SEATTLE CITY LIGHT

TRANSPORTATION ELECTRIFICATION STRATEGY

BY LYNN DANIELS AND BRENDAN O'DONNELL

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SUGGESTED CITATION
Lynn Daniels and Brendan O'Donnell, *Seattle City Light: Transportation Electrification Strategy*, Rocky Mountain Institute, 2019, **https://rmi.org/insight/seattle-city-light**

All images from iStock unless otherwise noted.

ACKNOWLEDGMENTS
The authors thank the following individuals/organizations for offering their insights and perspectives on this work:

James Baggs, Seattle City Light
Jaya Bajpai, Seattle City Light
Lynn Best, Seattle City Light
Judy Blinder, Seattle City Light
Darnell Cola, Seattle City Light
Scott Cooper, Seattle City Light
Evan Costagliola, Seattle Department of Transportation
Andrea deWees, Seattle City Light
Kate Engel, Seattle City Light
Seema Ghosh, Seattle City Light
Hutch Hutchinson, Rocky Mountain Institute
Darrin Kinney, Seattle City Light
E.J. Klock-McCook, Rocky Mountain Institute
Paula Laschober, Seattle City Light
Chris Nelder, Rocky Mountain Institute
Andrea Pratt, Seattle Office of Sustainability & Environment
Reagen Price, Seattle City Light
Chuck Ray, Rocky Mountain Institute
Kelly Rula, Seattle Department of Transportation
Shannon Walker, Seattle Department of Transportation

ABOUT ROCKY MOUNTAIN INSTITUTE
Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in Basalt and Boulder, Colorado; New York City; the San Francisco Bay Area; Washington, D.C.; and Beijing.

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EXECUTIVE SUMMARY

The market and policy landscape for transportation electrification is changing rapidly. Every month, automakers are announcing new electric models. Private developers are investing heavily in charging stations. In the heavy-duty sector, improving technologies and government targets are accelerating the electrification of buses, ferries, freight, and fleets. With such rapid change in this space, Seattle City Light seeks to refresh its approach with a clearer understanding of how best to play an enabling role and respond to opportunities as they emerge, while simultaneously aligning with organizational priorities and the broader mobility goals of the City of Seattle.

This work builds on City Light's initial efforts. In 2015, the utility completed a study with E3 Consulting to understand the effects of electric transportation. The study found that there is a net benefit for transportation electrification and that City Light's distribution system can largely handle the increase in projected transportation load. Based on these results, the utility has invested in two pilot programs for residential and public charging.

However, as adoption scales, so too must City Light's market presence and strategic vision. To address this need, this paper examines four primary issues: (1) values framework—the core priorities for City Light that will guide its investments; (2) market intelligence—the state of the electric mobility market; (3) impact to the business—the nuanced impacts of new transportation loads; and (4) recommendations—the interventions that City Light should pursue.

To identify core values, Rocky Mountain Institute (RMI) facilitated a workshop and focused working groups with City Light staff, resulting in three core values—grid, environment, and equity. City Light's goal is to have a portfolio of programs that reflects balance: some may combine all three values while some will be more targeted.

The market intelligence focused on understanding five electric mobility segments: personally owned vehicles, medium-duty trucks, heavy-duty trucks, buses, and shared mobility. Across all segments, battery price is the primary driver of initial cost. Vehicle costs are soon to reach a tipping point as batteries reach $150/kWh in 2019 and manufacturers produce a growing number of vehicle models. Similarly, total cost of ownership will be heavily sensitive to fuel price.

The business impact analysis addressed how scale in these market segments will impact City Light's system. This study updated projections and reconfirmed that personal electric vehicle adoption and distributed fast charging are not anticipated to pose much risk for City Light to accommodate given its current grid capacity. However, spot loads associated with electrified buses or medium- and heavy-duty trucks have the very real potential to overwhelm available capacity and require grid upgrades. As electric bus and truck technologies rapidly improve, these segments are likely to electrify quickly because they are responsive to the favorable economics of electricity as fuel.

Given this state of the mobility market and City Light's core values, we provide the following recommended interventions for City Light to pursue.

EXHIBIT 1

Key Strategies for the Electric Transportation Market

Invest in charging infrastructure with emphasis on universal access and expanding coverage

Continue to drive the robust development of public charging.

- Deploy City Light-owned direct current fast chargers (DCFCs).
- Explore make-ready investments or equipment incentives to support private DCFC deployment.

Support expanded residential and workplace charging with an emphasis on multiunit dwellings and underserved communities.

- Target customers for which cost and feasibility of charging are significant barriers.
- Provide incentives and technical expertise for residential and workplace charger installation.

Support or invest in charging infrastructure for high-mileage applications, including carsharing and ridehailing.

Develop new rates and improve customer service for the transportation market

Pursue rates that meet the needs of electric transportation customers.

- Explore and pilot transportation-specific rate designs.
- Understand the impact of demand charges on large customers and DCFC operators.

Improve core City Light business processes for customers investing in charging.

- Create a streamlined and transparent interconnection and service upgrade process.
- Consider new queues for electric vehicle customers.
- Develop digital content to help customers make informed decisions.

Investigate the viability of managed charging.

- Establish standards for residential smart charging.
- Explore demand-response programs.

Prepare for heavy-duty electrification

Support the aggressive electrification commitments of partner agencies and large customers.

- Partner directly with King County Metro, the Port of Seattle, and Washington State Ferries.
- Develop a deep expertise of customer needs and respond with a broad suite of solutions—responsive rates, incentives, grid infrastructure, technology demonstrations, and siting analysis.
- Proactively plan for large loads.

Anticipate how access to charging will influence urban freight and fleet markets.

- Monitor key market tipping point metrics and engage with local fleets.
- Develop packaged charging solutions, including financing, make-ready investments, smart charging, and charging depots.

1 SEATTLE TRANSPORTATION ELECTRIFICATION—BACKGROUND

SEATTLE TRANSPORTATION ELECTRIFICATION—BACKGROUND

Seattle is experiencing the first wave of an electric transportation awakening. It is among the top metro areas outside of California with more than 8,000 registered electric vehicles (EVs),[1] representing 5% of new vehicle sales. Moreover, policy and environmental goals have moved government agencies and businesses to consider electrification of heavy-duty vehicles, such as buses, freight, and ferries.

Seattle City Light has a vested interest in understanding this market opportunity, thereby leveraging its abundant carbon-neutral electricity. In 2015, City Light completed a study in partnership with E3 Consulting that addressed the role of utilities in accelerating this market and the potential costs and benefits to City Light's system.[2] The study's three primary findings were:

1. There is a net benefit to the utility system of roughly $1,250 per passenger EV over its lifetime. There is also a positive benefit from buses and other modes of heavy-duty transportation.

2. City Light's distribution network can largely accommodate the increase in load from considerable adoption of passenger EVs, although extremely large spot loads like bus-charging bases will remain highly site specific.

3. There is very strong customer demand, particularly for electrification of the shared transportation sector.

Based on this work, City Light's initial role has been to increase access to its carbon-neutral electricity through enabling charging infrastructure, including a commitment to two early market pilot programs: installing and owning 20 DC fast-charging stations and a residential pilot leveraging a lease model to install 200 home charging stations.

Since this initial study, the market and policy landscape has changed quickly, requiring City Light to broaden its approach. The following examples illustrate the pace of change in Seattle's electric transportation market:

- Washington state's passenger vehicle market continues to see strong growth, with 2016–2017 year-over-year market share increasing 31%.[3] To support this, private charging developers, with support from the Washington State Department of Transportation (WSDOT) and the Seattle Department of Transportation (SDOT),[4] are investing heavily in EV charging stations.

- Seattle's major public transit agency, King County Metro (Metro), has established a goal to fully electrify its fleet of more than 1,400 buses by 2040.[5] To date, Metro operates 11 all-electric buses and has plans to procure 120 more by 2020.

- In 2017, the Port of Seattle established a strategic objective to be the greenest, most efficient port in North America, including carbon neutrality by 2050 on both direct and indirect sources of greenhouse gas emissions (GHGs).[6] Supporting this effort, the Port has implemented a Clean Truck program, as a partner in the Northwest Seaport Alliance.[7]

- The City of Seattle has set an ambitious target of 30% EV adoption, along with a commitment to a fossil-fuel-free municipal fleet, both by 2030.[8]

- State legislation, specifically HB 1512 and potential future fuel standards, creates significant financial mechanisms for clean transportation investment from the utility sector.

- The city has committed to environmental equity through its Race and Social Justice Initiative,[9] including a particular focus on transportation equity.[10] As a city department, City Light has deepened its focus on historically marginalized communities and racial equity in its decision-making process.

In addition to changes in the market, City Light has been tasked by Seattle City Council to rethink its rate design and revenue requirement, to be completed by April 2019.[11] Key to this effort will be identifying both new revenue opportunities and cost-reduction opportunities for upgrades to City Light's system.

Therefore, City Light needs a clear vision for how the utility can play an enabling role that is aligned closely with the broader mobility goals of a rapidly developing city. City Light has partnered with Rocky Mountain Institute to investigate the changing transportation electrification landscape and identify a strategic vision. This effort includes team members from across the City Light organization as well as members from the Seattle Office of Sustainability & Environment (OSE) SDOT. This report identifies a set of interventions to best position City Light to take advantage of the opportunity that transportation electrification represents while minimizing risks of under or overinvesting.

OBJECTIVES OF THIS REPORT

- Establish a values framework to guide City Light strategy.
- Assess the electrified transportation market and policy landscape.
- Identify how transportation electrification will impact City Light.
- Recommend high-impact interventions for City Light to pursue.

2 VALUES FRAMEWORK

VALUES FRAMEWORK

Electric transportation has a sweeping set of potential benefits.[12] For City Light, designing and implementing programs, partnerships, and policies requires determining which are most important. In this section, we establish a values framework to ensure that market interventions are aligned to these values on behalf of City Light's customers.

We have identified three core values for City Light—grid, environment, and equity. We define each below and highlight how they can be measured. Recognizing that not all value can be quantified, we highlight possible metrics below to consider and identify data needed to assess impacts.

The goal for City Light is to have a portfolio that reflects balance. Many programs will combine all three values, but some will be targeted. Certain programs might heavily prioritize equity, while some might focus on value to the utility system. However, each value is important and should be reflected in a portfolio approach.

1. GRID

Electric transportation at scale has the potential to bring great value to the electric grid. Vehicle charging can be a highly flexible and shiftable load. As such, it can make better use of the distribution system and integrate more variable renewable generation by matching supply with demand. However, without direction from City Light, these potential sources of value could become risks that ultimately require higher levels of infrastructure investment.

A City Light intervention that demonstrates grid benefit will:

- Ensure that transportation load is flexible and well aligned to the operation of the power system
- Avoid, defer, or minimize infrastructure upgrade costs
- Improve reliability and resiliency
- Deliver revenue sufficient to cover costs to serve transportation customers

Possible metrics to ensure benefits to City Light's grid and ratepayers include:

- Electricity demand and load from electrified transportation
- Available distribution capacity at each feeder
- Utilization of available distribution capacity
- Cost recovery/return on City Light investment

2. ENVIRONMENT

The City has established a goal to be carbon-neutral by 2050. Because transportation emissions account for two-thirds of GHG emissions, the transportation sector must be heavily electrified to meet this commitment. This will require a broad focus on electrifying many modes of transport—fleets, freight and goods movement, personal and shared mobility, marine—to replace petroleum with City Light's carbon-neutral electricity. In addition to carbon and other greenhouse gases, City Light should emphasize pollution from particulates.

A City Light intervention that is beneficial to the local environment will:

- Deliver the largest potential GHG savings benefit
- Prioritize high-usage vehicles and high-capacity modes to increase overall transportation system efficiency
- Positively impact areas with poor air quality or a history of significant environmental impacts

Possible metrics to evaluate and track to ensure benefits to the local environment include:

- GHG emissions reductions
- Electric passenger and freight vehicle miles traveled
- Air quality measures (e.g., particulate matter, ozone), including long-term and immediate exposure to emissions
- Adoption of electric vehicles in fleet and commercial applications

3. EQUITY

Though the City of Seattle has made great strides to be green, it faces the same challenge as the broader US environmental movement: structural and institutional racism continue to keep environmental benefits from reaching all people. It is primarily white, upper-income communities that shape and benefit from environmental policies, programs, and projects; and, it is disproportionately communities of color that are impacted by environmental hazards such as poor air quality and increased climate pollution. Electrified transportation has the potential to enable less costly transportation options and provide economic benefits to marginalized communities. As part of Seattle's commitment to eliminate racial disparities and achieve racial equity, the City launched the Race and Social Justice Initiative (RSJI) in 2004. City Light has additionally committed to advance racial and social justice through its Environmental Equity program.

