MAY 2020

AMPLY

FLEET CHARGING SIMPLIFIED

Unlocking the Cost-Saving Potential of Electric Fuel

An AMPLY Power White Paper

Executive Summary

Cities, municipalities, and private companies around the United States are transitioning fleets with internal combustion engines (ICE) to fleets powered by electric batteries, leveraging new technologies and business models to operate cleaner fleets at lower operating costs.

This AMPLY white paper simplifies complex electricity rate structures given fleet vehicle requirements by comparing the cost to “fuel” different vehicle fleets in the Top 25 U.S. Metropolitan areas.

This updated report, authored by AMPLY Power, attempts to distill and simplify the interaction of complex electricity rate structures with fleet vehicle requirement by providing a comparative assessment of how electricity rate structures in the Top 25 U.S.Metropolitan areas impact the cost to “fuel” different vehicle fleets.

In over 84% of the Top 25 Metropolitan areas based on population in the United States, it is cheaper to re-fuel electric trucks, buses, and passenger vehicles with electricity than fossil fuels.

We introduced the Dollar-per Gallon-equivalent (DPGe)—a comparison of mile-for-mile gasoline/diesel fueling costs versus mile-for-mile electric fueling costs across each metropolitan area—in our 2019 White paper, and are excited to apply this metric to more vehicles to demonstrate the potential of AMPLY’s optimal management strategy.

We have added delivery vans (medium-duty) and Class 8 Trucks (heavy-duty) fleets to our analysis in addition to updating the DPGe for light-duty and city bus fleets.

In this white paper, we outline the methodology and logic for calculating the DPGe, present the results and insights gleaned from DPGe for the Top 25 U.S. Metros, and issue a nationwide call-to-arms to industry, regulators, fleet operators, and energy providers to work together to unleash the profound financial and societal benefits that fleet electrification can bring to the United States.

AMPLY Power has developed the **Dollar per Gallon-equivalent (DPGe) metric.** The Dollar per Gallon-equivalent is a direct, apples-to-apples comparison that allows us to assess the electric dollar per gallon-equivalent of gasoline (or diesel) for specific cities, incorporating regional-specific electricity rate structures, fleet-specific charging strategies, and vehicle class efficiencies into a single, comprehensible metric that can be used to assess, plan, and budget for a fleet transition.

The DPGe shows that there is real economic value to transitioning fleets from ICE to electric, but that value must be understood in locational-and operational-specific terms. Electric fueling generates cost savings in 23 of the Top 25 U.S. Metros for light-duty vehicles, 21 Metros for medium-duty vehicles, 22 Metros for heavy-duty vehicles, and 24 of the Top 25 U.S. Metros for city bus fleets.

Definition: **Dollar-Per-Gallon-equivalent (DPGe)** is the dollars needed to drive an electric vehicle (EV) the same number of miles compared to an internal combustion engine (ICE) vehicle, expressed in a per-gallon basis and adjusted for city-specific electricity rates structures and vehicle efficiencies.

A Targeted or Managed Charging Strategy is Cost-Critical in Most Metros

Take, for example, New York. In New York, it would be illogical and quite costly to transition a medium-duty fleet to electric vehicles without a targeted management strategy—with the DPGe (and annual fuel cost) almost three times as expensive as gasoline if unmanaged. However, with a targeted management strategy, the decision is almost a no-brainer the other way: **A fleet transition would yield almost over 30% savings on fuel.**

Where a city's DPGe is not meaningfully lower than that city's equivalent gasoline or diesel price, transitions may be stalled, or absent altogether. Careful rate design, incentives, or other mechanisms must be utilized to encourage this paradigm shift to electric fleets. Well-designed state and local policies, incentives, and rate structures can ensure predictable electric fuel prices that are lower than fossil fuel, will encourage targeted clean economic development, and can be used as a tool by grid operators to optimize and manage their networks.

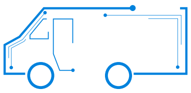
The environmental benefits of these efforts can parallel or exceed the economic benefits, where each fleet transition will substantially reduce carbon emissions into the atmosphere. For each 15-vehicle fleet that transitions to electrification, hundreds of thousands of kilograms CO_2 -equivalent is saved. But realizing these economic and environmental benefits requires the cooperation of fleet operators, industry, utilities, and regulators alike.

2020 Spotlight: Medium-Duty and Heavy-Duty Fleets

In addition to updating the light-duty and city bus fleet comparisons, AMPLY extended the analysis to include medium-duty and heavy-duty fleets. These larger vehicles, encompassing delivery vans and Class 8 trucks, highlights the potential AMPLY's optimal management strategy and electrification have to unlock all parts of the vehicular market.

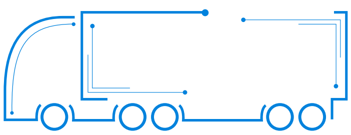
We applied the same model as from our first Whitepaper with added new assumptions associated with medium-duty and heavy-duty fleets. Using the FHA's metric for annual miles-traveled per vehicle type[1] and then applying an electric vehicle "efficiency factor", we are able to find the kWh consumed per vehicle type on a daily basis. Then to calculate charging cost, we compare "unmanaged charging" from solely on-peak periods to "managed charging" from solely off-peak periods. To better understand demand charges, we assume that medium-duty fleet vehicles incur a 19 kW demand and that heavy-duty fleet vehicles incur a 120 kW demand spike.[2] AMPLY's project experience suggests that a targeted strategy can reduce that demand by about 67% for medium-duty and heavy-duty fleets.[3]

