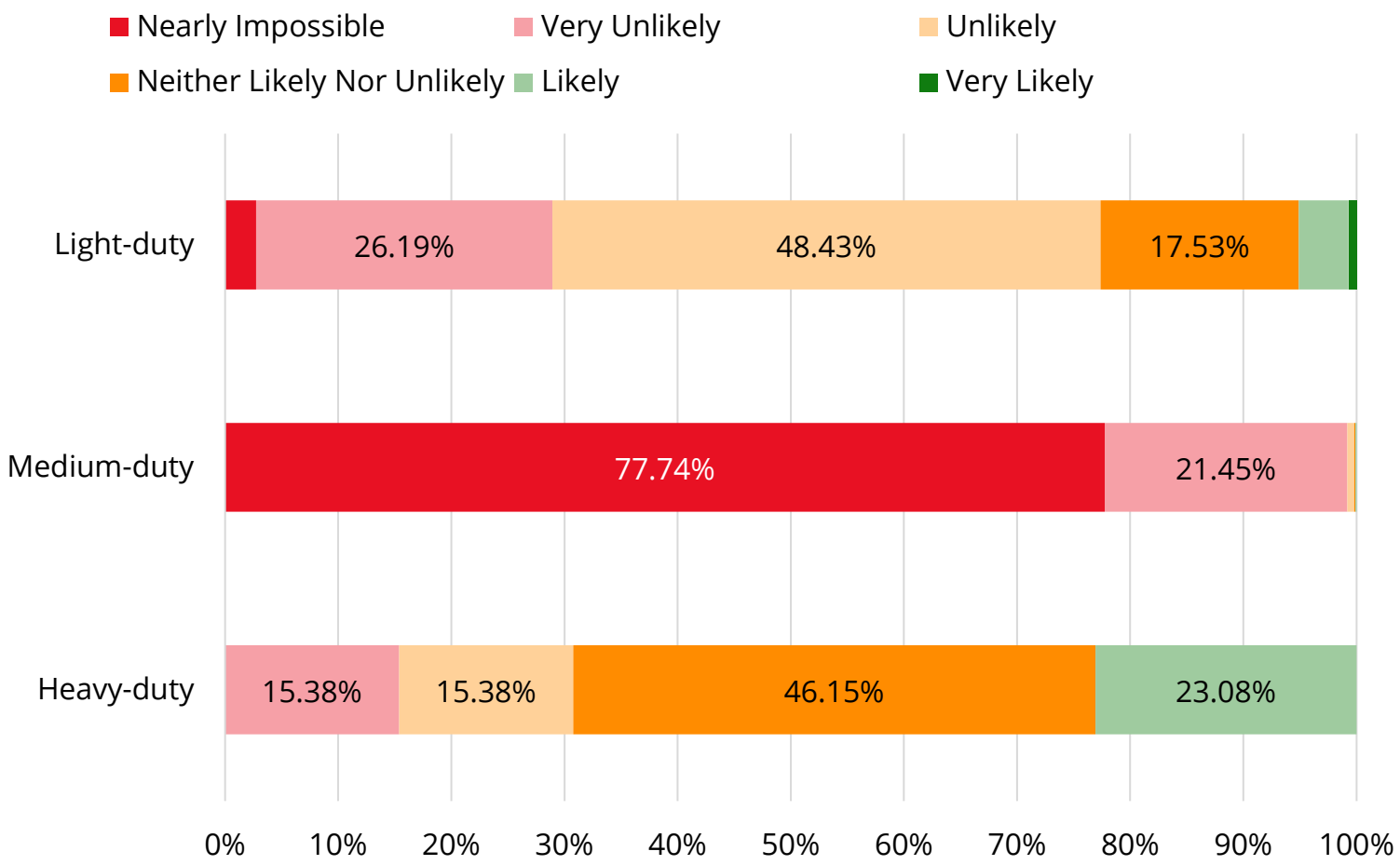
