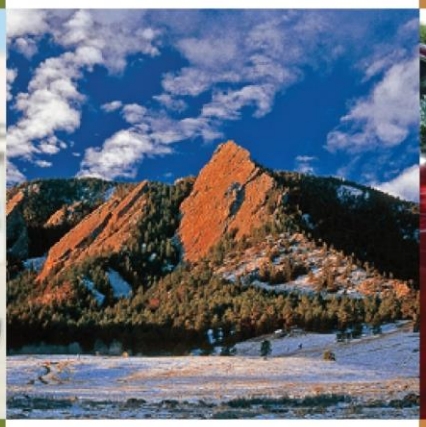

Electrifying Transportation: Boulder County's Clean Future

How the County can spark electric vehicle use by its fleet, employees and residents

By Mike Salisbury

January 2018

Acknowledgements

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Boulder County, Colorado is known for its scenic views, open spaces, and progressive energy policies.
Photo: Boulder County

SWEEP

SOUTHWEST ENERGY EFFICIENCY PROJECT

About SWEEP

The Southwest Energy Efficiency Project is a public interest organization dedicated to advancing energy efficiency in Arizona, Colorado, Nevada, New Mexico, Utah and Wyoming. For more information, visit www.swenergy.org

About the Author

Mike Salisbury is an associate in SWEEP's transportation program, which focuses on strategies to expand the adoption of electric vehicles, improve the fuel efficiency of the vehicle fleet, and to reduce motor vehicle use. In 2008, Mike received a master's degree from the University of Delaware's Center for Energy and Environmental Policy, completing his thesis on major transitions in the U.S. transportation sector in the 20th century and how lessons from those transitions can be applied to current attempts to alter transportation in the United States. Previously, he worked in the office of Congressman Mike Castle, with a focus on energy and environmental issues, and with the League of Conservation Voters in Washington, D.C.

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Acronym List

BEV	Battery Electric Vehicle
CAFÉ	Corporate Average Fuel Economy
CARB	California Air Resources Board
CAC	Charge Ahead Colorado
DCFC	Direct Current Fast Charging
EPA	Environmental Protection Agency
ERP	Electricity Resource Plan
ETC	Employee Transportation Coordinators
GHG	Greenhouse Gas
IRS	Internal Revenue Service
MPG	Miles per Gallon
NHTSA	National Highway Traffic Safety Administration
NOx	Nitrogen Oxide
OSTC	Open Space and Transportation Campus
PACE	Property Assessed Clean Energy
PEV	Plug-in Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
RAQC	Regional Air Quality Council
RFI	Request for Information
RFP	Request for Proposals
RTD	Regional Transportation District
SWEEP	Southwest Energy Efficiency Project
Taas	Transportation as a Service
TNC	Transportation Network Companies
TMO	Transportation Mobility Organization
VOC	Volatile Organic Compounds
VMT	Vehicle Miles Traveled

Over the longer term, vehicle electrification is necessary to achieve deep reductions in carbon emissions from the transportation sector.

Boulder County could benefit by installing more electric car charging stations, like this one in the city of Boulder. *Photo: City of Boulder*

Introduction

In 2015, SWEEP completed a report for the City of Boulder, Boulder County and the University of Colorado-Boulder on what steps these institutions could take to encourage the adoption of plug-in electric vehicles (PEVs) in their communities. Boulder County implemented one of that report's recommendations, an electric vehicle group purchase program, leading to a significant number of PEV sales and the development of similar programs across the country. This follow-up report provides Boulder County with a detailed analysis for a series of actions that the commissioners are considering regarding the electrification of the County's fleet vehicles, the provision of workplace charging for the County's employees, and on efforts to increase adoption of PEVs by the general public.

Executive Summary

As part of its commitment to sustainability, Boulder County is investigating the potential to electrify its own vehicle fleet and increase plug-in electric vehicle (PEV) adoption by its own employees and the general public.

Vehicle electrification offers one of the best opportunities to significantly reduce the greenhouse gas (GHG) emissions from the County's fleets and its employees, which is a necessary step to achieve the County's goal of carbon neutrality in its operations.