CONSUMPTION PROFILE ASSUMPTIONS



MEDIUM-DUTY

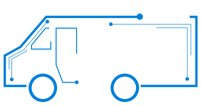
50.3 (MILES TRAVELED/DAY (a)) / **1.00** (MILES TRAVELED/kWh (b)) = **50.3** (kWh/CONSUMED/DAY (c = a/b))



HEAVY-DUTY

125 (MILES TRAVELED/DAY (a)) / **0.31** (MILES TRAVELED/kWh (b)) = **409** (kWh/CONSUMED/DAY (c = a/b))

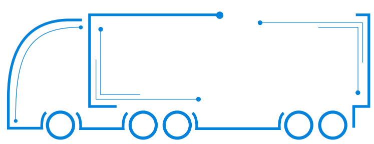
DEMAND PROFILE ASSUMPTIONS



MEDIUM-DUTY

19 kW UNMANAGED

6.27 kW MANAGED



HEAVY-DUTY

120 kW UNMANAGED

40.9 kW MANAGED

The results for medium-duty and heavy-duty fleets demonstrate the profound power of electrification and optimal management strategies. AMPLY found in 21 of the Top 25 U.S. Metros for medium-duty and in 22 of the Top 25 U.S. Metros for heavy-duty that fueling these fleets with electricity generates significant costs savings. [3] Removing these cities that did not experience savings, electric fuel is on average 41% cheaper than gasoline for medium-duty vehicles and 47% cheaper than diesel for heavy-duty vehicles.

[1] *U.S. DOT, Federal Highway Administration, Table VM-1.*

[2] *AMPLY recognizes that this figure lacks a publicly-referenceable citation, in large part because EV fleets—and optimizing them—are nascent. However, based on the AMPLY team's experience working with its partners to optimize their fleets, AMPLY uses the 67% metric here as a conservative approximation for demand reduction capabilities with optimization.*

[3] *The exact amount for each fleet will inherently depend on the size, operating requirements, vehicles, and driving profile of those fleets.*

A Primer on Electricity Rate Structures in the U.S.

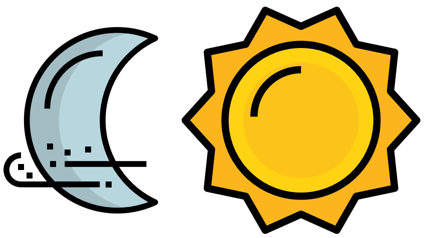
The complexity of electricity rate structures coupled with confusing or conflicting metrics is a fundamental impediment to a global transition to electric vehicle (EV) fleets. Unlike gasoline or diesel fuel prices (all-too-well-understood in the U.S. as a fixed number of dollars per volumetric gallon), electricity prices can vary significantly on a volumetric (measured in kWh) basis.

The 3 Basic Components of an Electricity Bill

- **Energy Charges:** In $/kWh, these are simply how many electrons you consume. Much like gasoline, this charge is purely volumetric (e.g., to fill a 100 kWh battery you would need 100 kWh); however, as compared to gasoline, the volumetric price per kWh in most cities will vary depending on the time of day or day of week that you charge the battery ("time of use" energy pricing). In some cities, "on peak" energy charges (e.g., charging in the middle of the afternoon) can be nearly six times as costly as "off peak" energy charges (e.g., charging at 2AM). Imagine paying $3.00/gallon of gasoline in the evening but $12/gallon in the daytime, and in most U.S. Metros, this is only part of the equation!

- **Demand Charges:** Demand charges (in $/kW) refer to the instantaneous rate at which you charge the vehicle, and for the majority of the Top 25 Metros, are typically calculated using the single highest 15- or 30-minute "spike" registered in a month. The demand charge is much more a derivative of the charging infrastructure than it is the vehicle: DC Fast Charging infrastructure can charge vehicles at rates above 50 kW whereas Level 2 Chargers typically max out around 10 kW—or, in other words, a DC Fast Charger can get a lot more energy into your vehicle in a much quicker timeframe. A 15-minute charge with a 50 kW DC Fast Charger on a $30/kW demand charge tariff would cost $1,500; but, it's critical to understand that this once-per month cost can (and should) be amortized over the course of all other charges in that month. Much like energy charges, demand charges in the Top 25 Metros typically also have on and off-peak rates, thus, designing a fueling strategy to limit demand both overall and during on-peak periods is critical.

- **Fixed Charges:** Fixed charges (in $/month) simply refer to the regulator-approved fixed components of any electricity bill. For the most part, these charges are not impacted by charging strategies and should be amortized across all consumption over the course of the month.



Imagine paying **$3.00/gallon** for gasoline at night but **$12/gallon** in the late afternoon, but only during weekdays. In most U.S. metros, this is only part of the challenge!

EV Specific Rates: In California and Colorado, some utilities have proposed specific rates to encourage fleet transitions to electric vehicles. These rates contain little to no demand charges but relatively higher energy charges. In general, these will be in place for five years before returning to more conventional rate structures with a reintroduction of demand charges. An optimal fuel management strategy is vital for navigating these changing rate structures and to take advantage of these opportunities.

Understanding DPGe from Atlanta to San Francisco

Rates structures in the Top 25 Metros are best understood by comparing two cities with drastically different rate design—Atlanta and San Francisco:

ATLANTA, GA

For the most part, Atlanta's pricing structure minimally provides an optimization incentive. At about $0.06/kWh for energy year-round, and with non-TOU demand charges, vehicle charging is more or less agnostic to exactly when or the rate at which it charges. We found Atlanta's DPGe for city bus fleet vehicles to be $1.54.