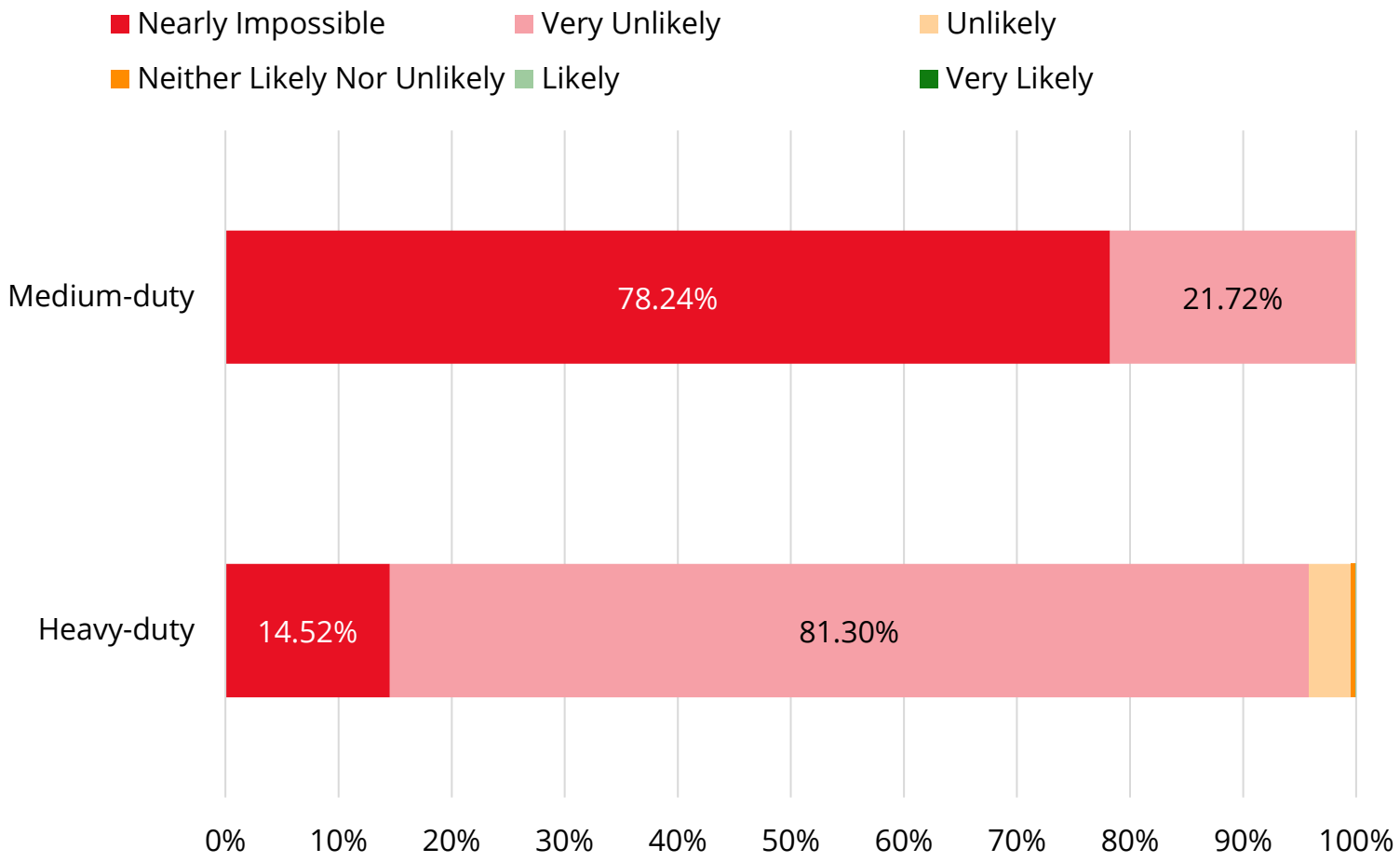
APPENDIX