Social justice is both process and outcome. To that end, an equitable City Light intervention will:

- Expand opportunity and access for underserved communities so that all people benefit from clean transportation
- Promote racially inclusive collaboration, ensuring that all communities are engaged in and have opportunities to lead the decision-making process to set environmental priorities
- Affect systemic change through institutional reform and changes to policies and practices
- Assess community conditions and the desired community impact using citywide tools such as the Racial Equity Toolkit

Possible metrics to evaluate and track to ensure equitable outcomes in underserved and marginalized communities include:

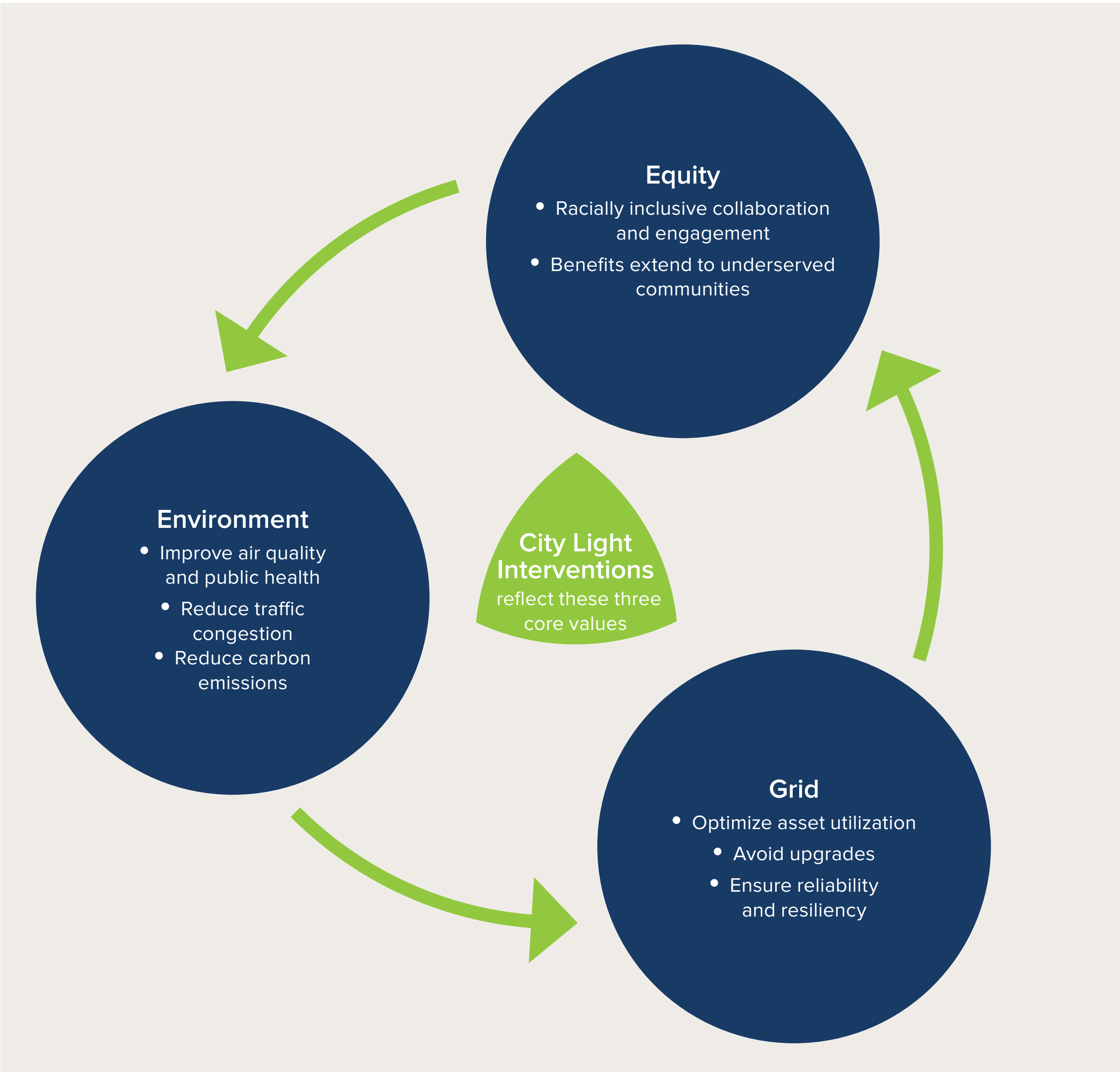
- Air quality measures in environmental justice communities
- Access to electrified transportation modes and charging infrastructure, for example number of residents within a certain distance of public charging
- Number of EV owners in environmental justice communities

BENEFITS TO THE CITY OF SEATTLE

In addition to these three core values, Seattle seeks to maintain its leadership in transportation electrification, ensuring that its clean hydropower is an accessible benefit to all citizens. Positioned to be the largest carbon-neutral transportation fuel provider in the state, City Light can be a catalyst for change for other communities and utilities. Through well-designed, equitable interventions that benefit its grid, ratepayers, and the local environment, City Light can transform the transportation sector through leadership and demonstration.

EXHIBIT 2

City Light's Core Values



3 MARKET INTELLIGENCE

MARKET INTELLIGENCE

In this section, we examine the electric transportation market in 2018 with projections to 2030 in order to identify:

- City Light partnership opportunities
- Interventions where City Light's investment is essential and can be leveraged to have maximum impact
- Interventions where City Light's investment is not needed or duplicative
- Ways City Light can improve EV charging network interoperability—the ability for City Light-owned charging stations to be used by any electric vehicle—and the customer experience

This section will look at trends and forecasts for adoption in five key market segments:

1. Personally owned passenger electric vehicles
2. Medium-duty electric trucks
3. Heavy-duty electric trucks
4. Electric buses
5. Electric, driverless mobility services

EXHIBIT 3

The Five Key Market Segments Examined

PERSONALLY OWNED CARS

The market for personally owned light-duty electric cars is approaching a tipping point where adoption could begin to increase rapidly: 2017 marked the first year with more than 1 million new EV sales globally, with 66% of those being battery electric.[13] EV sales growth in the United States increased in 2018 with a compound annual growth rate of 81% despite domestic fuel prices remaining low and changes to the policy environment.[14]

The global battery-electric vehicle market is likely to continue its growth as automakers respond to more aggressive emissions targets and diesel bans in Europe and China, with global sales forecasts ranging from to 5.7 million to 30 million units sold annually by 2030.[15] Several market factors are shaping US demand for electric cars:

- **Electric vehicle model availability.** In the United States, the vast majority of available EVs—and thus sales—are small or midsize models (Tesla Model 3, Tesla Model S, Chevrolet Bolt, and Nissan Leaf are the highest sellers) with very few SUV or crossover options. In contrast, 45% of overall car sales in the United States are crossovers and SUVs. This is important because buyers will likely consider an EV purchase only if the vehicle fits their preferences and lifestyle. As a result, automakers have committed to electrify up to 289 vehicle models[16] (including many crossover and SUV models) and invest at least $90 billion in EV technologies over the next several years.[i]

- **Upfront cost.** Lithium-ion battery pack costs continue to drop, averaging $176/kWh in 2018 and projected to reach $150/kWh or less in 2019,[17] resulting in the upfront costs of EVs reaching parity with internal combustion engine vehicles on an unsubsidized basis by 2024.[18] That being said, parity in cost is insufficient to motivate customers to change technologies and incentives will continue to be an important policy lever.

- **Charging infrastructure.** Availability of public charging infrastructure could become a bottleneck that stalls market growth. Fortunately, the range of new EV models is typically greater than 200 miles per full charge, helping to eliminate range anxiety as a barrier to adoption; and roughly 60% of US households are detached single-family homes where home charging will be the most economical charging option.[19] However, public charging will be driven by several needs: long-distance trips that exceed a vehicle's range; dense urban centers with limited parking space; and multiunit dwellings, where home charging is typically unavailable even with parking.

Because personally owned vehicles (POVs) are most likely to see strong adoption in the near term, the question of *how* they are charged—Level 2 versus direct current fast chargers (DCFCs)—will be of paramount interest for City Light and other utilities. In terms of charging speed, Level 2 charging will likely meet many EV owners' charging needs at home or workplace in the near term and the majority of chargers deployed to date have been Level 2. Moving forward, significant effort is focused on DCFCs, which have much higher installation and operating costs. Tesla, in particular, has built a nationwide network of fast charging stations for its customers, and EVgo recently installed its 1,000th fast charger. However, the national network of public chargers has large gaps.[20]

Two important trends point to a greater need for both public and fast charging options: (1) to support

[i] Mercedes-Benz AWD electric SUV EQC will be available in the United States in 2020; Jaguar's i-Pace SUV in 2019; Tesla is shipping its Model X 75D; Audi is taking reservations for its electric E-Tron SUV; BMW announced its all-electric iX3 SUV for 2020. All models are expected to have more than 200 miles of range, charge up to 150 kW, and be priced in the $70K–$80K range.

new EV models with larger batteries and range, many drivers will demand a charging experience similar to refueling at a gas station (especially for cross-country travel where rapid recharging will be necessary); and (2) to enable EV adoption at scale for multiunit dwellings, the need for publicly available infrastructure will be all the more essential, since these households are less likely to have access to garage or off-street parking.[ii]

In addition to third-party charging infrastructure operators—such as ChargePoint, EVgo, Blink, Tesla, Greenlots, and SemaConnect—more utilities are beginning to invest in public charging infrastructure. California's three largest investor-owned utilities (SDG&E, SCE, and PG&E) have submitted plans to support 60,000 Level 2 chargers and 234 DCFCs.[21] Significant additional investment is needed over the next decade in public charging to meet demand, upward of 20 million chargers at a cost of $10 billion, with about one-third being public.[22]

- **Policy.** Policies can significantly impact the adoption of EVs in the United States, particularly by reducing the purchase costs for consumers, requiring public agency fleets to buy EVs, setting state targets for EV adoption, and encouraging and/or requiring automakers to manufacture more zero-emission vehicles. In the near term though, the US Environmental Protection Agency is likely to relax its vehicle emission standards; several states, including Washington, have joined California's lawsuit to preserve their right to set higher emissions standards.[23] The US federal government offers a tax credit up to $7,500 for an EV purchase, but the three automakers representing the majority of US sales (Tesla, GM, and Nissan) are reaching the number of vehicles eligible for the full tax credit.[24] Additionally, many states have tax credits or rebates available, including Washington's sales tax exemption reauthorized in 2019 by SHB 2042.[25]

As these factors shape the US market, individual states are taking the lead in accelerating EV adoption. Washington state has the third-highest total annual sales and share of new vehicle sales that are electric with 7,068 EVs sold in 2017. With the majority of these sales in Seattle, the city is in a leadership position for car electrification. Further, Seattle's electricity–gasoline price differential is more favorable to EVs: Seattle has one of the lowest electricity rates in the nation (~$0.111/kWh) and the third-highest gasoline prices in the nation ($3/gallon in January 2019);[26] this improves operational cost savings for EV owners, resulting in average annual savings of $1,250 per vehicle.[iii] Washington state ranks fourth in absolute terms of public charging availability with 1,861 chargers, 9% of which are DCFCs.[27]

Using several years of EV registration data from Washington's Department of Licensing, City Light has developed a methodology to create business-as-usual (BAU), aggressive, and conservative forecasts for the adoption of personally owned all-electric vehicles in Seattle.[iv] As a standard approach for modeling

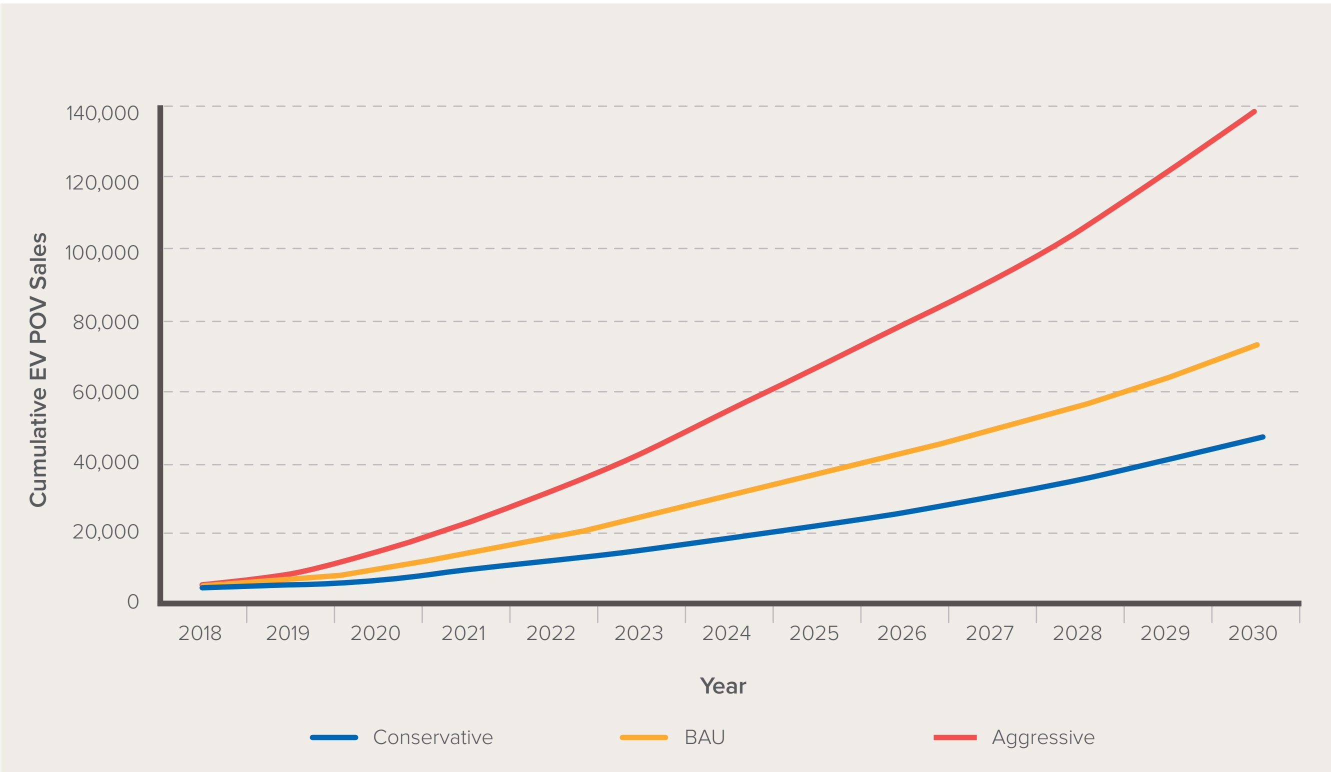
[ii] Unlike single-family homes, multiunit dwellings have a split incentive since a property manager would likely need to install, own, and operate on-site charging infrastructure. Property managers are unlikely to invest unless it puts them at a competitive advantage. This chicken-and-egg problem will perpetuate the demographic disparity in EV ownership as lower-income individuals live disproportionately in multiunit dwellings.

[iii] Assumes 3.5 miles/kWh for EV and 25 miles/gal for gasoline vehicle, for 12,000 miles traveled.

[iv] We explore only battery-electric vehicles as these will have a more significant impact on City Light's grid than plug-in hybrids. Recent announcements by GM and other market trends also indicate that, as more EV models are produced, consumers will shift away from hybrids (https://www.greentechmedia.com/articles/read/why-general-motors-is-ditching-the-chevy-volt#gs.9=31pWo).

EXHIBIT 4

EV POV Forecasts for Seattle City Light Service Territory



the adoption of new technology, City Light uses a generalized Bass diffusion model based on historic adoption rates of comparable technologies.[v] The resulting forecasts are shown in Exhibit 4. With the most conservative set of assumptions, City Light will see a nearly 10-times increase in the number of POVs charging within its service territory, to 50,000 vehicles by 2030. Using more aggressive assumptions, adoption may reach 140,000 vehicles by 2030. With that number of vehicles representing new annual load ranging from 117,000 MWh to 344,000 MWh, the charging behavior of the owners (e.g., off-peak at-home charging versus fast charging during peak hours) will be critically important.