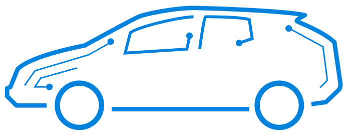
SAN FRANCISCO, CA

San Francisco, conversely, has extreme time-variable rates. Under San Francisco's new proposed commercial EV tariff, charging during peak times costs over $0.30/kWh for energy whereas charging during off-peak times costs under $0.09/kWh, plus monthly subscription charges. Given the complex structure and multiple optimization avenues to save on energy and demand, San Francisco's DPGe ranges between $0.72 and $2.47, or in other words, a range that can be two-thirds more expensive or twice as cost-effective as Atlanta depending on how charging the fleet is managed!

**Californian IOU utilities are proposing or implementing 5-year demand charge holidays that will reduce DPGe costs and incentivize short-term electric fleet adoption.*

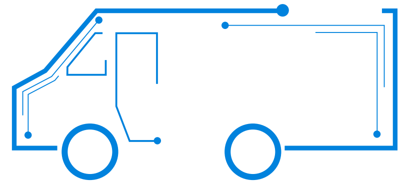
Insights

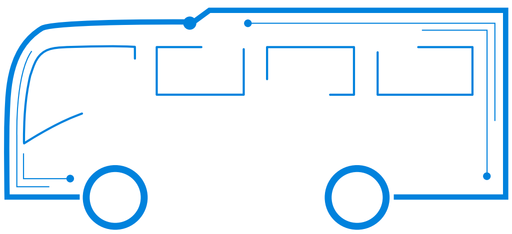
The results of the DPGe calculation across the Top 25 U.S. Metros yield significant findings:



Light-duty fleets: With our updated assessment, we found that well-managed light-duty EV fleets can see a lower fuel cost than their ICE fleet counterparts in **23 of the Top 25 U.S. Metros.** In those 23 Metros, it is **47% cheaper than gasoline** to fuel light-duty vehicles with electricity.

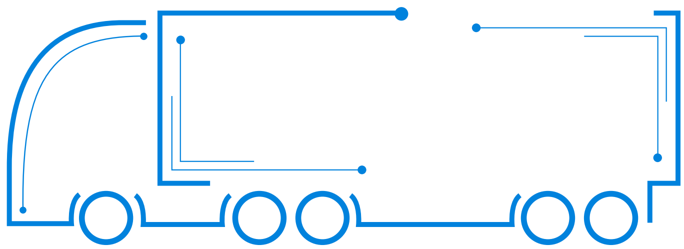
Medium-duty fleets: The DPGe study indicates that with a fueling management strategy, fueling light-duty vehicles with electricity is cheaper than fueling using gasoline in **21 of the Top 25 U.S. Metros.** Removing the four cities that did not experience cost-savings, electric fuel is, on average across these cities, **41% cheaper than gasoline** for medium-duty vehicles.





City bus fleets: In **24 of the Top 25 U.S. Metros** we found that switching from diesel to electricity generates cost savings. We see on average larger savings than last year with electric fueling being **64% cheaper than diesel** in those 24 Metros.

Heavy-duty fleets: Fueling heavy-duty vehicle fleets with electricity in **22 of the Top 25 U.S. Metros** provides significant costs savings with a managed charging strategy. On average, it is **47% cheaper than diesel** to fuel heavy-duty fleets in these 22 Metros.



The AMPLY DPGe Navigator (http://www.amplypower.com/comparison-map/)

The DPGe continues to demonstrate that there is real value to transitioning fleets to electric, but that value must be understood in locational-and operational-specific terms. In some metros, such as New York, it would be illogical and quite costly to transition a light-duty fleet to electric without a targeted management strategy. A targeted management strategy, is almost a no-brainer. Other metros with lower electricity rates, such as Seattle, face a simpler quandary: whether or not the fleet is managed or otherwise, there is real value to be had in fleet electrification. In every metro, a fleet management strategy can generate even greater savings and yield increased value to organizations that decide to transition.

Where in the highest-variable Metros **a managed charging strategy can reduce fuel costs by as much as 85%**, fleet operators must truly understand the dynamics of both their city's electricity structure and their fleet requirements. Detailed studies, analyses, route planning, and assessments must be completed to realize these savings—but this hard work and thorough diligence will generate very meaningful value to stakeholders, and will flip the discussion of a fleet transition from **"a costly sustainability action"** to **"a must-have cost reduction measure."**

City-Specific Rates. These statistics are astounding; they highlight both the incredible efficiencies of an electric vehicle versus its ICE counterpart, and the hypercritical value of fleet management and optimization. The DPGe for each of the Top 25 U.S. Metros are listed below in Table 1, Table 2, Table 3, Table 4.