STATE AGENCY FLEET RESULTS



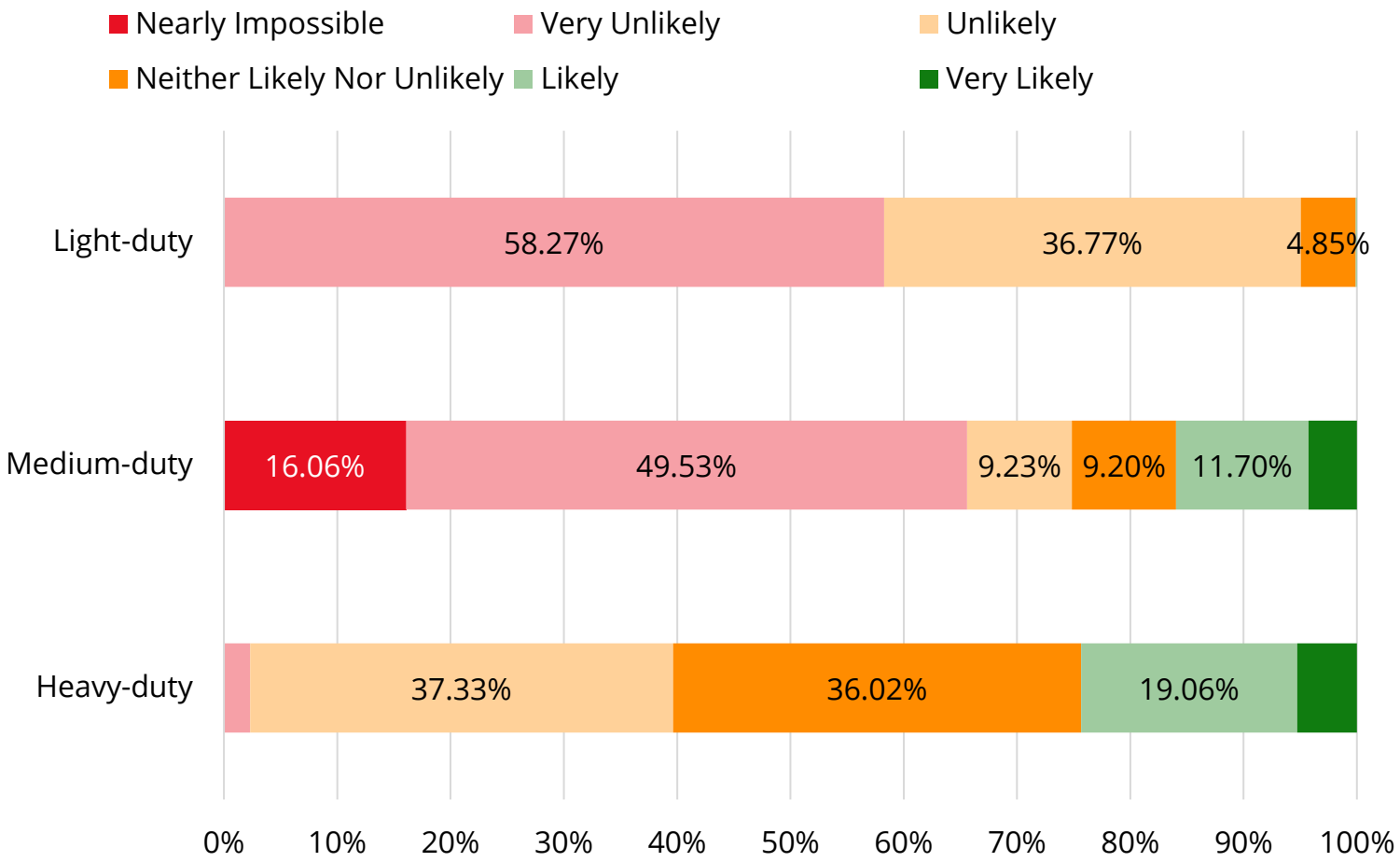
- Light-duty vehicles near tipping point for widescale electrification
- Limited, expensive EV options reduce electrification likelihood of medium-duty vehicles in present day
- Some heavy-duty vehicles offered high potential for savings from electrification
  - High annual mileage allowed vehicles to accumulate large operational cost savings