[v] For the conservative case, City Light uses the historic Seattle EV market growth rate of 1.7%; for the aggressive forecast, the adoption rate of diesel cars in Europe; and the BAU forecast uses parameters averaged across the historical EV, hybrid, and European diesel car adoption. Another key input is price elasticity: City Light assumes a 4% increase in adoption for every 1% decrease in EV price.

MEDIUM- AND HEAVY-DUTY TRUCKS

Battery-electric medium- and heavy-duty trucks (MDT and HDT)[vi] are either on the road or nearing production today and are increasingly viable as a replacement for diesel commercial vehicles. Compared to electric cars, these vehicles have larger batteries and will likely charge in more concentrated geographical locations, resulting in higher potential impact on City Light's distribution grid. But, adoption of electric trucks is at a very early stage and will vary greatly depending on the specific use case for each vehicle. We have identified several important market factors that will influence truck electrification:

- **Total cost of ownership.** Fleet purchasing decisions, in contrast to personal vehicles, place greater weight on economics; in particular, whether the total cost of ownership (TCO) for an electric truck is less than that of a diesel. TCO is a function of many variables, including:
  - battery cost, density, and durability
  - production scale of electric trucks, since truck initial costs will fall as production scales up
  - the differential between electricity and diesel costs
  - use case (for example, short-haul or long-haul routes)
  - charging needs (for example, whether or not fleets can manage charging to minimize electricity costs)
  - costs to upgrade grid infrastructure borne by fleet operators
- **Charging infrastructure.** The availability of charging infrastructure will constrain which use cases are economically viable. For example, long-haul applications where daily miles traveled exceed battery capacity mean that trucks must fast charge on-route. To be viable, long-haul applications require a network of truck "mega-chargers"[28]—a technology still in development—to enable these use cases. By contrast, short-haul trucks where battery size is matched to daily miles traveled can return to a centralized depot for overnight charging.
- **Policy and regulatory environment.** Policies such as diesel bans and fuel economy mandates can drive adoption if they are well designed. As a cautionary tale, the Port of Seattle adopted emissions standards in 2008 that would require all drayage trucks to have a model year 2007 or later engine by 2018.[29] Currently, this emissions standard requirement is at 53% compliance, in large part because independent truck operators cannot afford new trucks (whereas large fleet operators have already upgraded their trucks). It is important that policies designed to support truck electrification take into consideration the actual use cases and ownership models to ensure greater compliance and success.
- **Fleet risk tolerance.** Larger fleets may adopt electric truck technologies more quickly because owners may have greater capital availability than smaller fleets and independent operators. However, the industry is generally conservative when adopting new technologies, often requiring established credibility through demonstrations. As such, truck electrification is likely to begin with small-scale production and pilots.
- **Model availability and manufacturer response.** Many electric trucks today are being produced on a small scale by start-ups whereas fleets may prefer that traditional manufacturers produce the vehicles.[30] As such, model availability will likely constrain adoption in the near term even if total cost of ownership reaches parity with diesel trucks for many use cases. Many traditional manufacturers are focusing on electric light-duty trucks due to the similarity of technology to passenger vehicles though many have announced plans to produce medium- and heavy-duty electric trucks.

[vi] For this report, medium-duty trucks are considered Class 3–7 vehicles, with a gross vehicle weight rating from 10,001–33,000 pounds. Heavy-duty is considered Class 8 with gross vehicle weight rating of greater than 33,000 pounds.

What these factors point to is that electric trucks will be viable for certain use cases earlier than others. In particular, MDTs and HDTs with short-haul local and regional routes represent the best early adopter business case to electrify: they carry predictable weights over shorter, local routes; they return to the same distribution center at the end of the day where they can be charged overnight; and battery size can be matched to typical route length to minimize upfront costs. Long-haul routes, especially those served by HDTs, may be the last segment to electrify due to weight and range constraints. Trucks on typical long-haul diesel routes drive 200–500 miles a day, requiring on-route mega-chargers along major freight corridors.

Seattle is in a unique position to lead on truck electrification. In general, US diesel cost is low, meaning TCO parity is more difficult to obtain for electric trucks.[31] Seattle's comparatively low electricity prices, however, shift the electricity-diesel cost differential in favor of electric trucks and may drive greater local adoption compared to the rest of the United States.

Forecasts for the adoption of electric MDTs and HDTs are fairly speculative today and serve primarily to highlight a range of possible outcomes for which Seattle City Light should be prepared. Our approach estimates business-as-usual (BAU), aggressive, and conservative scenarios for the percentage of MDT and HDT truck sales that will be electric by 2030 based on the following:

- NACFE and McKinsey estimate a range of dates when TCO parity with diesel will be reached.[32] We use this range as the starting point for when sales begin, with BAU adoption beginning at the middle of the range.
- We estimate a range of 10%–20% of MDT sales and 0%–2% of HDT sales in 2030 will be all-electric, based on the highest and lowest sales projections from several sources.[33]
- We assume linear growth in sales.

PORT AND FERRY ELECTRIFICATION

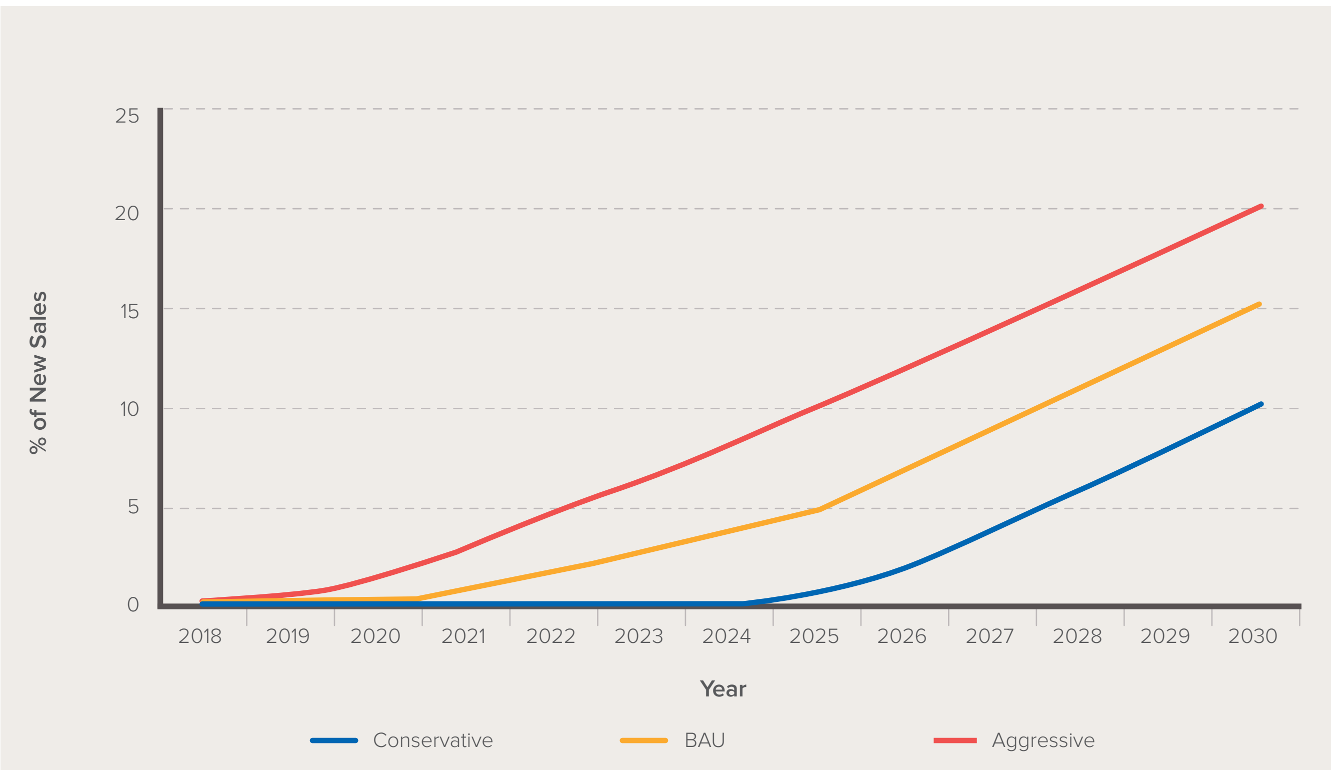
The Northwest Seaport Alliance (NWSA)—comprised of the Ports of Seattle and Tacoma—established a goal to reduce diesel particulate matter by 80% by 2020 and greenhouse gas emissions by 15% by 2020. With more than 4,400 trucks representing 28% of GHG emissions at the Ports, cleaner trucks and cargo-handling equipment are a core component of that strategy. As of 2016, 40% of trucks were model year 2007 or newer, meeting emissions standards.[34] Although currently there are no explicit goals for truck electrification, City Light should stand ready to lead or support any NWSA programs to electrify vehicles at the Port of Seattle.

Ferry electrification is poised to move forward in 2019. The Washington State Department of Transportation ferry system is the largest in the nation and represents more than 50% of air pollution from harbor vessels. In parallel with the installation of charging infrastructure, a phased approach will enable all ferries to run fully on electric power by 2023. The power and energy requirements for these vehicles—an electric ferry launched in Norway was equipped with a 1 MWh battery with 1.2 MW fast charging—will require close partnership with City Light to ensure a successful fleet transition.

The most aggressive assumptions for medium-duty trucks, based on Washington State Department of Licensing data for new commercial vehicle registrations,[vii] suggest 1,300 electric medium-duty trucks operating by 2025 with more than 4,000 in operation by 2030. The most conservative set of assumptions results in negligible adoption through 2025 growing to 1,100 medium-duty electric trucks operating by 2030. For heavy-duty trucks, all forecasts project a negligible number of operating vehicles through 2030.

EXHIBIT 5

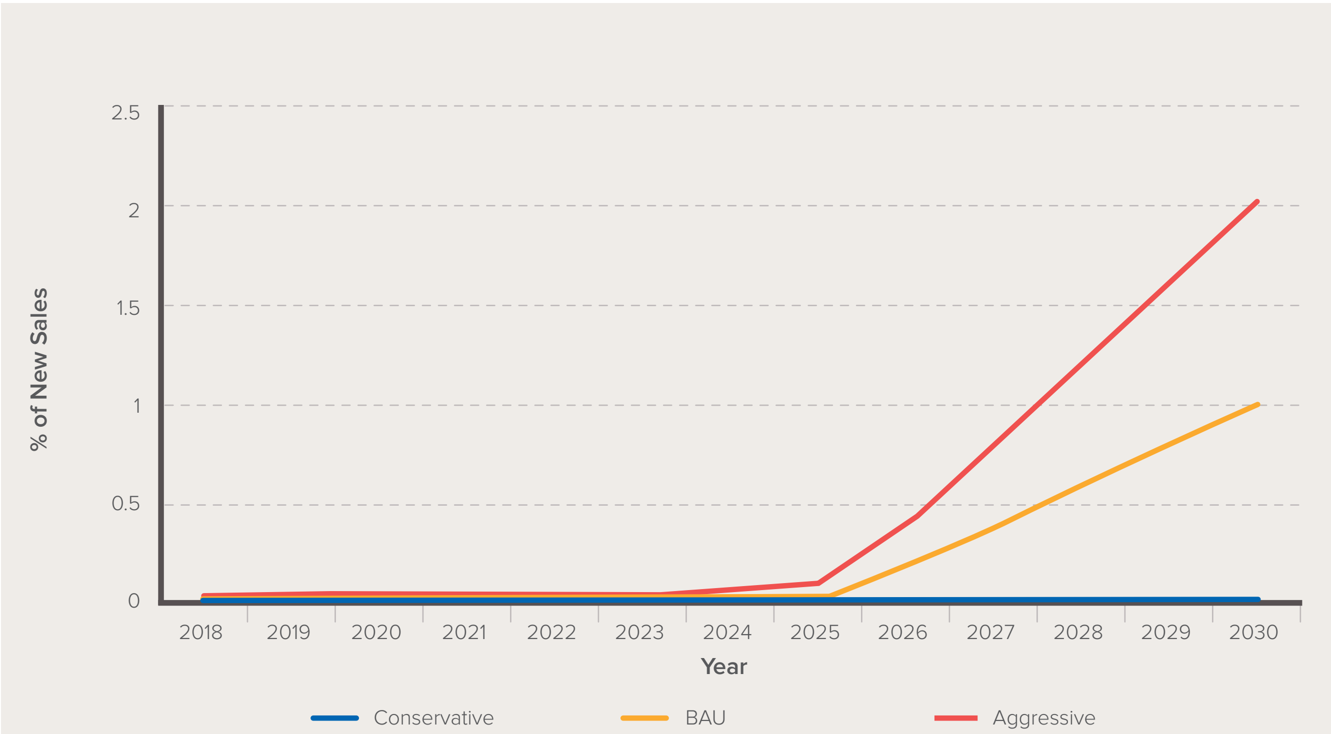
Forecasts for the Adoption of Medium-Duty Trucks in the Seattle City Light Service Territory



[vii] Washington State Department of Licensing data does not report truck class, so we assume that Class-8 trucks represent approximately 7.5% of annual sales of all commercial trucks.

EXHIBIT 6

Forecasts for the Adoption of Heavy-Duty Trucks in the Seattle City Light Service Territory



ELECTRIC BUSES

Bus electrification is driven by similar market factors as for MDTs and HDTs, with several key differences:

- The higher upfront cost of electric buses—$750,000 compared with a diesel bus at $435,000[35]—can potentially be offset by lower fuel and maintenance costs. However, the structure of electricity tariffs, in particular demand charges, strongly influences total cost of ownership for electric buses and, in some cases, can make them more expensive than diesel.

- Bus adoption may be driven by policy as cities could accept these higher upfront costs in favor of meeting environmental goals. In fact, many cities and transit agencies are announcing aggressive bus electrification goals (though actual procurement has been cautious with less than 1% of the total US bus fleet all-electric[36]).