The County should compare not just the incremental capital costs, but total lifecycle costs of PEVs compared to regular gasoline vehicles.

Boulder County covers 740 square miles of cities, plains, foothills and mountains. Photo: City of Boulder

Fleet Electrification

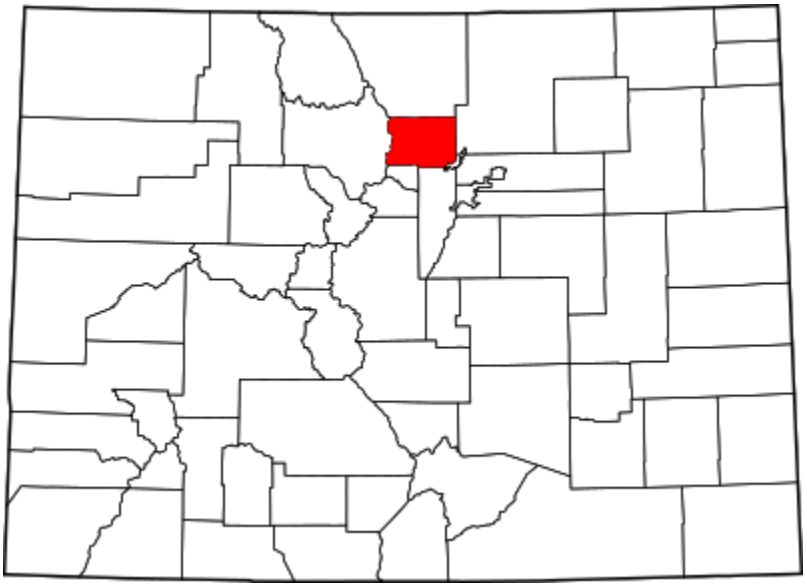
On average, vehicles in the County's fleet travel between 25 and 30 miles per day, making PEVs a very viable option for most vehicles.[1] With affordable, longer-range PEVs, such as the Chevy Bolt (240 miles of electric range) becoming available, even the longest daily travel by County vehicles will be possible with an electric vehicle.

As the number of available models of plug-in electric vehicles increases over the next couple years, battery electric vehicles (BEVs), using only electricity, can be used to replace sedans while plug-in electric hybrid vehicles (PHEV), using electricity and gasoline, should be able to replace larger and heavier vehicles such as SUVs and pickups. Eventually, if battery costs continue to fall and vehicle range continues to increase, BEVs will be able to serve most or all heavier duty vehicle types.

As each vehicle in the County's fleet is replaced, we recommend that the County evaluate the vehicle's use case to determine if a BEV or PHEV will be adequate and if the total cost of ownership is comparable to a gasoline or diesel vehicle.

Vehicle electrification offers one of the best opportunities to significantly reduce the greenhouse gas (GHG) emissions from the County's fleets and its employees, which is a necessary step to achieve the County's goal of carbon neutrality in its operations.

[1] Average daily driving is the only data currently available for County vehicles. It will be important to obtain specific data from each vehicle in the County's fleet to better understand how much each vehicle drives each day. We recommend use of onboard telematics for this purpose.



Boulder County, Colorado, is northwest of Denver and has about 320,000 residents. Its communities are known as outdoor recreation destinations and for their innovative high-tech companies, world-class research institutions and the University of Colorado-Boulder Campus, which boasts several Nobel Prize-winning scientists.

Map: Wikipedia.

In order to deepen the adoption of electric vehicles in the county fleet, give clarity both to the fleet manager and to individual departments, and to communicate a clear message to the public, the Board of County Commissioners should adopt short- and long-term targets for PEV adoption that will move the County's fleet towards carbon neutrality.

Currently, Boulder County's vehicle fleet consists of approximately 419 light-duty vehicles (sedans, SUVs, pickups and vans) and 115 larger, heavy-duty vehicles. While this analysis focuses primarily on the light-duty sector, there is also potential for emissions reductions from heavy-duty vehicles.

Fleet electrification targets could be incorporated into the County's Sustainability Plan, which will likely be updated in 2018. Examples of electrification targets include:

General Fleet: Starting in 2019, all new light-duty vehicles in the general fleet are PEVs.