SCHOOL BUS FLEET RESULTS



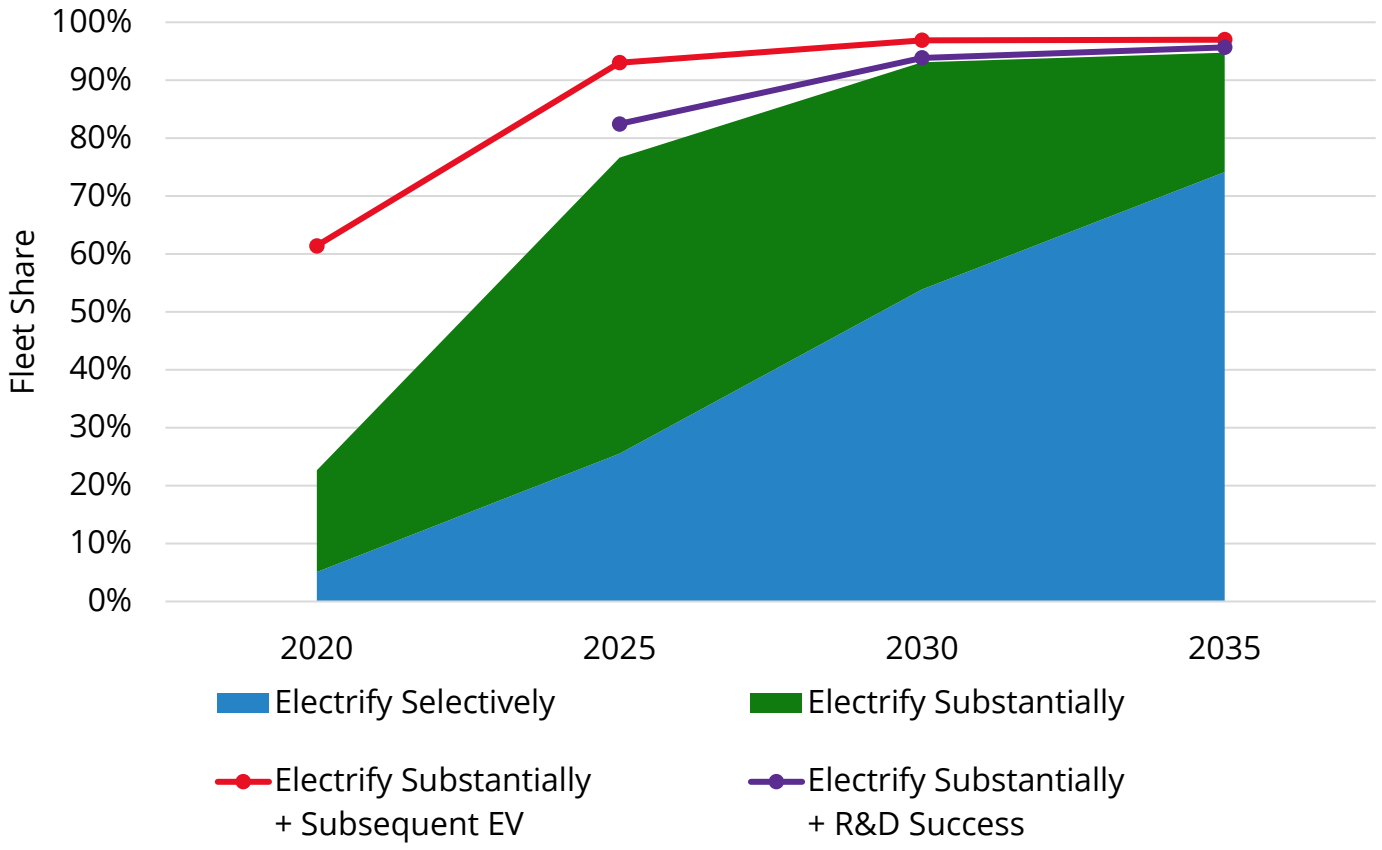
- School buses had lowest share of vehicles that met 5% TCO threshold across all vehicle types
  - High price premiums, low annual mileages resulted in nearly no vehicles meeting the threshold
- Funding from VW settlement will remain essential for electrification in near term