DPGe versus DPG for the Top 25 U.S. Metros Medium-Duty Fleets

TABLE 1. MEDIUM-DUTY FLEETS

METROS	$/GASOLINE			DIFFERENCE		PERCENTAGES	
TOP 25 METROS IN ORDER OF GREATEST DPGE GAINS	UNMANAGED ELECTRIC	MANAGED ELECTRIC	ICE GASOLINE	COMPARED TO UNMANAGED	COMPARED TO MANAGED	CHANGE UNMANAGED	CHANGE MANAGED
1 *Los Angeles-Long Beach-Anaheim	$0.73	$0.38	$3.57	$2.85	$3.19	80%	89%
2 *Riverside-San Bernardino-Ontario	$0.73	$0.38	$3.50	$2.78	$3.12	79%	89%
3 Portland-Vancouver-Hillsboro	$2.29	$0.87	$3.08	$0.79	$2.21	26%	72%
4 *San Francisco-Oakland-Hayward	$4.24	$1.24	$3.56	-$0.67	$2.32	-19%	65%
5 *Denver-Aurora-Lakewood	$2.65	$0.83	$2.34	-$0.32	$1.50	-14%	64%
6 Seattle-Tacoma-Bellevue	$1.92	$1.31	$3.21	$1.29	$1.90	40%	59%
7 Tampa-St. Petersburg-Clearwater	$3.03	$1.04	$2.38	-$0.65	$1.34	-27%	56%
8 San Diego-Carlsbad	$5.32	$1.82	$3.55	-$1.77	$1.73	-50%	49%
9 Baltimore-Columbia-Towson	$2.60	$1.36	$2.42	-$0.18	$1.06	-7%	44%
10 Chicago-Naperville-Elgin	$2.79	$1.62	$2.68	-$0.11	$1.06	-4%	39%
11 Philadelphia-Camden-Wilmington	$2.91	$1.53	$2.51	-$0.40	$0.98	-16%	39%
12 Houston-The Woodlands-Sugar Land	$2.95	$1.38	$2.15	-$0.80	$0.77	-37%	36%
13 Orlando-Kissimmee-Sanford	$3.25	$1.61	$2.37	-$0.88	$0.75	-37%	32%
14 Miami-Fort Lauderdale-W Palm Beach	$4.05	$1.80	$2.48	-$1.57	$0.67	-63%	27%
15 New York-Newark-Jersey City	$7.89	$1.98	$2.61	-$5.28	$0.63	-202%	24%
16 Phoenix-Mesa-Scottsdale	$5.49	$2.31	$2.98	-$2.50	$0.67	-84%	22%
17 Charlotte-Concord-Gastonia	$2.54	$1.91	$2.29	-$0.25	$0.37	-11%	16%
18 Washington-Arlington-Alexandria	$3.48	$2.18	$2.42	-$1.06	$0.24	-44%	10%
19 St. Louis	$2.57	$2.06	$2.27	-$0.29	$0.22	-13%	10%
20 Minneapolis-St. Paul-Bloomington	$4.25	$2.20	$2.32	-$1.93	$0.12	-83%	5%
21 Dallas-Fort Worth-Arlington	$5.15	$2.09	$2.16	-$2.99	$0.07	-139%	3%
22 San Antonio-New Braunfels	$4.70	$2.16	$2.06	-$2.64	-$0.10	-128%	-5%
23 Atlanta-Sandy Springs-Roswell	$2.64	$2.64	$2.31	-$0.33	-$0.33	-14%	-14%
24 Boston-Cambridge-Newton	$7.13	$3.72	$2.52	-$4.61	-$1.20	-183%	-48%
25 Detroit-Warren-Dearborn	$9.06	$4.67	$2.46	-$6.59	-$2.21	-268%	-90%

**Utilities with proposed special EV charging rates*

NOTE: Gasoline (light- and medium-duty) and diesel (heavy-duty and city buses) prices effective as of 02/23/2020. Source: AAA (https://gas prices.aaa.com)

NOTE: For all the Metros, managed charging unlocks larger savings. AMPLY handles all aspects of charging operations on behalf of fleet owners, and AMPLY's managed charging systems are optimized for the lowest electricity costs through navigating demand charges and different tariff rates.

DPGe versus DPG for the Top 25 U.S. Metros Heavy-Duty Fleets

TABLE 2. HEAVY-DUTY FLEETS

METROS	$/GASOLINE			DIFFERENCE		PERCENTAGES	
TOP 25 METROS IN ORDER OF GREATEST DPGE GAINS	UNMANAGED ELECTRIC	MANAGED ELECTRIC	ICE GASOLINE	COMPARED TO UNMANAGED	COMPARED TO MANAGED	CHANGE UNMANAGED	CHANGE MANAGED
1 *Los Angeles-Long Beach-Anaheim	$0.42	$0.22	$3.90	$3.48	$3.68	89%	94%
2 *Riverside-San Bernardino-Ontario	$0.42	$0.22	$3.83	$3.41	$3.61	89%	94%
3 Portland-Vancouver-Hillsboro	$0.98	$0.53	$3.23	$2.25	$2.70	70%	84%
4 *San Francisco-Oakland-Hayward	$2.47	$0.72	$3.92	$1.46	$3.20	37%	82%
5 *Denver-Aurora-Lakewood	$1.20	$0.54	$2.64	$1.44	$2.10	55%	80%
6 Seattle-Tacoma-Bellevue	$0.89	$0.80	$3.40	$2.51	$2.60	74%	76%
7 Tampa-St. Petersburg-Clearwater	$1.25	$0.65	$2.73	$1.48	$2.08	54%	76%
8 San Diego-Carlsbad	$3.10	$1.06	$3.84	$0.74	$2.78	19%	72%
9 Baltimore-Columbia-Towson	$1.12	$0.85	$2.76	$1.63	$1.91	59%	69%
10 Houston-The Woodlands-Sugar Land	$1.26	$0.84	$2.58	$1.32	$1.74	51%	68%
11 Philadelphia-Camden-Wilmington	$1.18	$0.97	$2.96	$1.79	$1.99	60%	67%
12 Chicago-Naperville-Elgin	$1.19	$1.01	$2.88	$1.70	$1.87	59%	65%
13 Orlando-Kissimmee-Sanford	$1.28	$1.04	$2.70	$1.43	$1.67	53%	62%
14 New York-Newark-Jersey City	$2.89	$1.25	$3.17	$0.28	$1.91	9%	60%
15 Miami-Fort Lauderdale-W Palm Beach	$1.54	$1.18	$2.88	$1.34	$1.70	47%	59%
16 Charlotte-Concord-Gastonia	$1.24	$1.15	$2.71	$1.47	$1.56	54%	58%
17 Washington-Arlington-Alexandria	$1.54	$1.34	$2.87	$1.33	$1.52	46%	53%
18 St. Louis	$1.30	$1.23	$2.60	$1.30	$1.37	50%	53%
19 Minneapolis-St. Paul-Bloomington	$1.70	$1.40	$2.87	$1.16	$1.46	41%	51%
20 Phoenix-Mesa-Scottsdale	$2.00	$1.53	$3.02	$1.02	$1.49	34%	49%
21 Dallas-Fort Worth-Arlington	$1.98	$1.33	$2.55	$0.56	$1.21	22%	48%
22 Atlanta-Sandy Springs-Roswell	$1.54	$1.54	$2.88	$1.34	$1.34	47%	47%
23 San Antonio-New Braunfels	$1.85	$1.40	$2.52	$0.66	$1.12	26%	44%
24 Boston-Cambridge-Newton	$2.87	$2.36	$3.01	$0.15	$0.65	5%	22%
25 Detroit-Warren-Dearborn	$3.62	$2.98	$2.97	-$0.65	-$0.00	-22%	-0%