- There are some examples of technological or operational challenges, with electric buses unable to meet advertised range in certain climates and weather conditions or utilized on a route for which they are poorly suited. These may be isolated incidents, though, as transit agencies overcome the learning curve of adopting a new technology.

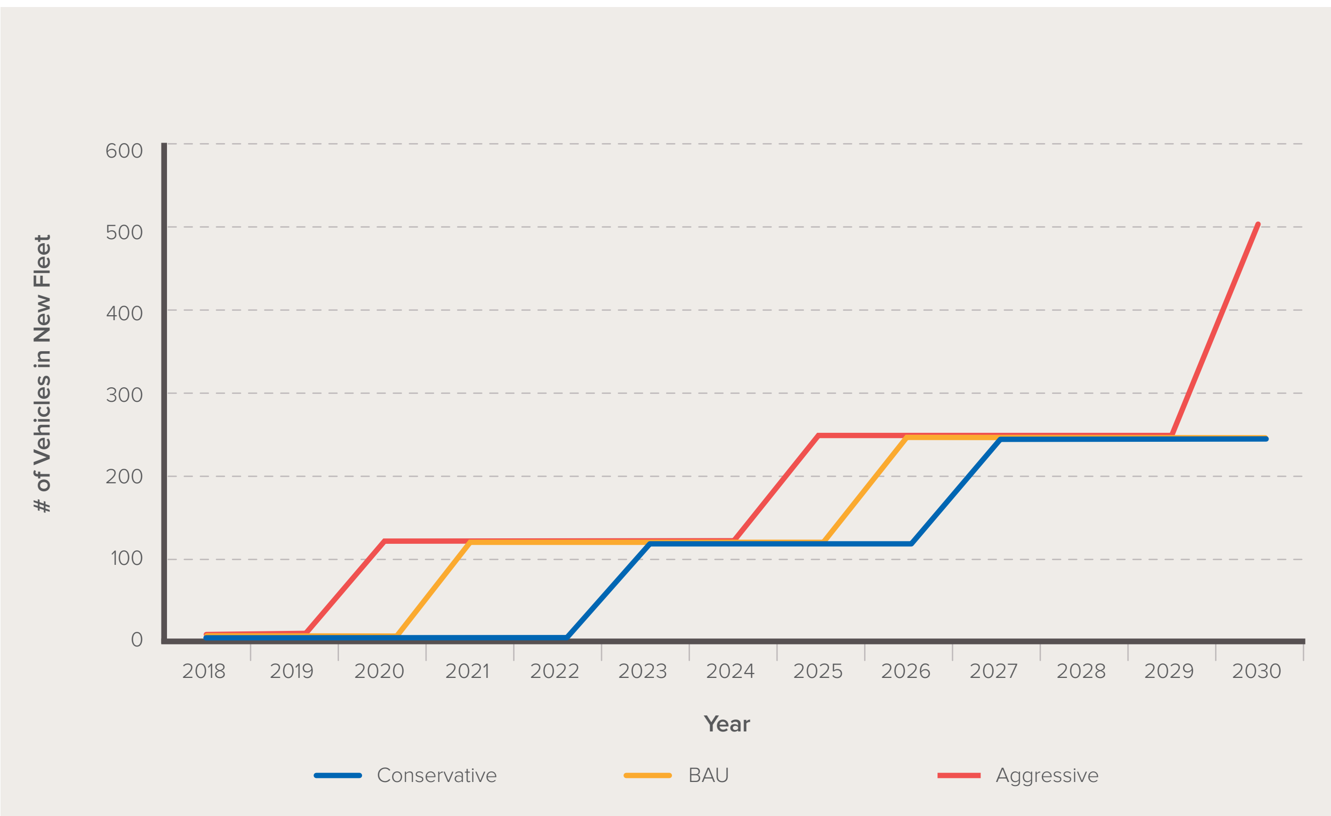
- Currently, 14 manufacturers are making electric bus models, including shuttle buses, double-decker buses, and articulated buses, indicating that the technology is available for increased adoption.[37]

Despite these challenges, buses represent an ideal use case for electrification, similar to short-haul MDT applications. The average city bus travels 140 miles per day on a fixed route and returns to a centralized depot for overnight charging, so battery size can be matched to daily needs.

Seattle's public transit agency, King County Metro (Metro), is a national leader in reducing emissions from its fleet and has a goal of full fleet electrification by 2040.[38] Metro has operated at least three electric buses since 2016 and will pilot an additional nine in 2019, with a commitment to purchase 120 by 2020. To project the adoption of electric buses in Seattle, we developed BAU, aggressive, and conservative forecasts based on these commitments as well as proposed interim goals.[viii] In particular, the BAU case assumes the electrification goal is met by 2040, the aggressive case by 2034, and conservative case by 2045.

EXHIBIT 7

Forecast for Number of Electric Buses in Seattle City Light's Service Territory to 2030



[viii] Conversation with Danny Ilioiu. Proposed interim goals for KCM fleet electrification include: one bus base with 250 all-electric buses by 2025, and a second bus base with 250 additional buses by 2030.

DISRUPTION—SERVICE-BASED DRIVERLESS MOBILITY SERVICES

The possibility of fully autonomous vehicles has been receiving a significant amount of news coverage in the past few years, especially as mobility services such as Uber, Lyft, Car2Go, Zipcar, and others have been rapidly growing. Prognosticators in this space foresee a wide range of possible outcomes,[39] from vehicle ownership being replaced by driverless robotaxi services to meet all personal mobility needs, to a suite of mobility options (scooters, bikes, cars) that complement public transit and provide first- and last-mile options, to some coexistence of ownership- and service-based mobility paradigms.

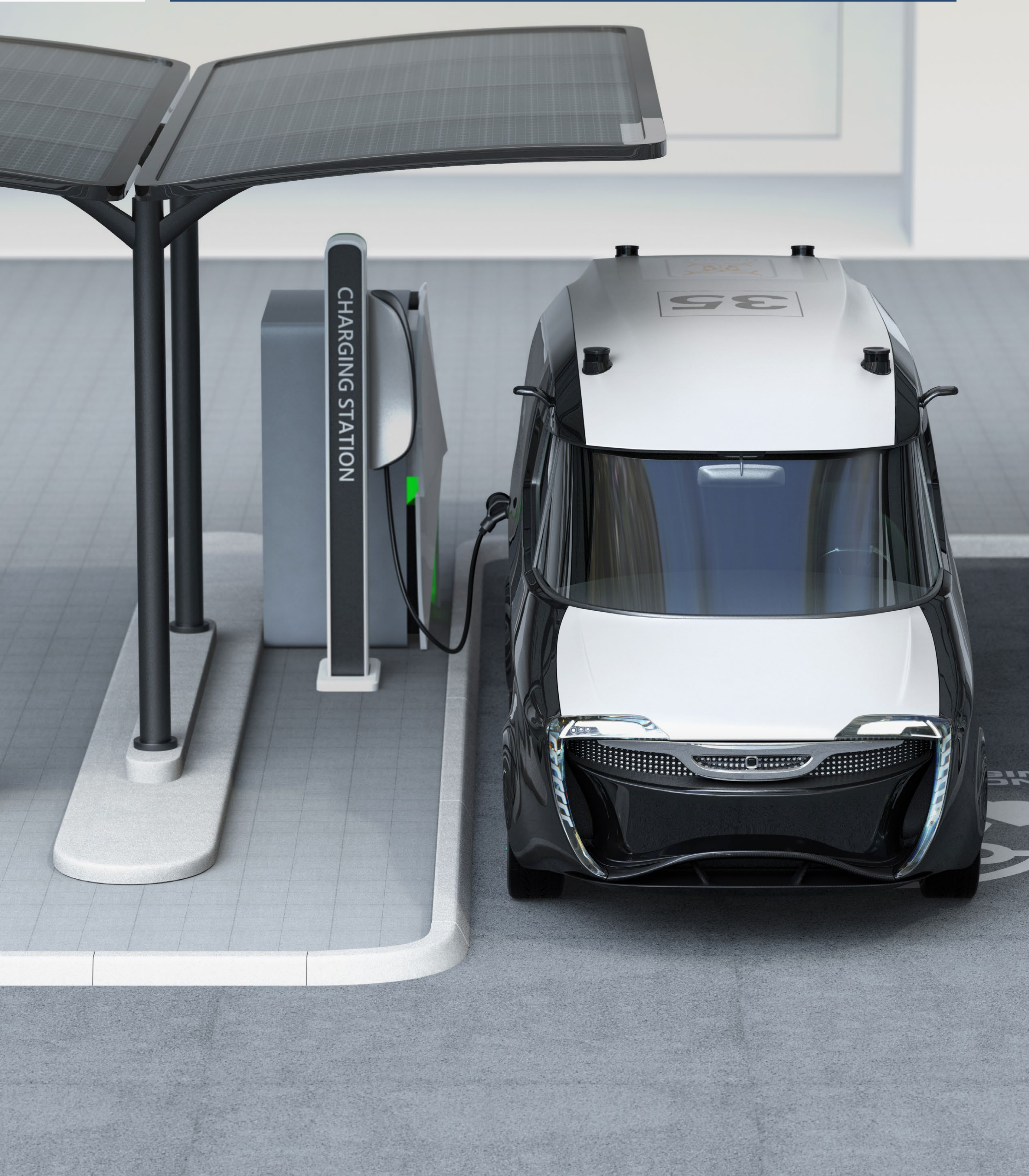
Autonomous, electric mobility-as-a-service has the opportunity to reduce personal mobility costs while creating trillions of dollars in new business opportunities and consumer savings. And this concept of an always-available fleet of robotaxis will result in higher utilization of the vehicles themselves (more miles traveled), while potentially requiring far fewer vehicles to serve a population's mobility needs (though this may depend on a user's willingness to share rides).[40] With these business models built around a centralized fleet operator, financial considerations will be key to decision-making and there will be a strong incentive for fleet operators to own all-electric fleets: operating expenses are the most important cost with high utilization vehicles, as operating costs can be significantly reduced.[41]

City Light has an opportunity to support electric, autonomous mobility services as new, predictable revenue streams where charging load can be managed and optimized directly through relationships with fleet operators. Further, because many of these fleets will be light-duty vehicles, the per-vehicle grid impact is much less than that of electric trucks and buses.

Forecasts range widely on how this future plays out—from 95% of passenger miles service-based by 2030 to similar outcomes not being realized until the late 2030s (or later).[42] At this time, it's unclear how the load of robotaxis might affect City Light's grid. What is clear is that Seattle-specific data shows consistent growth in ridehailing usage and associated vehicle miles traveled. Combined trips using Uber and Lyft have more than doubled between 2016 and 2018, topping 7 million trips during the first quarter of 2018. More data and pilots will be required with EV fleets in the future to understand how to optimize charging times while ensuring accessible vehicles for all trips on ridehailing services.

Given the early stage of this market segment, the results of pilots and success of new companies in this space has been mixed. For example, despite significant growth, Uber and Lyft are not yet profitable and have had several regulatory battles with cities in the US;[43] pilots with microtransit start-ups have had low ridership;[44] and a high-profile death caused by a driverless vehicle has called into question the readiness of autonomous technology for on-road pilot programs.[45] Despite these hurdles, there is significant global interest in the autonomous mobility future and its potential benefits. City Light should pay close attention to how this segment evolves over time to take advantage of opportunities to electrify these services.

4 IMPACTS TO SEATTLE CITY LIGHT



IMPACTS TO SEATTLE CITY LIGHT

We examine how electrification will affect City Light so that we can understand how to address the associated risks, as a continuation of E3 Consulting's cost-effectiveness study completed in 2015. We emphasize three types of impact:

1. Impact of transportation electrification loads on City Light's grid
2. Financial impacts, especially limiting the need for system upgrades
3. Customer service impacts, including changes to City Light operations

IMPACTS OF POV ELECTRIFICATION

To estimate the impacts of increased adoption of electric POVs, we extend the hosting capacity analysis from City Light's prior study with E3. Using EV registration data for each zip code in City Light's service territory, we assume that the number of EVs registered in each zip code, as a percentage of EVs in City Light's service territory, stays constant through 2030.[ix] Using our electric POV adoption forecasts, we estimate how many EVs will be sold in City Light's service territory each year then allocate these new EVs by zip code accordingly, out to 2030.

We base our analysis here on City Light's current distribution planning. This assumes a managed charging load profile, such that the vast majority of new EV load growth occurs during off-peak hours. Most charging is via Level 2 chargers and assumes a demand of 6 kW per vehicle. We note that this represents an optimal set of assumptions as new Level 2 chargers allow for 21 kW charging and we cannot know how customers will actually charge their vehicles. However, City Light's prior study with E3 examined in detail the revenue and cost difference between managed and unmanaged POV charging, and even unmanaged charging resulted in a net benefit to City Light.

The results of this analysis suggest that, for residential charging based on these assumptions, there will be minimal impact to City Light—in fact, there will be a net benefit, based even on our most aggressive POV adoption forecasts. There is, however, great uncertainty with this conclusion, and City Light will need to continually reexamine this result and proactively facilitate managed charging behavior. First, charging patterns and behaviors may change over time resulting in more charging events during peak hours or more drivers may prefer DCFCs. As electric vehicle supply equipment (EVSE) networks are built, the relative utilization of DCFCs versus Level 2 chargers will be an important metric to track. Second, some neighborhoods could see much greater adoption than anticipated, leading to a geographic concentration of charging loads.

With more and more City Light customers owning electric vehicles, the experience City Light offers for these customers will be an important consideration. This could include tailored customer service options such as EV-owner customer connection queues as well as new revenue opportunities through specific EV rates or packages for EV owners that might include support for on-site solar and/or storage.[x] These service offerings will have to be balanced with the potential need for additional customer support staff and associated costs to serve this new customer base.

There are significant positive impacts to City Light as well. Given City Light's ongoing rate redesign and

[ix] We recognize the deficiencies of this assumption as it does not take into account population growth/shifts or that as EV costs go down, lower-income communities may increase adoption relative to today. And of course, City Light programs can explicitly target Seattle neighborhoods with lagging EV purchases to accelerate adoption.

[x] Seattle City Light has designated queues for customer types (i.e., residential or commercial) with the potential to add new queues for new customer types.