TRANSIT AGENCY FLEET RESULTS



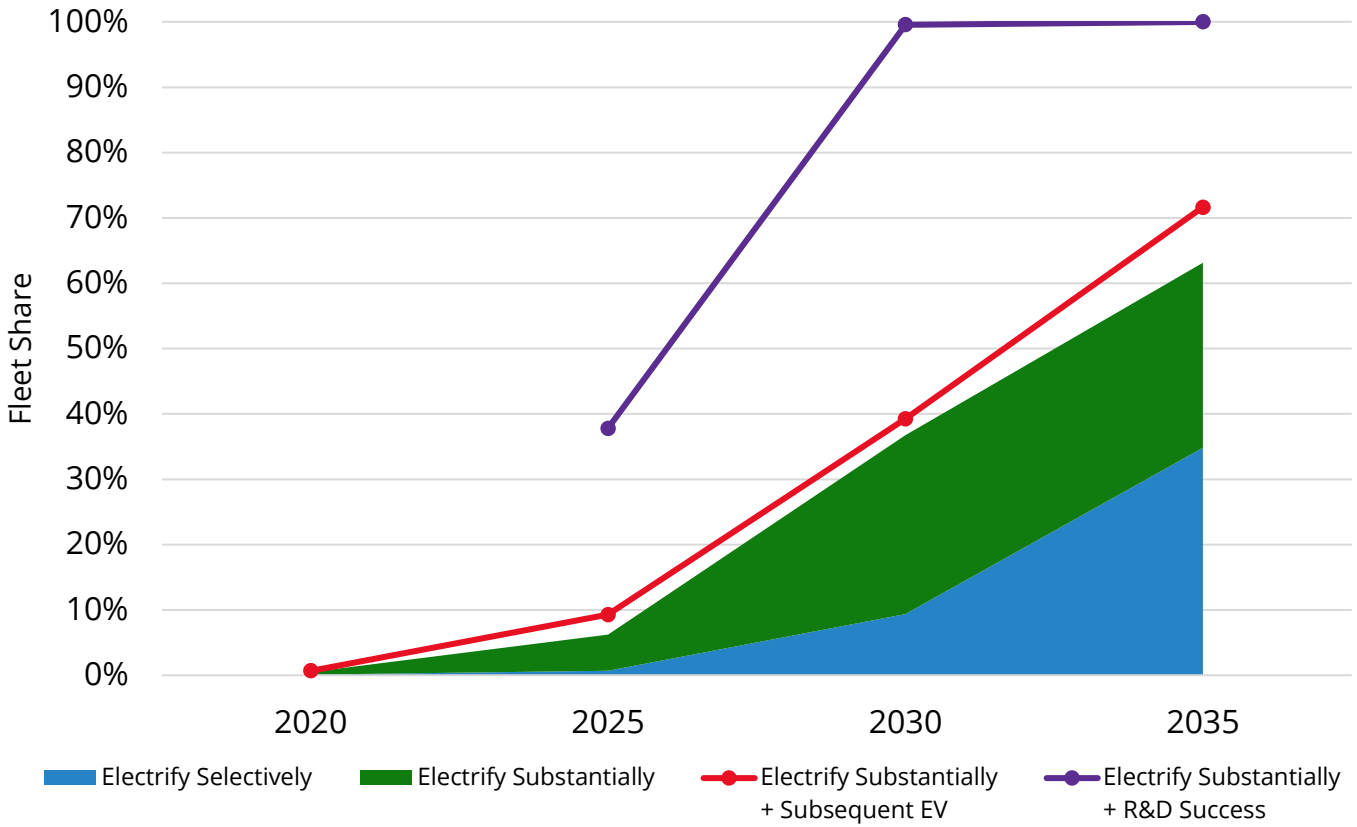
- Transit buses offered highest share of vehicles that met 5% TCO threshold and greatest savings
  - Accounted for >90% of total savings from fleet electrification
  - >1,200 vehicles met threshold in an initial EV deployment, 1,500 in subsequent EV deployment
- No minivans met threshold in initial EV deployment
  - Vast majority of light-duty vehicles
  - Limited EV options, all with high price premiums