General and Sheriff's Fleet: Starting in 2019, all new light-duty vehicles (save police Interceptors) are PEVs.

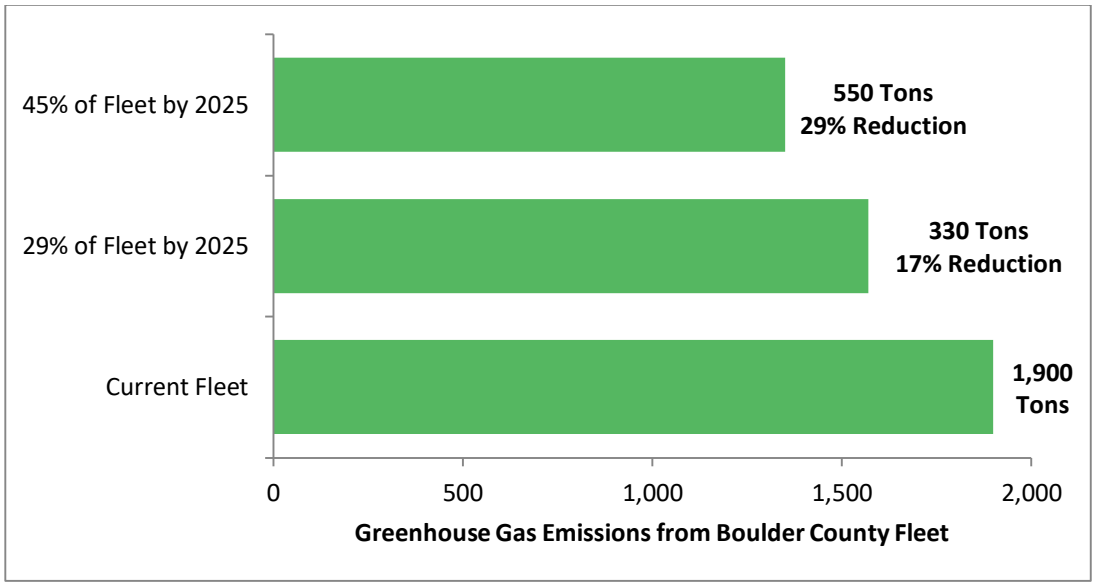
In each of these scenarios, the number of PEVs purchased would correspond with those identified to be replaced due to regular vehicle attrition.

Table ES-1. Potential Boulder County Fleet Electrification Replacement Schedule

		2019	2020	2021	2022	2023	2024	2025
General	New PEVs	21	22	14	12	16	19	16
	Total PEVs	21	43	57	69	85	104	120
General & Sheriff	New PEVs	32	31	21	29	25	27	26
	Total PEVs	32	63	84	113	138	165	191

These two scenarios would offer significant emissions reductions from the County's fleet operations. By 2025, the General Fleet scenario would reduce annual GHG emissions by 330 tons and the General and Sheriff Fleet scenario would provide reductions of 550 tons.

Figure ES-1. Greenhouse Gas Emissions Scenarios for County Fleet



The County should compare not just the incremental capital costs, but total lifecycle costs of PEVs compared to regular gasoline vehicles. While many electric vehicles may carry a higher initial price tag, they also have lower fuel and maintenance expenses, so their total cost of ownership will often be lower. The table below estimates the total incremental capital costs that the County would need to invest in each of the fleet electrification scenarios between 2019 and 2025, and the fuel and maintenance savings for each scenario. If no new PEVs were purchased after 2025, the existing PEVs would provide $814,000 to $1.3 million in fuel and maintenance savings over their lifetimes.

Table ES-2. Costs and Savings from PEVs

	Capital Cost Estimates		Fuel & Maintenance Savings	
	Low End	High End	2019-2025	2019-2034
General	$353,000	$989,000	$342,000	$814,000
General and Sheriff	$605,000	$1.6 million	$547,000	$1.3 million

To put these numbers in perspective, the County has budgeted $27.4 million during the same period for replacement vehicles.