**Utilities with proposed special EV charging rates*

City-Specific Rates. These statistics are astounding; they highlight both the incredible efficiencies of an electric vehicle versus its ICE counterpart, and the hypercritical value of fleet management and optimization. The DPGe for each of the Top 25 U.S. Metros are listed in Table 1, Table 2, Table 3, Table 4.

NOTE: Gasoline (medium-duty vehicles) and diesel (heavy-duty) prices effective as of 02/23/2020. Source: AAA https://gas prices.aaa.com

DPGe versus DPG for the Top 25 U.S. Metros Light-Duty Fleets

TABLE 3. LIGHT-DUTY FLEETS

METROS	$/GASOLINE			DIFFERENCE		PERCENTAGES	
TOP 25 METROS IN ORDER OF GREATEST DPGE GAINS	UNMANAGED ELECTRIC	MANAGED ELECTRIC	ICE GASOLINE	COMPARED TO UNMANAGED	COMPARED TO MANAGED	CHANGE UNMANAGED	CHANGE MANAGED
1 *Los Angeles-Long Beach-Anaheim	$0.33	$0.17	$3.57	$3.24	$3.40	91%	95%
2 *Riverside-San Bernardino-Ontario	$0.33	$0.17	$3.50	$3.17	$3.33	91%	95%
3 San Francisco-Oakland-Hayward	$1.93	$0.57	$3.56	$1.64	$3.00	46%	84%
4 *Portland-Vancouver-Hillsboro	$1.26	$0.56	$3.08	$1.82	$2.52	59%	82%
5 *San Diego-Carlsbad	$2.42	$0.83	$3.55	$1.13	$2.73	32%	77%
6 Seattle-Tacoma-Bellevue	$1.01	$0.85	$3.21	$2.20	$2.36	68%	74%
7 Denver-Aurora-Lakewood	$1.42	$0.76	$2.34	$0.92	$1.58	39%	68%
8 Tampa-St. Petersburg-Clearwater	$1.69	$0.80	$2.38	$0.69	$1.59	29%	67%
9 Houston-The Woodlands-Sugar Land	$1.62	$0.85	$2.15	$0.53	$1.30	25%	61%
10 Baltimore-Columbia-Towson	$1.42	$1.04	$2.42	$1.00	$1.38	41%	57%
11 Chicago-Naperville-Elgin	$1.53	$1.22	$2.68	$1.15	$1.46	43%	55%
12 Charlotte-Concord-Gastonia	$1.30	$1.13	$2.29	$0.99	$1.16	43%	51%
13 Philadelphia-Camden-Wilmington	$1.64	$1.26	$2.51	$0.87	$1.25	35%	50%
14 St. Louis	$1.29	$1.15	$2.27	$0.99	$1.13	43%	50%
15 Atlanta-Sandy Springs-Roswell	$1.20	$1.20	$2.31	$1.11	$1.11	48%	48%
16 Orlando-Kissimmee-Sanford	$1.85	$1.41	$2.37	$0.51	$0.96	22%	40%
17 New York-Newark-Jersey City	$4.63	$1.62	$2.61	-$2.02	$0.99	-77%	38%
18 Washington-Arlington-Alexandria	$1.88	$1.53	$2.42	$0.54	$0.90	22%	37%
19 Miami-Fort Lauderdale-W Palm Beach	$2.34	$1.72	$2.48	$0.14	$0.76	5%	31%
20 Phoenix-Mesa-Scottsdale	$3.22	$2.36	$2.98	-$0.24	$0.62	-8%	21%
21 Minneapolis-St. Paul-Bloomington	$2.40	$1.84	$2.32	-$0.08	$0.48	-4%	21%
22 Dallas-Fort Worth-Arlington	$2.96	$1.76	$2.16	-$0.80	$0.40	-37%	19%
23 San Antonio-New Braunfels	$2.68	$1.95	$2.06	-$0.62	$0.11	-30%	5%
24 Boston-Cambridge-Newton	$4.02	$3.09	$2.52	-$1.50	-$0.57	-60%	-23%
25 Detroit-Warren-Dearborn	$5.13	$3.93	$2.46	-$2.66	-$1.47	-108%	-60%

Utilities with proposed special EV charging rates

NOTE: Gasoline (light- and medium-duty) and diesel (heavy-duty and city buses) prices effective as of 02/23/2020. Source: AAA (https://gas prices.aaa.com)

NOTE: For all the Metros, managed charging unlocks larger savings. AMPLY handles all aspects of charging operations on behalf of fleet owners, and AMPLY's managed charging systems are optimized for the lowest electricity costs through navigating demand charges and different tariff rates.