FUTURE STATE AGENCY FLEET RESULTS



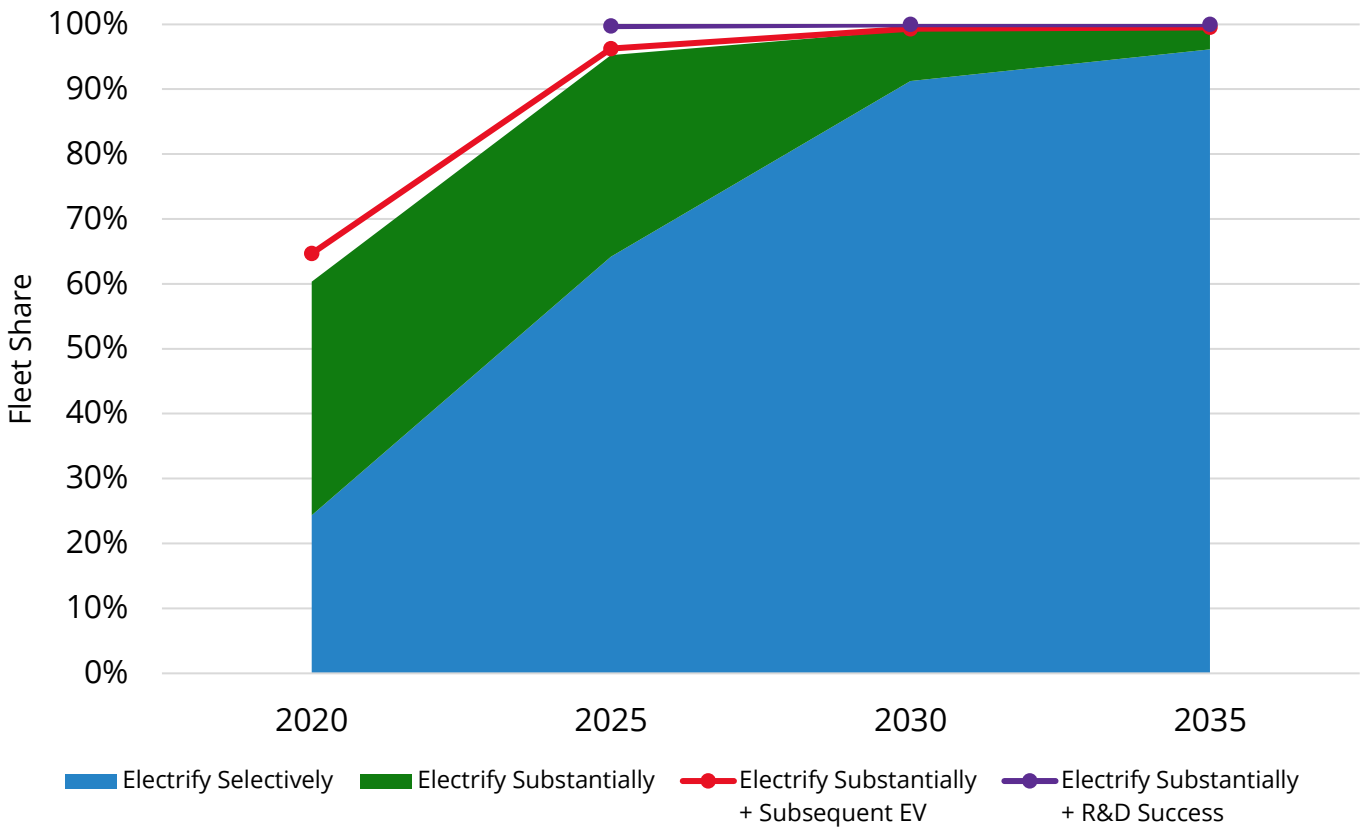
- 70% of light-duty vehicles cost competitive in 2035 even under worst-case assumptions
- Discounting charging infrastructure raises fleet share to over 90% by 2025
- R&D Success less relevant for light-duty electrification compared to other weight classes

FUTURE SCHOOL BUS FLEET RESULTS



- Almost entirely reliant on R&D success for large-scale electrification
- Manufacturing costs expected to decrease substantially over the next decade
- Minimally affected by discounted charging infrastructure