To support these levels of fleet electrification, the County would need to make investments in charging stations at its facilities. Infrastructure investments (such as additional electrical service, new wiring and upgraded panels) generally would need to be started two years before electric vehicles are purchased. Sites that house the largest number of light-duty fleet vehicles include: Open Space and Transportation Complex (OSTC), the Kaiser Building, Pine St., the Justice Center, Courthouse, Broadway and Iris, and

Coffman St. The estimated cumulative cost of installing Level 2 charging stations to serve the number of electric vehicles in each scenario is shown in the table below.

Table ES-3. Cost of Charging Stations for Fleet Vehicles

	Low Cost Estimate	High Cost Estimate
General (32 stations)	$120,000	$248,000
General & Sheriff (51 stations)	$191,000	$395,000

Providing new electrical service for these stations would cost approximately $140,000.

The table below provides a summary of the estimated vehicle, charging stations and electrical infrastructure costs under the two scenarios, along with the expected fuel and maintenance savings.

Table ES-4. Costs and Savings Summary from PEVs

	2019	2020	2021	2022	2023	2024	2025	Cumulative
General Fleet								
Low Cost	$124,579	$129,498	$80,009	$61,336	$66,423	$79,430	$71,178	$612,452
High Cost	$284,701	$286,266	$175,112	$133,850	$144,164	$186,539	$166,516	$1,377,148
Savings	$14,611	$30,457	$40,083	$47,859	$57,375	$69,761	$81,440	$341,584
General and Sheriff Fleets								
Low Cost	$185,955	$178,921	$112,006	$130,485	$103,818	$113,224	$110,906	$935,316
High Cost	$414,934	$388,962	$256,667	$305,696	$243,294	$263,389	$264,903	$2,137,844
Savings	$22,703	$45,196	$59,838	$79,081	$95,028	$113,261	$132,170	$547,277

We also recommend that the County consider entering into a partnership with FleetCarma to evaluate the usage of current vehicles, which will allow the County to make informed decisions about which vehicles to electrify first and how much charging will be needed to support those vehicles.

The city of Boulder has some EV charging stations, but the County wants more at both rural and urban sites. Note that here, solar panels supply electricity.

Photo: City of Boulder.

Employee Charging

In addition to investing in the electrification of its own fleet, the County can also support the transition to electric vehicles for its employees. Based on a review of parking facilities at County buildings and a survey of County employees on their interest in PEVs, we can make several recommendations in this area.

First, to support workplace charging for those employees without access to charging at their homes, 10 percent of parking spaces at County employment centers should have access to PEV charging with infrastructure in place to expand to up to 20 percent of spaces. Second, based on employee interest in owning a PEV, the highest priority sites to provide workplace charging include North Broadway, the Courthouse, St. Vrain, OSTC, the Justice Center and the Kaiser Building. Note that space and infrastructure limitations may make it less feasible or too costly to provide a large number of stations at some of these sites.

Public Adoption

Boulder County currently leads Colorado in public electric vehicle adoption, but adoption will need to scale up dramatically to achieve the full benefits of improved air quality, decreased GHG emissions, and fuel cost savings for PEV owners that widespread transportation electrification can offer.

This table provides a brief overview of the potential actions Boulder County could take to promote PEV adoption in the general population. Potential partners who could help the County take the action are also identified.

Table ES-5. Potential Public Adoption Actions and County Partners

Action	Potential Partners
Set an EV Goal	Cities
Low Income Access	Cities, Xcel, Housing Agencies
Multi-Family Access	Cities, Xcel
EV Rideshare/Carshare	Cities, eGo CarShare, Zipcar, TNCs
Curbside Charging Stations	Cities
Streetlight Charging	Cities, Xcel
Review of County's Existing Chargers	Boulder County
DCFC Station Support	Cities
Improve Model Availability	Cities, Dealers, Manufacturers
Bus Electrification	RTD, Via Mobility, Utilities, School Districts
Group Purchase Program	Manufacturers, Dealers
Public Education	TMOs, ETCs
Workplace Charging	Boulder Chamber, TMOs, ETCs
L2 Stations at Recreational Destinations	Land management agencies; Eldora Ski Area
EV Showcase	City of Boulder
Charging Stations at Park and Rides	RTD
Vehicle Feebate	State Legislature

RTD, which already provides convenient transit options in Boulder County and metro Denver, is among the agencies with whom Boulder County could partner.