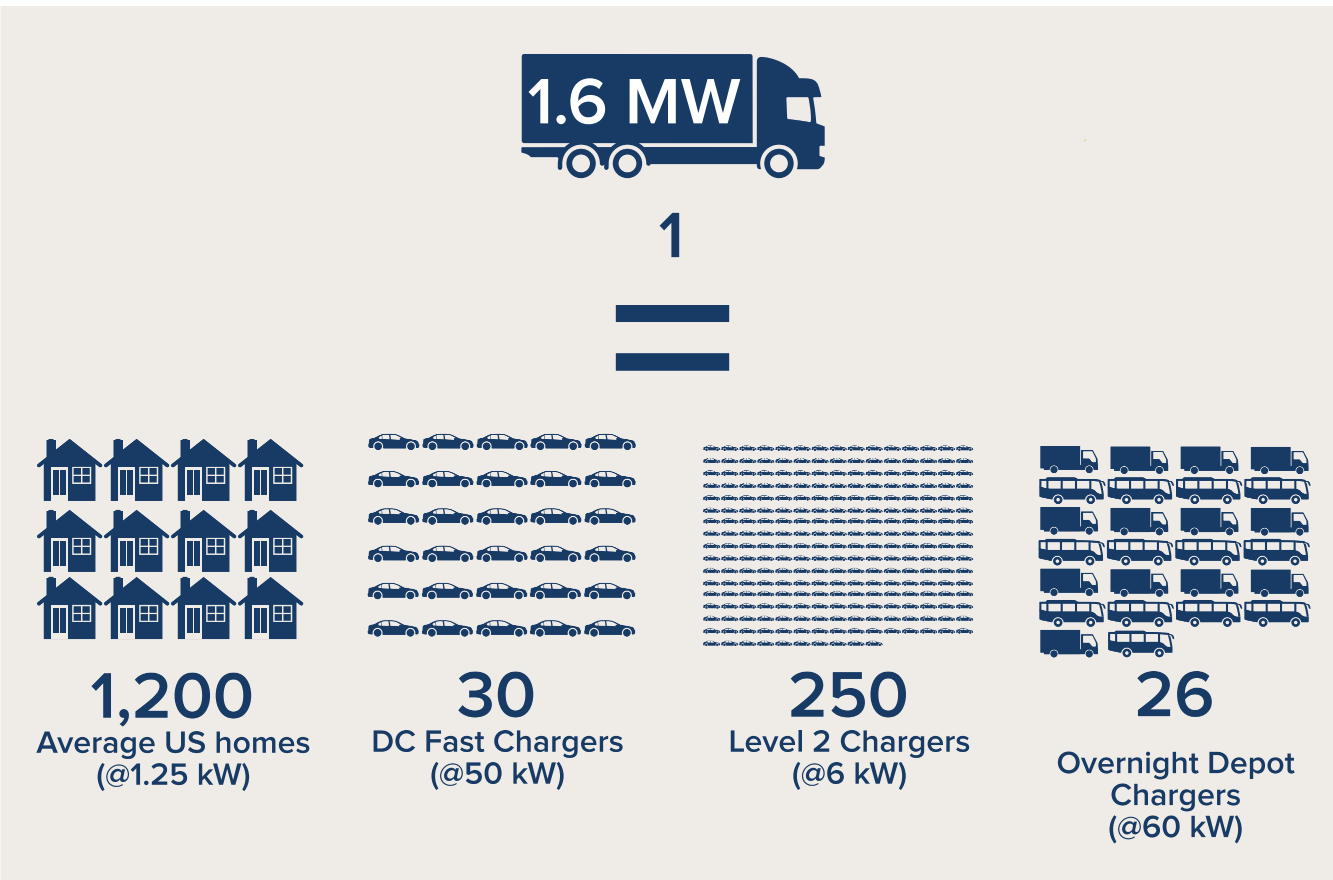
imperative to decrease rates, new revenue streams are needed to create downward rate pressure. In theory, EVs can put downward pressure on rates because of increased utilization of utility assets, with revenue from load growth exceeding costs. And since City Light's generation mix is predominantly hydropower, the emissions profile of EVs charged on City Light's grid has lower carbon and other greenhouse gas emissions compared with grids in other cities and states.

IMPACTS OF MEDIUM- AND HEAVY-DUTY TRUCK ELECTRIFICATION

Although trucks nationally represent only 4% of registered vehicles,[46] the impact of truck electrification to City Light may be significant. We demonstrate this in Exhibit 8, which shows the electricity demand for a single HDT mega-charging event compared with that of other appliances or vehicles.

EXHIBIT 8

Power Requirements (kW) of *One* Class-8 Truck "Mega-charging" Event (1,600 kW) Compared With Power Requirements of Other Vehicles and Homes



Electric trucks offer a double-edged sword in terms of their impact to the grid: they are likely to concentrate in industrial areas of cities making load planning simpler, but they draw significantly more power per charging event than POVs, potentially straining distribution grid capacity at those locations. If planned well, electric buses can improve grid asset utilization and present a new source of predictable revenue.

As noted above, fleet managers respond well to price signals that impact the total cost of ownership of their fleets. Many electric truck fleets will require their own infrastructure, which may make upfront costs prohibitively costly and require new financing mechanisms that reduce these costs for fleets. These costs and financing challenges may emerge as bottlenecks that slow overall truck electrification.

Utilities have a suite of tools that can be deployed to help accelerate and appropriately plan for truck electrification (in particular by influencing total electricity costs that can make or break the total cost of ownership for electric trucks). These include demand-charge relief, time-of-use rates, or other price signals to maximize off-peak charging, and innovative financing for on-site solar and/or storage at fleet charging depots. It is, however, uncertain how effective these approaches will be because, unlike POVs, electric trucks must charge according to vehicle operation schedules and electricity price signals may not be able to shift charging to off-peak hours. And, pairing electric truck charging depots with on-site solar and/or storage or smart charging systems will significantly increase upfront capital costs for fleet operators.

Because of the early stage of this market, it is difficult to estimate specific truck and ferry electrification impacts on City Light. Instead, we use the following approach:

For short-haul routes (primarily MDTs[xi]):

1. Assume trucks with 100 kWh batteries charging at a 20–60 kW charge overnight at a centralized distribution center, for a typical 100-mile daily route.

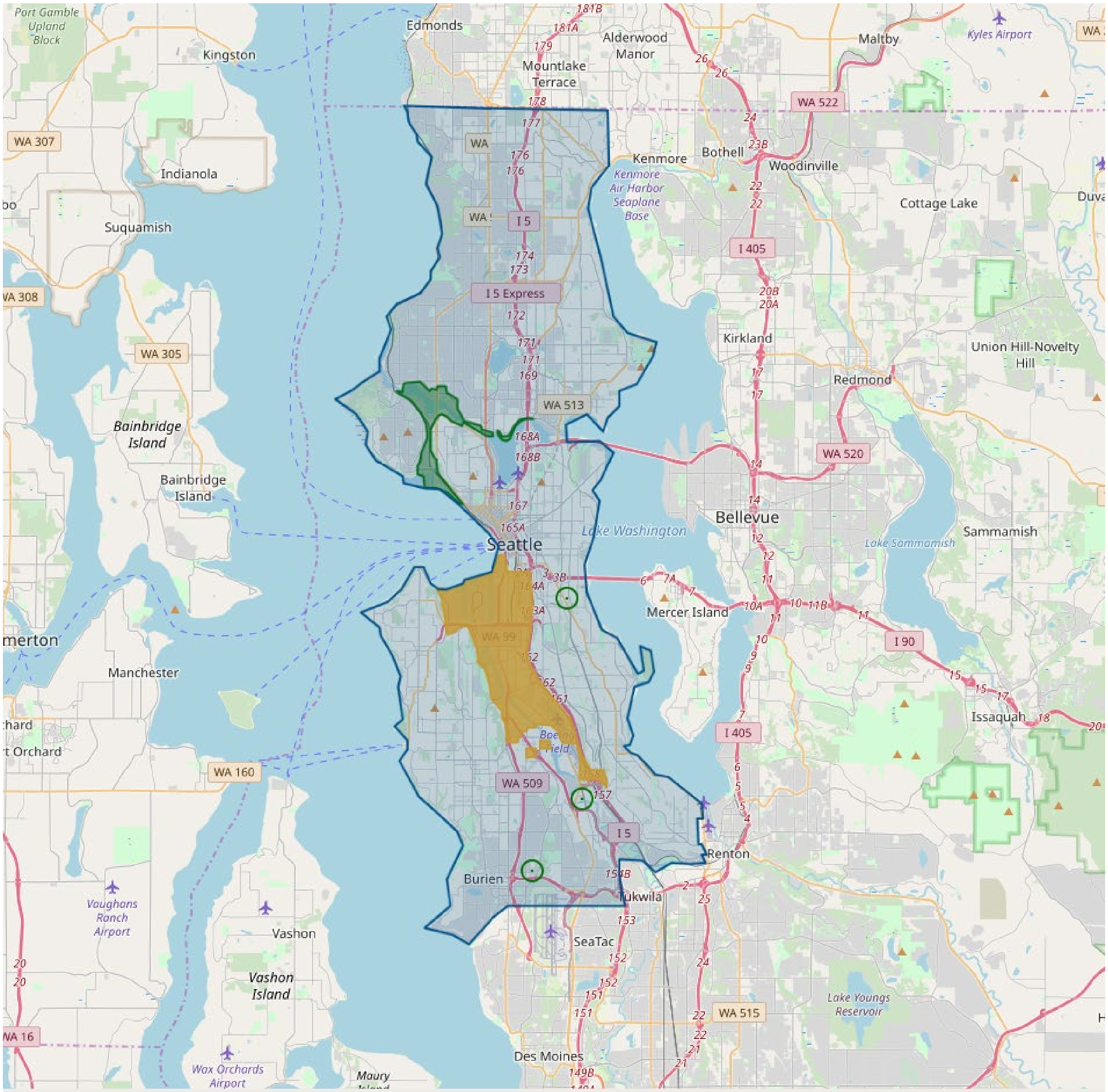
2. Identify the location of most distribution centers and warehouses in Seattle (as a proxy for where charging will occur overnight) and identify distribution grid feeders assigned to these geographies. As shown in Exhibit 9, MDT charging will likely occur in Seattle's two large manufacturing and industrial centers (MICs): Ballard/Interbay Northend and Greater Duwamish (which includes the Port of Seattle).

As shown in Exhibit 10, we identified 61 feeders assigned to either the Duwamish or Ballard/Interbay MICs, 15 of which are at or above 90% loading. Based on the above assumptions, a large fleet of 200 medium-duty trucks charging overnight at a single depot will draw 4–12 MW. Since feeders and substations can be reconfigured to balance loads, fleets requiring 4 MW for overnight charging are likely to have minimal impact on City Light's grid. We note that capacity is only one indicator of impact on City Light's system, and other upgrades may be required even if there is available capacity. For example, at 4 MW for a single installation, there may be need to reconductor a lateral with an estimated cost of $1,000/foot of overhead installation or $1,500/foot for underground installation. However, for fleets on the higher end of the range (above 10 MW), system impact studies will be required as this size load may require a dedicated feeder.

[xi] We note that HDTs are used for short-haul routes as well; however, depending on the route, fleet operators will be able to optimize battery size, so charging patterns and power demand will likely be comparable to MDTs.

EXHIBIT 9

Map of City Light Territory Depicting Manufacturing and Industrial Centers



City Light Service Territory

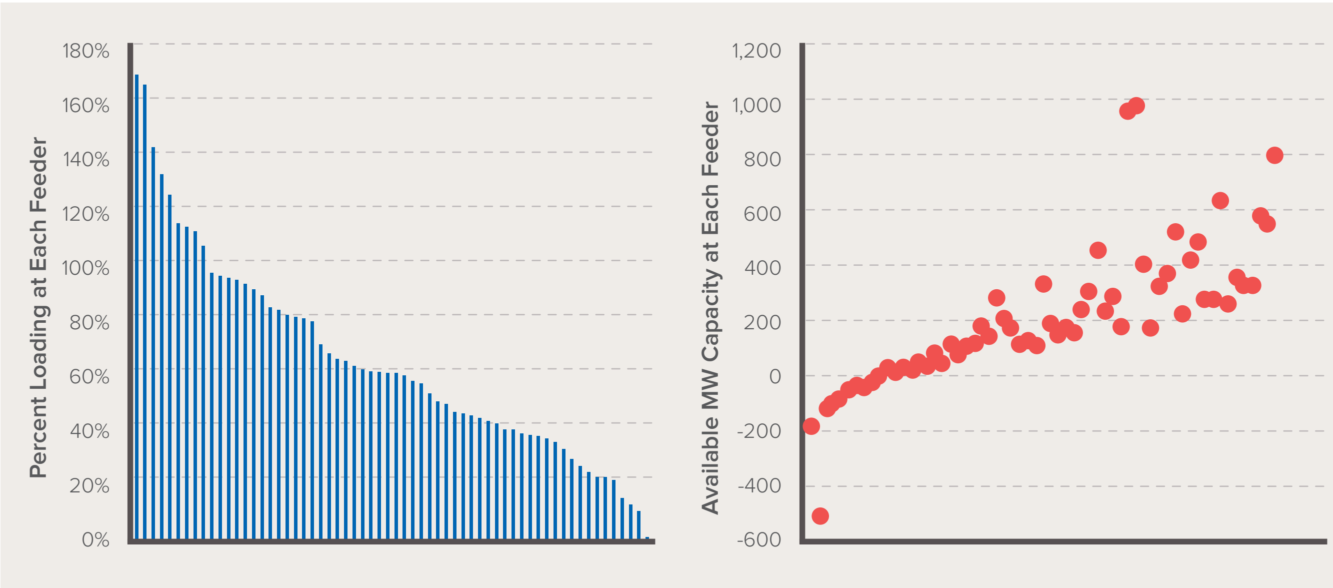
Greater Duwamish MIC

Ballard-Interbay MIC

Other Major Warehouses or Distribution Centers

EXHIBIT 10

Percent Loading and Available Capacity (MW) at All Feeders Assigned to Either the Duwamish or Ballard/Interbay MICs. The X-Axis Represents Unique Feeder ID



For long-haul routes (primarily HDTs):

1. Assume that many trucks serving long-haul routes will mega-charge their 300–1,000 kWh batteries along major freight corridors, for a typical 200–500-mile daily route. Tesla has proposed a mega-charger providing 400 miles of range in 30 minutes, roughly a 1.6 MW load per charging event.