DPGe versus DPG for the Top 25 U.S. Metros City Bus Fleets

TABLE 4. CITY BUS FLEETS

METROS	$/GASOLINE			DIFFERENCE		PERCENTAGES	
TOP 25 METROS IN ORDER OF GREATEST DPGE GAINS	UNMANAGED ELECTRIC	MANAGED ELECTRIC	ICE GASOLINE	COMPARED TO UNMANAGED	COMPARED TO MANAGED	CHANGE UNMANAGED	CHANGE MANAGED
1 *Los Angeles-Long Beach-Anaheim	$0.42	$0.22	$3.90	$3.48	$3.68	89%	94%
2 *Riverside-San Bernardino-Ontario	$0.42	$0.22	$3.83	$3.41	$3.61	89%	94%
3 Portland-Vancouver-Hillsboro	$0.98	$0.53	$3.23	$2.25	$2.70	70%	84%
4 *San Francisco-Oakland-Hayward	$2.47	$0.72	$3.92	$1.46	$3.20	37%	82%
5 *Denver-Aurora-Lakewood	$1.20	$0.54	$2.64	$1.44	$2.10	55%	80%
6 Seattle-Tacoma-Bellevue	$0.89	$0.80	$3.40	$2.51	$2.60	74%	76%
7 Tampa-St. Petersburg-Clearwater	$1.25	$0.65	$2.73	$1.48	$2.08	54%	76%
8 San Diego-Carlsbad	$3.10	$1.06	$3.84	$0.74	$2.78	19%	72%
9 Baltimore-Columbia-Towson	$1.12	$0.85	$2.76	$1.63	$1.91	59%	69%
10 Houston-The Woodlands-Sugar Land	$1.26	$0.84	$2.58	$1.32	$1.74	51%	68%
11 Philadelphia-Camden-Wilmington	$1.18	$0.97	$2.96	$1.79	$1.99	60%	67%
12 Chicago-Naperville-Elgin	$1.19	$1.01	$2.88	$1.70	$1.87	59%	65%
13 Orlando-Kissimmee-Sanford	$1.28	$1.04	$2.70	$1.43	$1.67	53%	62%
14 New York-Newark-Jersey City	$2.89	$1.25	$3.17	$0.28	$1.91	9%	60%
15 Miami-Fort Lauderdale-W Palm Beach	$1.54	$1.18	$2.88	$1.34	$1.70	47%	59%
16 Charlotte-Concord-Gastonia	$1.24	$1.15	$2.71	$1.47	$1.56	54%	58%
17 Washington-Arlington-Alexandria	$1.54	$1.34	$2.87	$1.33	$1.52	46%	53%
18 St. Louis	$1.30	$1.23	$2.60	$1.30	$1.37	50%	53%
19 Minneapolis-St. Paul-Bloomington	$1.70	$1.40	$2.87	$1.16	$1.46	41%	51%
20 Phoenix-Mesa-Scottsdale	$2.00	$1.53	$3.02	$1.02	$1.49	34%	49%
21 Dallas-Fort Worth-Arlington	$1.98	$1.33	$2.55	$0.56	$1.21	22%	48%
22 Atlanta-Sandy Springs-Roswell	$1.54	$1.54	$2.88	$1.34	$1.34	47%	47%
23 San Antonio-New Braunfels	$1.85	$1.40	$2.52	$0.66	$1.12	26%	44%
24 Boston-Cambridge-Newton	$2.87	$2.36	$3.01	$0.15	$0.65	5%	22%
25 Detroit-Warren-Dearborn	$3.62	$2.98	$2.97	-$0.65	-$0.00	-22%	-0%

**Utilities with proposed special EV charging rates*

NOTE: Gasoline (light- and medium-duty) and diesel (heavy-duty and city buses) prices effective as of 02/23/2020. Source: AAA (https://gas prices.aaa.com)

NOTE: For all the Metros, managed charging unlocks larger savings. AMPLY handles all aspects of charging operations on behalf of fleet owners, and AMPLY's managed charging systems are optimized for the lowest electricity costs through navigating demand charges and different tariff rates.

Detailed Methodology

AMPLY's analysis seeks to simplify complex energy rate structures and electric vehicle efficiency metrics into a single, comprehensible figure that consumers understand and use daily—the price per gallon of gasoline. To that end, we have developed the city-specific Dollar per Gallon-equivalent (DPGe) and calculated the DPGe for the Top 25 U.S. Metro Areas. DPGe is the dollars needed to drive an electric vehicle the same number of miles compared an ICE vehicle, expressed in a per-gallon basis. Because cities' electricity rate structures can be complex, and vehicle fleet requirements can vary far and wide, we have provided a range for this figure between an unmanaged charging scenario (without having, or with a suboptimal, charging strategy) and an automated or other well-managed charging scenario (using an optimized charging strategy). Fleet operators should view these figures as a range of potential costs; depending on the fleet's operating demands, these costs are likely to vary between the high and low case. The DPGe calculation methodology is described below.

TABLE 5. kWh CONSUMED/DAY CALCULATION

Vehicle	MILES TRAVELED/DAY (a)		MILES TRAVELED/kWh (b)		kWh/CONSUMED/DAY (c = a/b)
LIGHT-DUTY	43.5	/	2.2	=	19.8
MEDIUM-DUTY	50.3	/	1.00	=	50.3
HEAVY-DUTY	125	/	0.31	=	409
CITY BUS	93.3	/	0.4	=	233.2

Calculating the Annual Cost of Electricity

Rate & Rate Structure. For each city, we used the standard utility electric rate based on a 500 kW commercial load profile—typically the "general commercial" rate structure, or where specific EV rates are available, the EV rate applicable to a 500 kW commercial load. We applied EV rates in the Los Angeles, San Francisco, Riverside, San Diego, and Denver metro assessments as utilities there have proposed five-year commercial EV rates to encourage EV adoption. In regulated or quasi-regulated markets, we assume that the energy is bought through the local utility at the applicable rate—we do not assume any reduction in energy cost vis-à-vis third-party or community choice aggregators (CCAs, as in California). For fully deregulated markets, we assume a standard non time-of-use energy rate at publicly-available rates at the time of this writing.