Photo: RTD.

Fleet Vehicles

As part of its commitment to sustainability, Boulder County is investigating whether expanding access to charging at County buildings, and in the County as a whole, has the potential to help electrify its own vehicle fleet, increase plug-in electric vehicle (PEV) adoption by its own employees, and encourage the general public to buy PEVs. This section focuses on the County's own fleet and the potential for transitioning it to plug-in electric vehicles.

Boulder County has adopted a set of aggressive climate goals, both for the County as a community, and for internal County operations. For County operations, the goal is to achieve carbon neutrality, which the County's sustainability plan describes: "True carbon neutrality requires reducing carbon emissions as much as possible in all efforts, including transportation, building-energy use, factories, farming/ranching, etc." [2] Strategies related to transportation in internal operations are:

> Strategy 7: Implement controls and policies to limit idling of municipal and county vehicles;
>
> Strategy 8: Establish projects and programs to reduce the absolute number of employee commute trips;
>
> Strategy 9: Develop short-term and long-term conversion plans for the County vehicle fleet, to implement new vehicle technologies as they become available for testing and use;
>
> Strategy 10: Promote the use of sustainable, locally sourced biofuels derived from local waste oil within the Boulder County vehicle fleet.

While these statements provide some general direction, it may be appropriate for the County to consider adopting more specific goals on emissions from its fleet vehicles. When we review which local governments have made significant moves towards fleet electrification and de-carbonization, one universal feature has been a clear direction from the top executive level. This can include both goals for the reduction in GHG emissions from the fleet, and goals for adoption of electric vehicles. The table below shows some examples after which we describe some of these in more depth.

Boulder County has adopted a set of aggressive climate goals, both for the County as a community, and for internal County operations.

[2] Boulder County. 2012. Environmental Sustainability Plan. https://assets.bouldercounty.org/wp-content/uploads/2017/03/sustainability-plan-chapter-3.pdf

Table 1. Electrification Goals from Other Local Governments

Local Government	Goal	Context
Denver	200 EVs by 2020	10% of light-duty vehicles
Los Angeles	50% of new vehicles will be EVs	228 vehicles
Austin	330 EVs by 2020	16% of light duty vehicles
San Francisco	All new passenger vehicles must be Zero Emission Vehicles (ZEVs). All passenger vehicles must be ZEVs by 2022.	300 Passenger vehicles must be EVs by 2022.
Atlanta	20% by 2020	600 vehicles
Seattle	30% of all light duty vehicles by 2020	670 vehicles
Portland	180 EVs by 2020	30% of 'eligible' vehicles by 2020

Seattle: The City of Seattle has been a leader in municipal EV adoption. To date they have acquired 90 EVs, and have a goal of 30 percent (or 670 vehicles) by 2020. The city has an executive order signed by the mayor, and endorsed by the city council, that created the Drive Clean Seattle initiative. Key goals include:

- 50 percent reduction in fleet GHG emissions by 2025;
- As each vehicle is replaced at the end of life, the Department of Finance and Administration Services (FAS) will purchase a plug-in vehicle when a cost-effective, market-ready vehicle is available that matches the planned operations for that vehicle. "Cost effective" is defined as a total cost of ownership within 10 percent of the cost of a gasoline or hybrid vehicle. For instance, FAS will replace all sedans with zero-emission battery electric vehicles where range is adequate to perform the job of the City department and charging infrastructure is available.
- There is a requirement for annual reporting on progress towards the GHG emissions goal.

Portland: Portland, Oregon has also been a leader on electric vehicles. Its work is guided by an overarching EV policy, the City of Portland Electric Vehicle Strategy that was adopted by the city council. This strategy focuses both on community-wide goals (which calls for 10,000 registered EVs in the city by 2020), and on fleet targets. The fleet target is 180 EVs, or 30 percent of the fleet electrified by 2020.