2. Identify the location of most freight traffic volumes in Seattle (as proxy for where mega-chargers may be located) and identify distribution grid feeders assigned to these geographies. As shown in Exhibit 11, the greatest freight traffic volumes projected to 2035 will be found in the two MICs and along WA State Route 99 north of downtown Seattle.[47]

Of 24 feeders assigned along WA State Route 99 north of downtown Seattle, eight are at or above 90% loading. For fast charging of long-haul heavy-duty trucks, one truck charging could draw up to 2 MW of power over 30 minutes, so clustering these types of chargers could have significant impact on City Light's grid. With even a 10 MW load from five trucks charging simultaneously at a single location, there could be a need to reconductor the feeder backbone.

These larger installations have the potential to significantly impact City Light's system. However, fast charging for long-haul heavy-duty trucks is not expected until the late 2020s at earliest. Exhibit 12 demonstrates that there are some areas of constraint on City Light's grid, but, overall, there is plenty of available capacity to handle these types of installations (notwithstanding some upgrades such as reconductoring laterals or feeder backbones). Therefore, City Light must be proactive in supporting both location and operation of charging to minimize these impacts. This points to a clear impact on City Light's customer service and the potential need for managers dedicated to fleets of trucks and buses, or a notification process so that City Light can be adequately informed and involved in fleet electrification planning.

EXHIBIT 11

Map of City Light Territory Depicting Regions and Corridors With Significant Freight Volume

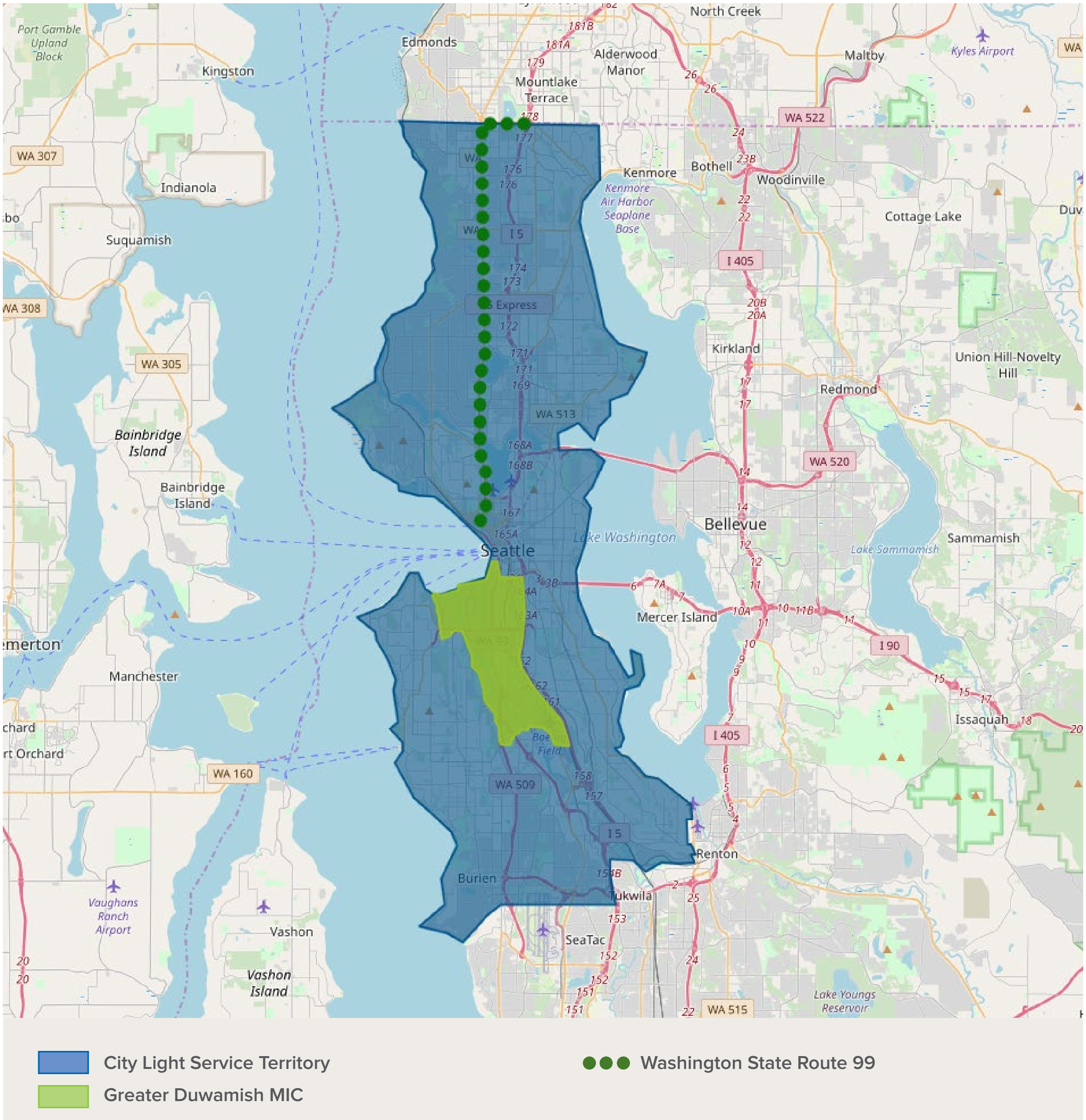
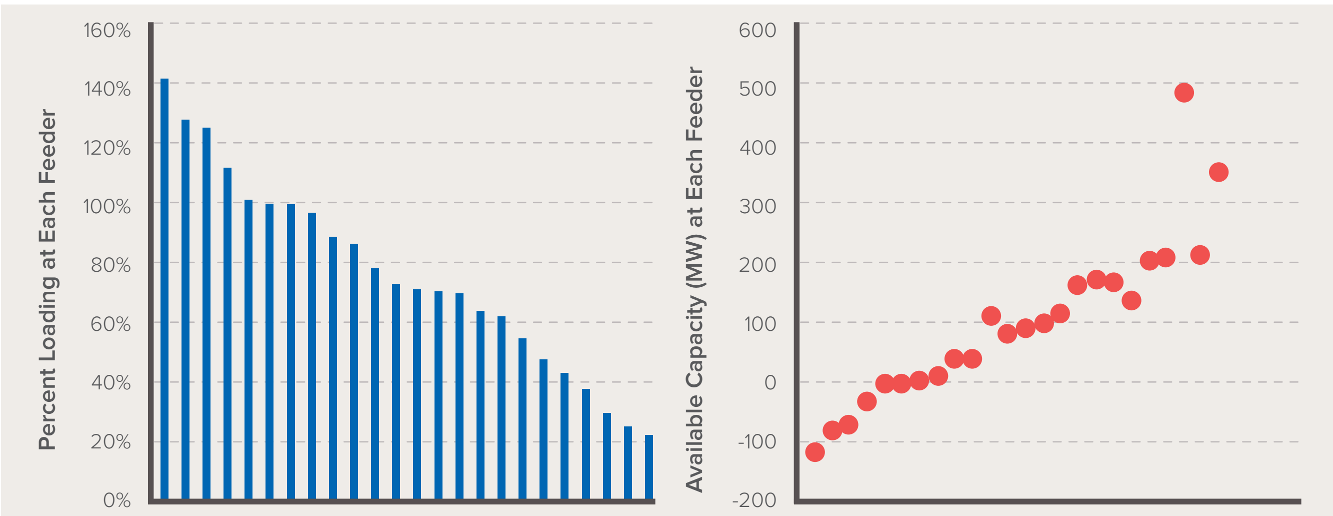


EXHIBIT 12

Percent Loading and Available Capacity (MW) at All Feeders Assigned to WA State Route 99 North of Downtown Seattle, Projected to Have the Greatest Freight Volume in City Light's Territory by 2035. The X-Axis Represents Unique Feeder ID



IMPACTS OF BUS ELECTRIFICATION

The impacts to City Light from bus electrification are quite similar to those for medium- and heavy-duty trucks detailed above. However, the approach we follow to understand bus electrification impacts is based on Metro goals and anticipated charging behavior, based on its experience with electric buses since 2016. In particular:

1. Assume buses will primarily charge overnight at centralized bus bases. Most buses will travel a daily route of 100–140 miles with a battery size of 300–450 kWh. Overnight bus charging will occur at existing Metro bus bases. Metro will also install "opportunity chargers" for short, on-route charging events located at transit hubs, major transfer points, and the ends of major routes.

2. Identify grid distribution feeders assigned to Metro bus bases, as shown in Exhibit 13.

In Exhibit 14, of the 20 feeders identified that serve Metro bus bases and transit centers, five of the feeders are at or above 90% capacity. Although this appears to show constrained capacity to serve new electric bus load, even a bus base of 250 electric buses charging simultaneously overnight would peak between 10 and 30 MW;[xii] all but two feeders have this much capacity available. However, any installation of this size will require a system impact study to determine if a dedicated feeder or other upgrades are required. For example, a recently completed impact study for an interim bus base for Metro estimated that upgrade costs (to replace existing overhead conductors and install regulator or capacitor banks) would be approximately $2.2 million.

[xii] Assuming 40–120 kW charge rate overnight.

EXHIBIT 13

Map of City Light Service Territory Depicting Bus Base Locations and Opportunity Charging Locations at Transit Centers

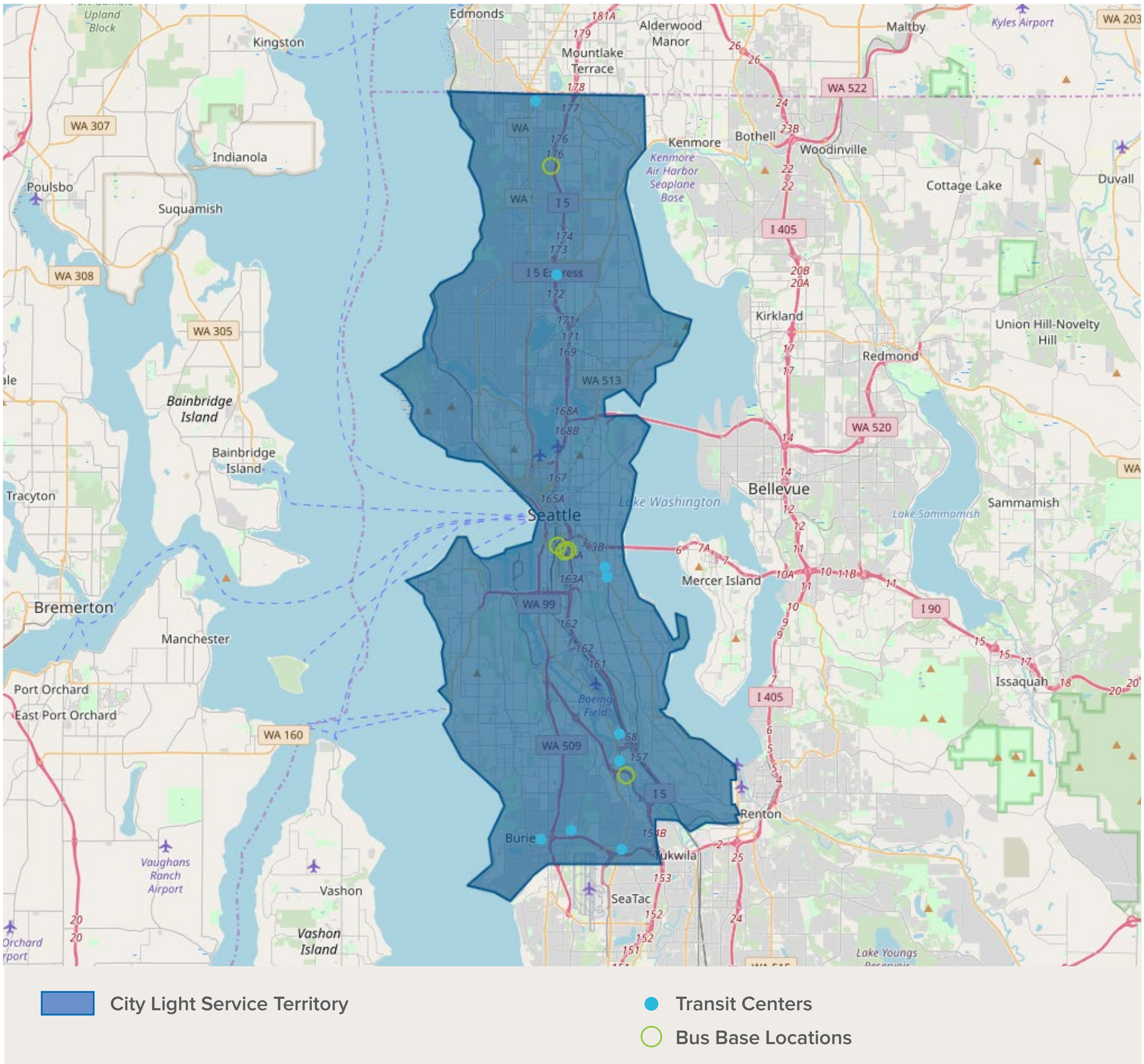
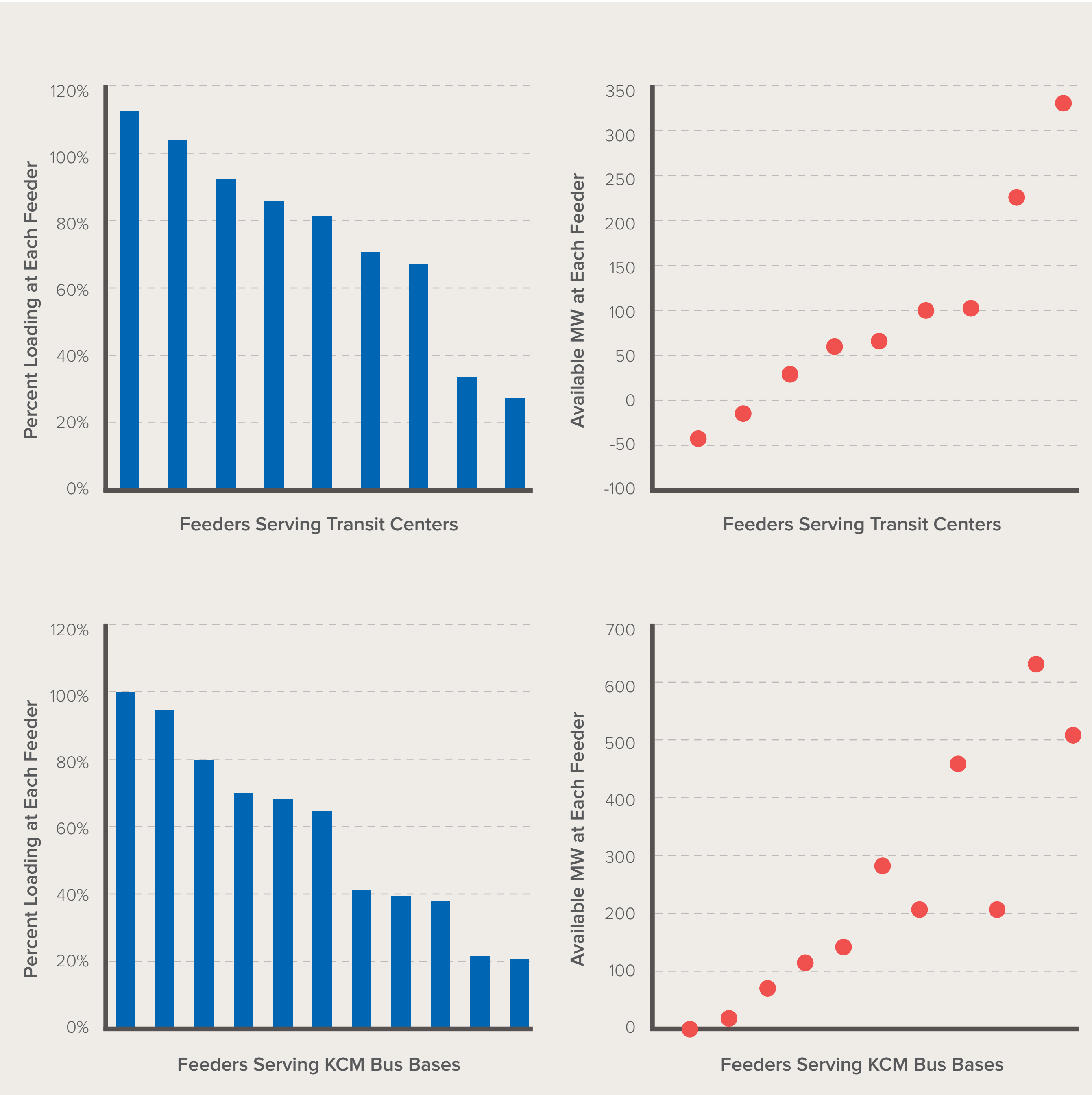