Accordingly, the DPGe presented for each city should be contextualized, and in some cases, may substantially understate the value to be had by transitioning a fleet. If a fleet's load is able to be served by a different rate class or by third-party energy providers (via a CCA, energy retailer, or renewable power purchase agreement (PPA)), the actual DPGe seen by that fleet may be significantly lower.

Calculating Vehicle Consumption Profile. To calculate each vehicle's consumption profile, we leverage the FHA's metric for annual miles-traveled by vehicle type[1], with which we are able to calculate daily miles traveled. By applying an electric vehicle "efficiency factor," or kWh consumed per each mile driven, we are able to calculate the kWh consumed per vehicle type per day. The assumptions and calculations are **(shown above in Table 5).**

Calculating Vehicle Charging Cost. The core to AMPLY's analysis is in calculating the low-to-high range of annual electric utility costs to charge each vehicle given a vehicle's consumption profile **(shown above in Table 5).** In other words, we need to understand and plan for "how" and "when" each vehicle will charge. To calculate energy costs, we calculate the two extreme cases for the year: (1) "unmanaged charging" assumes all vehicles charge in the on-peak period only and (2) "managed charging" assumes all vehicles charge in the off-peak period only, where the "on-" and "off-peak" periods in this analysis use the period with the lowest and highest price of energy for each electric utility, respectively (though typically daytime versus evening).

Detailed Methodology-continued

Getting from Annual Cost of Electricity to Dollars per Gallon-equivalent (DPGe)

For calculating the demand cost, AMPLY leverages its experience with fleet optimization to make assumptions on demand profiles

TABLE 6. DEMAND PROFILE ASSUMPTIONS

	LIGHT-DUTY	MEDIUM-DUTY	HEAVY-DUTY	CITY BUS
UNMANAGED DEMAND	10 kW	19 kW	120 kW	70 kW
MANAGED DEMAND	7 kW	6.27 kW	40.9 kW	49 kW

For "sub-optimal" charging, we assume that light duty fleet vehicles incur a 10 kW demand spike vis-à-vis a one-to-one ratio to a L2 charger and that City Buses incur a 70 kW demand spike vis-à-vis minimal charging overlap using high-powered DC-Fast chargers. Under the same framework, we assume that medium-duty fleet vehicles incur a 19 kW demand and that heavy-duty fleet vehicles incur a 120 kW demand spike. AMPLY's project experience suggests that a targeted strategy can reduce that demand by about 30% for light-duty and city bus fleets, and by about 67% for medium- and heavy-duty fleets. These assumptions are provided above in **Table 6**.[2] As with energy, we further calculate the extreme cases as (1) charging all vehicles in the on-peak period only and (2) charging all vehicles in the off-peak period only.

And finally, for the sake of completeness, we sum all electricity bill charges—energy, demand, and fixed— attributed to that vehicle over the course of the year.

To calculate the Dollars per Gallon-equivalent (DPGe), we first calculate the average cost per kWh of energy—which is simply the Annual Cost of Electricity divided by the total kWh consumed per vehicle in that year. Next, for each vehicle class, we calculate the cost of an "electric gallon" of fuel, or in other words, the cost of filling an "electric tank" to the same energy content as one gallon of gasoline or diesel. We do this by multiplying the cost per kWh times the energy content (in kWh) in a gallon of gasoline – the EPA states that each gallon of gasoline has the equivalent energy content as 33.7 kWh and each gallon of diesel has the equivalent energy content as 37.95 kWh.[3] It is worth noting at this point a stark comparison: in each of the Top 25 U.S. Metros, the cost of 33.7 kWh (or 37.95 kWh) was exceptionally higher than that same energy equivalent (one gallon) in gasoline or diesel.

**The calculation does not include the cost of vehicle acquisition.*

To reach our final calculation for DPGe, we multiply the cost of an electric gallon times a "vehicle efficiency factor"—or the MPG of an ICE vehicle divided by the MPGe of an electric vehicle. For ICE vehicle classes, we use the U.S. Department of Energy (DOE)'s MPG figure [4]. For MPGe, instead of relying on manufacturer-provided MPGe estimates based on ideal driving conditions, we use more conservative figures actually seen in the field by AMPLY partners and clients, which take into account less-than-ideal driving (e.g., a bus starts and stops every few blocks on a route). Our MPGe figure is calculated as the kWh energy content of a gallon of gasoline (or diesel) times the miles traveled per kWh, with the latter coming from clients and partners [5].

Though well-intentioned and appropriately recognizing the significant difference in the efficiency of an electric vehicle over an ICE vehicle, we believe the auto manufacturer-provided MPGe figure paints only a partial and misleading picture. MPGe provides no insights whatsoever into the regional-specific cost side of the equation, and is therefore of minimal (if any) value to a fleet operator assessing whether he or she should transition a fleet to electric vehicles, which cities they should pursue fleet transitions, and how to budget for that transition.

Getting from Annual Cost of Electricity to Dollars per Gallon-equivalent (DPGe)

[1] U.S. DOT, Federal Highway Administration. Table VM-1

[2] AMPLY recognizes that this figure lacks a publicly-referenceable citation, in large part because EV fleets—and optimizing them—are nascent. However, based on the AMPLY team's experience working with its partners to optimize their fleets, AMPLY uses the 30% and 67% metric here as a conservative approximation for demand reduction capabilities with optimization. The exact amount for each fleet will inherently depend on the size, operating requirements, vehicles, and driving profile of those fleets. See the table on page 9.