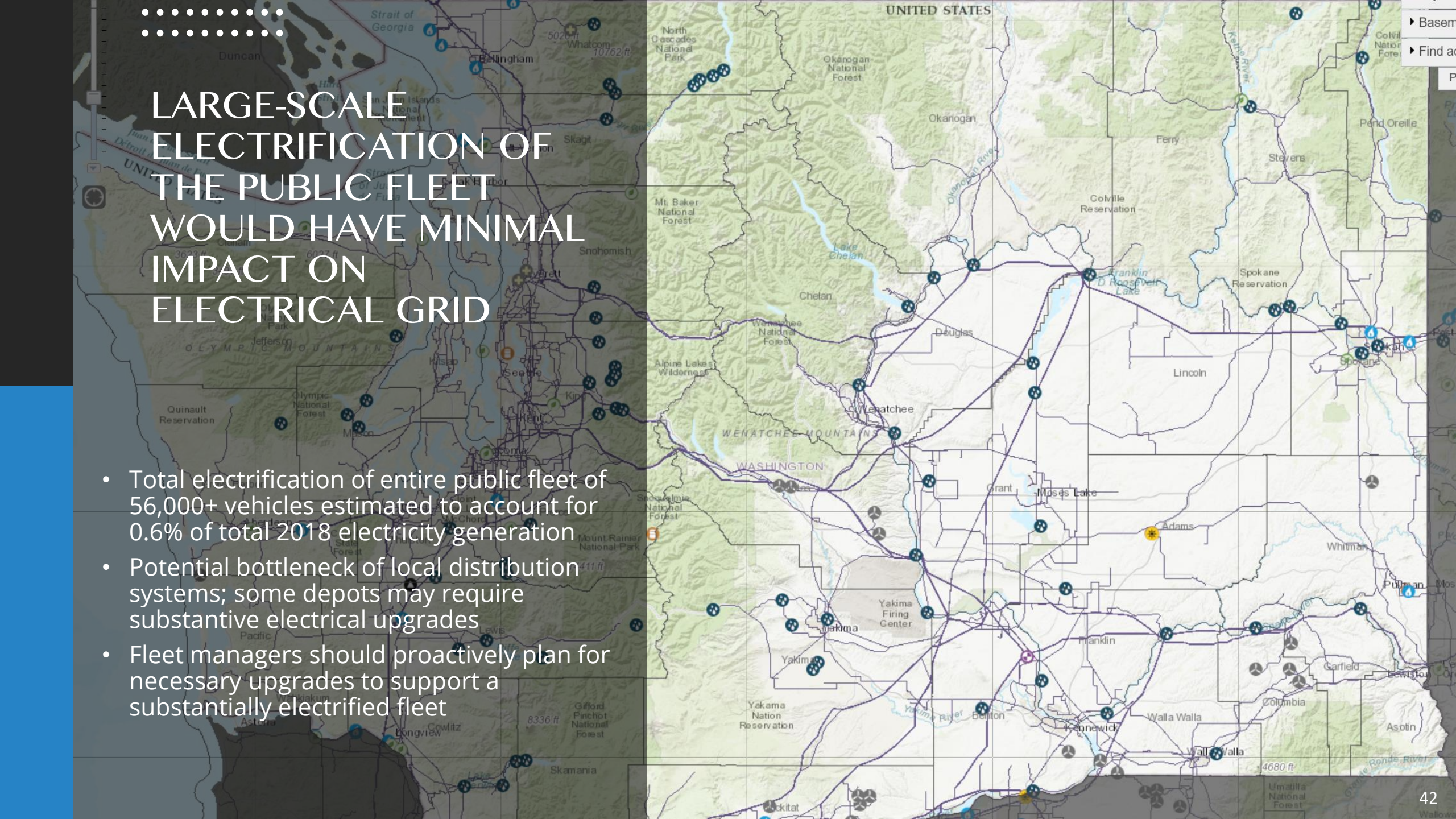
TRANSIT AGENCY FLEET RESULTS



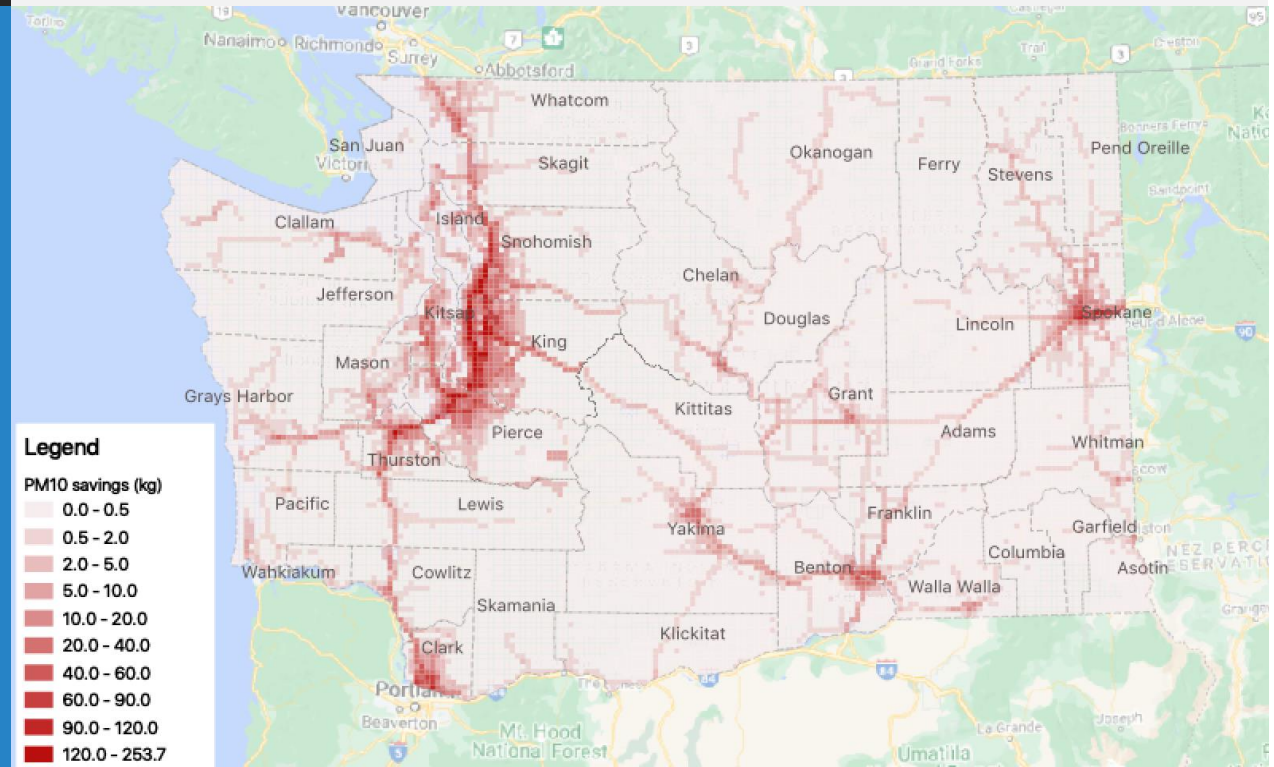
- Nearly all light-, medium- and heavy-duty vehicles will have EVs within 20% of TCO by 2035
- 95% of heavy-duty transit buses meet the 5% threshold by 2035
  - Expected to account for bulk of projected TCO savings

LARGE-SCALE ELECTRIFICATION OF THE PUBLIC FLEET WOULD HAVE MINIMAL IMPACT ON ELECTRICAL GRID

- Total electrification of entire public fleet of 56,000+ vehicles estimated to account for 0.6% of total 2018 electricity generation
- Potential bottleneck of local distribution systems; some depots may require substantive electrical upgrades
- Fleet managers should proactively plan for necessary upgrades to support a substantially electrified fleet



EMISSION REDUCTIONS CONCENTRATED ALONG HIGHWAY CORRIDORS AND DENSE URBANIZED AREAS



- Emissions broken down in a 2x2 mile grid
- Snohomish and King Counties had highest levels of emissions savings followed closely by Pierce and Thurston Counties
- Greater Seattle region a significant beneficiary of fleet electrification
- High traffic corridors (I-5, I-90, I-82) all had significant emissions savings