EXHIBIT 14

Feeders Assigned to Metro Bus Bases and Transit Centers and the Percent Loading and Available Capacity on Each. The X-Axis Represents Unique Feeder ID



5 SEATTLE CITY LIGHT INTERVENTIONS

SEATTLE CITY LIGHT INTERVENTIONS

City Light has many options available to it to accelerate the electric transportation market. Given limited resources and the need to maximize impact, this section identifies interventions that City Light should prioritize.

CRITICAL MARKET INDICATORS

Potential interventions are tightly linked to market evolution. We have identified three critical indicators to inform which forecast (BAU, aggressive, conservative) is aligned with actual adoption. Based on market research and expert interviews, we have identified three key market indicators to watch for as leading signs of accelerating electric transportation adoption.

EXHIBIT 15

Critical Market indicators

INDICATOR	IMPORTANCE	KEY METRIC, TODAY	TIPPING POINT
BATTERY COST	Batteries are 30%–40% of vehicle upfront cost and the primary driver of TCO.	$176/kWh for the battery pack.	For both cars and trucks, $150/kWh for the battery pack.[48]
MODEL AVAILABILITY	28% of light-duty vehicles sold annually are small or midsize cars, 10% are SUVs, and 35% are crossovers.[49] Many gasoline car drivers won't purchase an EV unless it suits their needs and lifestyle. For trucks, few commercial models are available today.	50% of electric POV sales from January to July 2018 were for five models available from three manufacturers.[50] These are Tesla's Model 3, Model S, and Model X, Chevrolet Bolt, and Nissan Leaf.	One electric SUV and one electric crossover model available from the majority of automakers, priced consistently within their category.[51] For trucks and buses, look for case studies that validate TCO savings for electric trucks and buses, especially as new models become available.
FUEL PRICE	For POVs, higher gasoline prices may lead to greater sensitivity to fuel economy and increase purchases of more fuel-efficient vehicles. The diesel-electricity price differential directly impacts value proposition for truck and bus fleet operators.	Seattle 2018 gasoline price ranged from $3.00 to $3.50. Seattle 2018 diesel price ranged from $3.00 to $3.20.	At roughly $5/gallon gasoline or diesel, individuals and fleet operators begin to more heavily weigh fuel efficiency measures. This can be heavily driven by both market forces and policy.

IMPORTANT MARKET ENABLERS

In addition to the critical indicators, many other changes in the market will be important as enablers of transportation electrification. City Light should monitor these in addition to the critical indicators in order to have a more complete sense of where the market is going.

EXHIBIT 16

Important Market Enablers

MARKET ENABLER	IMPORTANCE	METRIC TO WATCH
ADVERTISING SPEND ON EV MODELS BY AUTOMAKERS	Proxy for competition for sales.[52]	Amount spent as a percentage of gasoline-vehicle advertising.
MULTIUNIT HOUSING EV-CHARGING BUSINESS MODELS	In Seattle, 34% of all housing is multiunit apartments,[53] representing an opportunity to vastly expand the POV market.	Percentage of multiunit housing with on-site charging planned, under construction, or available.
PRODUCTION SCALE OF ELECTRIC TRUCKS	Production scale reduces upfront costs.	Percentage of trucks manufactured annually that are all-electric.
AUTONOMOUS VEHICLE PILOT PROGRAMS	Highly utilized driverless vehicles, for example those used for mobility services such as Uber and Lyft, are most cost-effective when electric. Autonomous technology can greatly accelerate the growth of EV miles traveled.	Autonomous vehicle programs that scale beyond pilots.
COSTS FOR EV CHARGING INFRASTRUCTURE, INCLUDING DC FAST CHARGING	Impacts TCO for POV owners where charging is primarily done at home and truck/bus fleets charged at fleet-owned depots.	Cost of infrastructure and installation.
PUBLIC CHARGING AVAILABILITY	Important for POV adoption to reduce range anxiety. Mega-charging may be critical for long-haul trucking applications.	Number of public Level 2 chargers and DCFCs. Announced plans to install mega-chargers on major freight corridors.
POLICY (STATE AND MUNICIPAL)	Policy incentives and mandates can alter the value proposition across markets.	State targets for EVs on the road, tax incentives, low-carbon fuel standard.

INTERVENTIONS

Market trends point to an increasingly electrified transportation future. Even in our most conservative forecast, the number of POVs in Seattle doubles by 2021 and the market share of electric trucks and buses could be even larger given their greater sensitivity to price and policy signals. Building on the work of other utilities grappling with this market transformation,[xiii] we identify a set of interventions that City Light should pursue to prepare for even the most conservative forecasts, while positioning City Light to take advantage of more aggressive adoption. These interventions are designed to align to City Light's core values and positioning in the market:

A. Invest in charging infrastructure with emphasis on universal access and expanding coverage

B. Develop new rates and improve customer service for the transportation market

C. Prepare for heavy-duty electrification

EXHIBIT 17
INVEST IN CHARGING INFRASTRUCTURE WITH EMPHASIS ON UNIVERSAL ACCESS AND EXPANDING COVERAGE

1. Continue to drive the robust development of public charging.

Business Reason:
Electric utility investment is necessary to complement the private market in creating a robust and accessible network of DCFC stations. Consumer desire for fast charging and its currently limited availability is a bottleneck to greater adoption of EVs, a barrier that City Light can directly influence across market segments.

Connection to Values Framework:
Addressing gaps in the EVSE network increases adoption and creates downward rate pressures for all customers.

City Light Actions:

- Based on gap analysis and stakeholder engagement,[xiv] deploy City Light-owned DCFCs to satisfy underserved or undercapitalized markets where private network operators are less likely to invest.
- Explore make-ready investments in grid infrastructure or equipment incentives to support private DCFC deployment that aligns with City Light's core values.

[xiii] Other sources for utility best practices include: **https://www.betterenergy.org/wp-content/uploads/2018/04/MTEC_White_Paper_April_2018-1-1.pdf**; **https://www.raponline.org/wp-content/uploads/2017/06/RAP-regulatory-considerations-transportation-electrification-2017-may.pdf**; **https://www.swenergy.org/data/sites/1/media/documents/publications/documents/How_Leading_Utilities_Are_Embracing_EVs_Feb-2016.pdf**; and **https://www.theicct.org/sites/default/files/publications/Power-utility-best-practices-EVs_white-paper_14022017_vF.pdf**.

[xiv] Specifically, an EVSE infrastructure gap analysis to identify future DCFC and Level 2 charging needs by matching the anticipated number of on-road vehicles to the number of charging stations needed to meet that load, assuming one or more ratios for Level 2 versus DCFC in future years. Gaps are indicated where there is need for charging infrastructure in City Light territory but private network operators are not planning to build.

EXHIBIT 17 (CONTINUED)
INVEST IN CHARGING INFRASTRUCTURE WITH EMPHASIS ON UNIVERSAL ACCESS AND EXPANDING COVERAGE

2. Support expanded residential and workplace charging with an emphasis on multiunit dwellings and underserved communities.

Business Reason:
City Light can expand who can benefit from electric transportation by targeting customers for which cost and feasibility are significant barriers. This is particularly true in multiunit dwellings and for residents without access to low-cost charging solutions where they live or work.

Connection to Values Framework:
Creating benefits to the environment by reducing barriers to EV ownership and expanding the market of potential EV owners. This enables greater access to City Light's clean electricity for transportation applications and reduces emissions, especially in communities with poor air quality.

City Light Actions:
- Provide incentives for residential installations, focusing on multiunit dwellings and considering higher levels of support in target markets.
- Develop creative solutions for customers without dedicated off-street parking.
- Provide incentives and technical expertise for commercial or industrial customers to install workplace chargers.
- Participate in current efforts by City of Seattle to revise building codes and EVSE standards. Potentially provide technical assistance or financing to support compliance with updated codes.

3. Invest in charging infrastructure for high-mileage applications.

Business Reason:
Market trends point to rapid change over the next decade in personal mobility with a potential shift away from vehicle ownership. City Light should position itself to accelerate electrification of these new business models as they emerge and encourage scale.

Connection to Values Framework:
Electric mobility services have the potential to provide a lower-cost mobility option for Seattle residents for whom vehicle ownership is prohibitively expensive or transit coverage is poor. More affordable mobility expands access and opportunities for residents of lower-income communities.

City Light Actions:
- Support shared (eventually driverless) mobility electrification. This could include charging infrastructure installed at designated Uber/Lyft pick-up and drop-off points or new rates specifically designed for shared mobility.
- Support charging for carsharing or other equity-focused programs, such as EV community carsharing. For example, rebates or incentives for charging infrastructure installation located at carshare parking spaces.

EXHIBIT 18
DEVELOP NEW RATES AND IMPROVE CUSTOMER SERVICE FOR THE TRANSPORTATION MARKET

1. Pursue rates that meet the needs of electric transportation customers.

Business Reason:
To accelerate transportation electrification, City Light should strive to make the cost of charging highly competitive with gasoline. With significant EV adoption (especially for trucks and buses), unmanaged charging poses risks to City Light's grid in terms of capacity and stability during peak hours—risks that City Light can directly mitigate with rate design.

Connection to Values Framework:
Creates benefits to the environment by supporting increased adoption of EVs (and associated reductions in emissions) by improving total cost of ownership for EVs. Creates grid benefits by mitigating impacts from peak-hour charging, minimizing need for upgrades. Better use of grid assets can lower utility and ratepayer costs.

City Light Actions:
- Explore and pilot time-of-use or other creative transportation-specific rate designs across all EV market segments.
- Understand the impact of demand charges on large customers (e.g., transit providers) and DCFC operators and explore options for relief to ensure fast charging network profitability.

2. Improve core City Light business processes for customers investing in charging.

Business Reason:
City Light needs to ensure a seamless customer experience for easy access to electricity as fuel. This builds on its existing expertise as a trusted advisor and leverages the utility's investments in customer service systems.

Connection to Values Framework:
For EV owners, the utility is their fuel provider. Interactions with the utility can make or break the user experience. Positive customer experience leads to positive word of mouth which can boost EV adoption and allow earlier realization of environmental benefits.

City Light Actions:
- Create a streamlined and transparent interconnection and service upgrade process for new and existing customers to install charging infrastructure.
- Consider new queues for EV customers, in addition to City Light's existing queues for residential, commercial, and industrial customers requesting service.
- Develop digital content that helps customers make informed decisions about their investment in electric transportation.

EXHIBIT 18 (CONTINUED)
DEVELOP NEW RATES AND IMPROVE CUSTOMER SERVICE FOR THE TRANSPORTATION MARKET

3. Investigate the viability of managed charging.

Business Reason:
While City Light's system can largely accommodate the increase in load from considerable adoption of EVs, large spot loads could pose a challenge. It is necessary to understand how to manage this challenge at scale.

Connection to Values Framework:
Ensures equity by allowing City Light to experiment with optimal means to mitigate grid and ratepayer impacts. In particular, to ensure EV owners pay their fair share of costs and are not subsidized by non-EV owning ratepayers.

City Light Actions:
- In collaboration with industry partners, establish standards for residential smart charging.
- Explore demand-response programs. Especially if City Light anticipates increased solar or wind generation, consider use of the EV load as a distributed energy resource to improve grid flexibility and determine how to compensate EV owners for this value.

EXHIBIT 19
PREPARE FOR HEAVY-DUTY ELECTRIFICATION

1. Support the aggressive electrification commitments of partner agencies and large customers.

Business Reason:
While these customers have set bold targets to electrify, many aspects of implementing nascent technology at scale remain a challenge. City Light is well positioned to offer technical assistance and a broad range of support for charging infrastructure.