[3] Alternative Fuels Data Center – Fuel Properties Comparison. https://afdc.energy.gov/fuels/fuel_comparison_chart.pdf.

[4] Alternative Fuels Data Center, Average Fuel Economy of Major Vehicle Categories. https://afdc.energy.gov/data/10310.

[5] AMPLY uses 2.2 miles traveled per kWh for light-duty Fleet Vehicles and 0.4 miles traveled per kWh for City Bus fleets. This translates to an MPGe of 74.14 MPGe for light-duty Fleet Vehicles and 15.18 MPGe for City Bus fleets.

COVID-19 Developments

We would be remiss not to address the ongoing COVID-19 pandemic and its impact on fuel costs. In these strange times, we commend the fleet operators moving essential workers and supplying essential goods around the country.

Through various processes, the U.S. has sought to decrease reliance on foreign fuel resources. This current fall in price demonstrates how domestic gasoline and diesel prices are still dependent on international exporters. The fall in price may also push out domestic producers who cannot operate at such low margins which in the long run could increase gasoline and diesel costs.

While electricity costs are also volatile, AMPLY navigates this uncertainty with a wealth of experience and expertise on behalf of the fleet customer. Using gasoline and diesel prices from March 23rd, 2020, AMPLY models that its optimal charging management strategy savings generates cost-savings for light-duty fleets in 22 out of 25, for medium-duty fleets in 18 out of 25, for heavy-duty fleets in 22 out of 25, and for city bus fleets in 24 out of the 25 Top U.S. Metros. COVID-19 is also demonstrating the possible environmental and social results of a zero-carbon-emission future. As more metros encourage EV adoption, communities could enjoy cleaner air on a more consistent basis.

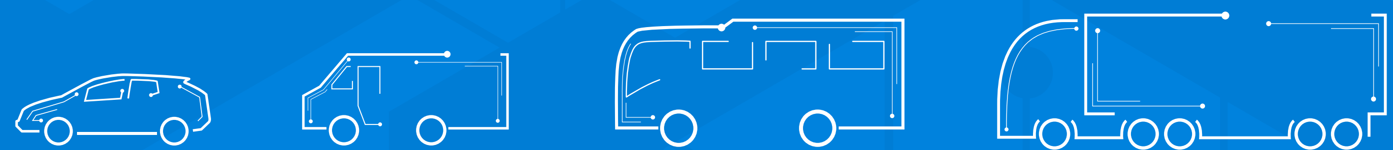
Conclusion

The Future of Electric Fleets

The future of electric vehicle fleets is bright: with new EV models seemingly being announced by the month, battery costs decreasing, and cities and utilities investing in and incenting EV fleets, there are very real reasons for operators to consider and invest in fleet electrification. Managing an EV fleet is complex, as shown by the exceptional variation in the DPGe across cities; but with complexity, comes value.

Optimal management strategies liberate fleet operators from the unpredictability of fuel prices and fuel-related operating cost spikes driven by global developments. With EV fleets under a sophisticated management strategy, there are tangible ways to take control and drive down your operating costs, increase revenues, and push your organization into the next era of clean transportation.

The societal and economic impacts of our collective efforts can be astonishing - for each 15-vehicle fleet that we transition, we eliminate a substantial amount of carbon dioxcide from the atmosphere:



PRIVATE PASSENGER FLEET	PRIVATE DELIVERY FLEET	PUBLIC BUS FLEET	PRIVATE TRUCK FLEET
65,000 $kgCO_2e$ SAVED/yr	**255,000** $kgCO_2e$ SAVED/yr	**1,785,000** $kgCO_2e$ SAVED/yr	**1,580,000** $kgCO_2e$ SAVED/yr

We cannot reach this era without the dedication, foresight, and cooperation of fleet operators, the industry, utilities, and regulators alike. Accordingly, AMPLY Power expands our global call-to-arms from light-duty and city bus fleets to medium-duty and heavy-duty fleets

To fleet operators: we challenge you to embrace this complexity, to commit to an EV fleet transition plan, and to push your peers to find the real economic value in EV fleets that can and should be realized by their organizations.

To utilities and regulators: we challenge you to embrace the incredible financial, economic, and environmental opportunity for fleet electrification, and to carefully craft your policies and rates in a way that can be used as a tool to bring down costs and induce even greater social and environmental benefits to society. We invite you to look to utilities in California such as PG&E, SCE, and SDGE, and to Colorado with Xcel Energy, and observe their implementation of EV-specific rates.

To the industry—AMPLY's peers: we challenge you not only to sell hardware to support your bottom line, but rather to design your businesses to generate real, intentional, and sustainable value to your clients, to our energy system, and to society. Working with other stakeholders, we as an industry are the critical link that can unlock a profoundly cost-effective and global transition toward zero emission transportation.

Unlocking the Cost-Saving Potential of Electric Fuel

MAY 2020

An **AMPLY Power White Paper**

AMPLY

FLEET CHARGING SIMPLIFIED

About AMPLY Power

FLEET CHARGING, SIMPLIFIED. AMPLY Power provides **Charging-as-a-Service** to de-risk and accelerate the adoption of electric buses, trucks, and passenger vehicles by public and private fleets through its simple price-per-mile-driven model. AMPLY provides a fully managed charging solution that enables municipal and commercial fleets to deploy electric vehicles confidently and without hassles. AMPLY handles all aspects of charging operations on behalf of fleet owners, and AMPLY's charging systems are optimized for the lowest electricity costs.

For more please visit **www.amplypower.com** and follow **@AMPLYPower** on Twitter and LinkedIn.