Connection to Values Framework:
Electrification of institution customers leads to substantial emissions reductions, especially to historically impacted neighborhoods. Transit, in particular, is an ideal way to ensure all customers benefit from electric transportation.

City Light Actions:
- Partner directly with King County Metro, the Port of Seattle, and Washington State Ferries to enable their transition to electricity.
- Develop a deep expertise of customer needs and respond with a broad suite of solutions, including responsive rates, incentives, grid infrastructure, technology demonstrations, and siting analysis.
- Proactively plan for these large loads and minimize costs and potential constraints on City Light's grid.

EXHIBIT 19 (CONTINUED)
PREPARE FOR HEAVY-DUTY ELECTRIFICATION

2. Anticipate how access to charging will influence urban freight and fleet markets.

Business Reason:
As an emerging market segment, there is a great deal of uncertainty around the scale and speed of electrification. City Light can lead by exploring novel solutions that address the barriers to charging in this market.

Connection to Values Framework:
Diesel trucks have outsized emissions relative to the percentage of vehicles they represent on the road. Electric trucks can immediately improve air quality and benefit the environment, especially in industrial zones and residential communities near them.

City Light Actions:
- Monitor tipping point metrics, particularly model availability for delivery and truck applications, and engage with local fleets.
- Similar to the approach for transit agencies, devote resources to better understand the use cases for charging in the freight/heavy-duty industry.
- Get creative with packaged charging solutions, including financing, make-ready investments, smart charging, and incentives.

ENDNOTES


INTERSTATE
5
SOUTH
Tacoma
Portland
To
INTERSTATE
90
EAST
Bellevue
Spokane
OUT

ENDNOTES

[1] Peter Slowik, Nic Lutsey, *The Continued Transition to Electric Vehicles in U.S. Cities*, The International Council on Clean Transportation, 2018, https://www.theicct.org/sites/default/files/publications/Transition_EV_US_Cities_20180724.pdf

[2] Chris Bast, Jessica Finn Coven, Tracy Morgenstern, *2017 Drive Clean Seattle Implementation Strategy*, Seattle Office of Sustainability & Environment, https://www.seattle.gov/Documents/Departments/Environment/ClimateChange/Drive_Clean_Seattle_2017_Report.pdf

[3] "EV Market Share by US State," accessed April 4, 2019, http://evadoption.com/ev-market-share/ev-market-share-state/

[4] "Electric Vehicle Charging Infrastructure," accessed April 4, 2019, https://www.wsdot.wa.gov/Funding/Partners/EVIB.htm; "Electric Vehicle Charging in the Public Right-of-Way," accessed April 4, 2019, https://www.seattle.gov/transportation/projects-and-programs/programs/new-mobility-program/electric-vehicle-charging-in-the-public-right-of-way

[5] *Feasibility of Achieving a Carbon-Neutral or Zero Emission Fleet*, King Country Metro Transit, 2017, https://kingcounty.gov/~/media/elected/executive/constantine/news/documents/Zero_Emission_Fleet.ashx

[6] "Century Agenda: Strategic Objectives," Port of Seattle, accessed April 4, 2019, https://www.portseattle.org/page/century-agenda-strategic-objectives

[7] "Clean Truck Program requirements," The Northwest Seaport Alliance, accessed April 4, 2019, https://www.nwseaportalliance.com/trucks

[8] Jenny Durkan, *Executive Order 2018-02: Green Fleet*, Office of the Mayor, City of Seattle, 2018, http://durkan.seattle.gov/wp-content/uploads/2018/04/Executive-Order-2018-02-Green-Fleet-.pdf

[9] "Race and Social Justice Initiative," City of Seattle, accessed April 4, 2019, https://www.seattle.gov/rsji

[10] Jenny Durkan, *Executive Order 2017-13: Race and Social Justice Initiative*, Office of the Mayor, City of Seattle, 2017, http://www.seattle.gov/documents/departments/mayordurkan/Executive-Order-2017-13-(Race-and-Social-Justice-Initiative).pdf

[11] Daniel Beekman, "Seattle council approves electricity-rate hikes, directs City Light to rethink rate structure," *Seattle Times*, accessed April 4, 2019, https://www.seattletimes.com/seattle-news/politics/seattle-council-approves-electricity-rate-hikes-directs-city-light-to-rethink-rate-structure/

[12] Ingrid Malmgren, "Quantifying the Societal Benefits of Electric Vehicles," *World Electric Vehicle Journal,* Volume 8, 2016, http://www.mdpi.com/2032-6653/8/4/996/pdf

[13] Patrick Hertzke, Nicolai Muller, Stephanie Schenk, Ting Wu. "The global electric-vehicle market is amped up and on the rise," McKinsey & Company, accessed April 7, 2019, https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-global-electric-vehicle-market-is-amped-up-and-on-the-rise

[14] Julia Pyper, "US Electric Vehicle Sales Increased by 81% in 2018," GreenTechMedia, accessed April 7, 2019, https://www.greentechmedia.com/articles/read/us-electric-vehicle-sales-increase-by-81-in-2018

[15] *Global EV Outlook 2018*, International Energy Agency, 2018, https://www.iea.org/gevo2018/; and *Electric Vehicle Outlook: 2018*, Bloomberg New Energy Finance, https://bnef.turtl.co/story/evo2018

[16] Ibid

[17] Ibid

[18] Logan Goldie-Scot, "A Behind the Scenes Take on Lithium-ion Battery Prices," Bloomberg New Energy Finance, 2019, https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/

[19] "Historical Census of Housing Tables," United States Census Bureau, accessed April 7, 2019, https://www.census.gov/hhes/www/housing/census/historic/units.html

[20] Kyle Field, "Evolution & Current State of Public EV Charging in the USA," CleanTechnica, 2018, https://cleantechnica.com/2018/04/09/evolution-current-state-of-public-ev-charging-in-usa

[21] Mike Salisbury, Will Toor, *How Leading Utilities are Embracing Electric Vehicles*, Southwest Energy Efficiency Project, 2016, https://www.swenergy.org/data/sites/1/media/documents/publications/documents/How_Leading_Utilities_Are_Embracing_EVs_Feb-2016.pdf

[22] Hauke Engel, Russell Hensley, Stefan Knupfer, Shivika Sahdev, "Charging ahead: Electric-vehicle infrastructure demand," McKinsey & Company, 2018, https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/charging-ahead-electric-vehicle-infrastructure-demand

[23] David Shepardson, Valerie Volcovici, "17 U.S. states sue Trump administration over vehicle emissions," Reuters, accessed April 7, 2019, https://www.reuters.com/article/us-autos-emissions/17-u-s-states-sue-trump-administration-over-vehicle-emissions-idUSKBN1I241H

[24] John Vincent, "How Does the Electric Car Tax Credit Work?" *U.S. News & World Report*, accessed April 7, 2019, https://cars.usnews.com/cars-trucks/how-does-the-electric-car-tax-credit-work

[25] "Renewable Energy/Green Incentives," Washington State Department of Revenue, https://dor.wa.gov/find-taxes-rates/tax-incentives/incentive-programs#1133

[26] Christine Clarridge, "Washington's gas-price surge not enough to deter summer travelers," *Seattle Times*, accessed April 7, 2019, https://www.seattletimes.com/seattle-news/washingtons-gas-price-surge-not-enough-to-deter-summer-travelers/

[27] Mark Kane, "Number of Charging Stations in U.S. Increased to 48,000 (15,000 in California)," InsideEVs, accessed April 7, 2019, https://insideevs.com/number-of-charging-stations-in-u-s-increased-to-48000-15000-in-california/

[28] "Close-up Look at the Tesla Semi 'Megacharger' Charging Port," Teslarati, accessed April 7, 2019, https://www.teslarati.com/tesla-semi-megacharger-charging-port-close-up-look/

[29] "Clean Truck Program," Port of Seattle, accessed April 7, 2019, https://www.portseattle.org/programs/clean-truck-program

[30] "When to Expect Electric Trucks," Minuteman Trucks, accessed April 7, 2019, https://www.minutemantrucks.com/when-to-expect-electric-trucks/

[31] Bernd Heid, Russell Hensley, Stefan Knupfer, Andreas Tschiesner, *What's Sparking Electric-Vehicle Adoption in the Truck Industry*, McKinsey & Company, 2017, https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/whats-sparking-electric-vehicle-adoption-in-the-truck-industry

[32] *Electric Trucks: Where They Make Sense*, North American Council for Freight Efficiency, accessed April 7, 2019, https://nacfe.org/future-technology/electric-trucks/; and Christie Tryggestad, "New reality: electric trucks and their implications on energy demand," Energy Insights by McKinsey, 2017, https://www.mckinseyenergyinsights.com/insights/new-reality-electric-trucks-and-their-implications-on-energy-demand/

[33] Ibid; and, *The Future of Trucks: Implications for energy and the environment* (Second edition), International Energy Agency, 2017, https://www.iea.org/publications/freepublications/publication/TheFutureofTrucksImplicationsforEnergyandtheEnvironment.pdf

[34] *Northwest Ports Clean Air Strategy 2016 Implementation Report*, Northwest Seaport Alliance, 2017, https://www.nwseaportalliance.com/sites/default/files/nwpcas_implementation_report_2016-updated_final-2017-11-28.pdf

[35] Sebastian Blanco, "The U.S. Just Spent $84M on Electric Buses," *Forbes*, 2018, accessed April 7, 2019, https://www.forbes.com/sites/sebastianblanco/2018/08/31/84-million-electric-buses/

[36] Silvio Marcacci, "Electric Buses Can Save Local U.S. Governments Billions. China's Showing Us How It's Done," *Forbes*, 2018, accessed April 7, 2019, https://www.forbes.com/sites/energyinnovation/2018/05/21/electric-buses-can-save-americas-local-governments-billions-chinas-showing-us-how-its-done/

[37] Angie Schmitt, "Why Are We Still Waiting for Electric Buses?," Streetsblog USA, accessed April 7, 2019, https://usa.streetsblog.org/2018/12/07/why-are-we-still-waiting-for-electric-buses/

[38] "Metro is building a zero-emissions fleet," King County Metro, accessed April 7, 2019, https://kingcounty.gov/depts/transportation/metro/programs-projects/innovation-technology/zero-emission-fleet.aspx

[39] Scott Corwin, Derek Pankratz, "Forces of change: the future of mobility," Deloitte, 2017, accessed April 7, 2019, https://www2.deloitte.com/insights/us/en/focus/future-of-mobility/overview.html

[40] Joschka Biscoff, Michal Maciejewski, "Simulation of city-wide replacement of private cars with autonomous taxis in Berlin," *Procedia Computer Science* 83 (2016): 237-244, https://core.ac.uk/download/pdf/157752221.pdf

[41] Charlie Johnson, Jonathan Walker, *Peak Car Ownership*, Rocky Mountain Institute, 2016, https://rmi.org/insight/peak-car-ownership-report/

[42] James Arbib, Tony Seba, *Rethinking Transportation 2020-2030*, RethinkX, 2017, https://www.rethinkx.com/transportation; and America's Workforce and the Self-Driving Future, Securing America's Future Energy, 2018, accessed April 7, 2019, https://avworkforce.secureenergy.org/

[43] "What is Lyft's Long-Term Revenue Growth Potential?," *Forbes*, accessed April 7, 2019, https://www.forbes.com/sites/greatspeculations/2018/10/16/what-is-lyfts-long-term-revenue-growth-potential/#2ec91e335312; and Heather Somerville, "Uber narrows loss but still a long way from profitability," Reuters, accessed April 7, 2019, https://www.reuters.com/article/uber-results/uber-narrows-loss-but-still-a-long-way-from-profitability-idUSL1N1V611I

[44] Angie Schmitt, "The Story of 'Micro Transit' is Consistent Dismal Failure," Streetsblog USA, 2018, accessed April 7, 2019, https://usa.streetsblog.org/2018/06/26/the-story-of-micro-transit-is-consistent-dismal-failure/

[45] Paul Eisenstein, "Fatal crash could pull plug on autonomous vehicle testing on public roads," *NBC News*, accessed April 7, 2019, https://www.nbcnews.com/business/autos/fatal-crash-could-pull-plug-autonomous-vehicle-testing-public-roads-n858151

[46] *2018 Pocket Guide to Large Truck and Bus Statistics*, US Department of Transportation Federal Motor Carrier Safety Administration, https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/safety/data-and-statistics/413361/fmcsa-pocket-guide-2018-final-508-compliant-1.pdf

[47] *City of Seattle Freight Master Plan*, Seattle Department of Transportation, 2016, https://www.seattle.gov/transportation/document-library/citywide-plans/modal-plans/freight-master-plan

[48] Xavier Mosquet, Hadi Zablit, Andreas Dinger, Gang Xu, Michelle Anderson, Kazutoshi Tominaga, "The Electric Car Tipping Point," 2018, accessed April 7, 2019, https://www.bcg.com/en-us/publications/2018/electric-car-tipping-point.aspx; and Bjorn Nykvist, Frances Sprei, Mans Nilsson, "Assessing the progress toward lower priced long range battery electric vehicles," *Energy Policy*, Volume 124 (2019), 144-155, https://www.sciencedirect.com/science/article/pii/S0301421518306487

[49] Auto Sales Overview Charts, *The Wall Street Journal*, accessed April 7, 2019, http://www.wsj.com/mdc/public/page/2_3022-autosales.html

[50] Steven Loveday, "July 2018 Plug-In Electric Vehicle Sales Report Card," InsideEVs, accessed April 7, 2019, https://insideevs.com/july-2018-plug-in-electric-vehicle-sales-report-card/

[51] "Average New-Car Prices Jump 2 Percent for March 2018 on SUV Sales Strength," *Kelley Blue Book*, accessed April 7, 2019, https://mediaroom.kbb.com/average-new-car-prices-jump-2-percent-march-2018-suv-sales-strength-according-to-kelley-blue-book

[52] Gina Coplon-Newfield, "Automakers Are Still Not Advertising Electric Cars," Sierra Club, 2018, accessed April 7, 2019, https://www.sierraclub.org/compass/2018/08/automakers-are-still-not-advertising-electric-cars

[53] "Quick Facts: Resident Demographics," National Multifamily Housing Council, accessed April 7, 2019, https://www.nmhc.org/research-insight/quick-facts-figures/quick-facts-resident-demographics/

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