Los Angeles: The city has a Sustainable City pLAn, adopted by the mayor and council, that includes a very well-defined set of goals and strategies for transitioning from fossil fuels to electric vehicles, both in the city fleet and in the community as a whole. More than many communities, Los Angeles' leaders also have a significant focus on electrifying heavy-duty vehicles, driven largely by the air pollution impacts of the heavy freight activity associated with the local seaports. In 2015, the city had already signed deals for over 288 electric vehicles and 26 electric motorcycles and scooters. Key fleet-related goals include:

- A short-term goal that at least 50 percent of new fleet vehicle purchases must be electric;[3]

[3] City of Los Angeles Department of General Services. 2017. 2015-2016 Annual Report. http://gsd.lacity.org/GSD%202015-16%20Annual%20Report.pdf

- A longer term goal of 80 percent of new fleet vehicles must be electric by 2025, and a 100 percent electric fleet by 2035[4].

Denver: The city has committed to 200 EVs in its fleet by 2020, and has said that its fleet department should consider whether an EV could suitably replace any vehicle due to be retired from the fleet. In the draft Denver 80x50 plan, the city also commits to 100 percent electric or zero-carbon for both light- and heavy-duty vehicles by 2050.

Electric vehicle chargers have been installed near Denver's world-famous Red Rocks amphitheater. Photo: iStock/Getty Images

New York: City agencies will immediately begin phasing in EVs to satisfy light-duty vehicle needs where operationally and economic feasible.

San Francisco: All new passenger vehicles must be BEVs unless a waiver is obtained.

We recommend that the Board of County Commissioners adopt short- and long-term targets for greenhouse gas emissions reductions specific to the County's fleet vehicles. This will drive deeper adoption of electric vehicles in the County fleet, give clarity both to the fleet manager and to individual departments, and communicate a clear message to the public. Adoption of specific, achievable targets will enable the County to reach its greenhouse gas emissions ultimate goal of a carbon-neutral fleet. For light-duty vehicles, electrification offers the best pathway to a carbon-neutral fleet, so targets for fleet conversion to electric vehicles should be established.

Reasonable PEV options already exist for any sedan/passenger vehicle applications. Options for larger vehicles (SUVs, pickups, vans) are more limited, but are rapidly developing.

There are very few electric options for medium- and heavy-duty vehicles today, with the exception of transit buses, but there is substantial technology development taking place, with Cummins, Tesla and a number of smaller companies working on heavy-duty electric trucks. The feasibility of affordable, larger vehicles depends largely on battery costs. The cost of lithium-ion batteries has dropped by 70 percent from 2010 to 2016 (from $1,000 per kilowatt-hour (kWh) to $300/kWh)[5] and could well drop to $100/kWh in the next five years. This drop in the price of batteries would translate to a Chevy Bolt (which currently has a battery of 60 kWh) costing $12,000 less. Since most of the incremental cost of

[4] GNA. 2014. City of Los Angeles-EV Roadmap. http://www.gladstein.org/gna-casestudies/city-of-los-angeles-ev-roadmap/

[5] Nature. 2015. Rapidly falling costs of battery packs for electric vehicles. https://www.nature.com/nclimate/journal/v5/n4/full/nclimate2564.html

PEVs is the battery cost, falling battery prices will make smaller PEVs cheaper, enable longer-range PEVs, and will allow larger PEVs to enter the marketplace.

Since Boulder County includes significant areas of rugged, mountainous terrain, the vehicle mix required may be more challenging to electrify than some of the municipal fleets described above. But, given the technology trends, it is probably still possible to set some fairly aggressive targets for fleet electrification. Later in this section, after we analyze the nature of the County fleet, we return to potential goals that the County could set.

Boulder County includes rugged, though spectacular, mountain terrain; Red Rock Lake, seen here, is in the national forest inside the County's borders. *Photo: iStock/Getty Images*

Light-Duty Battery Electric Vehicles and Plug-in Hybrid Electric Vehicles

Two types of plug-in electric vehicles (PEVs) are currently on the market: battery electric vehicles (BEVs), like the Nissan LEAF or Chevrolet Bolt, which operate only using a battery; and plug-in hybrid electric vehicles (PHEVs), like the Toyota Prius Prime or Chevy Volt, which use both batteries and gasoline engines.

BEVs offer the greatest emissions reductions but shorter-range BEVs may not be suitable for all fleet vehicle daily use if the vehicle is driven over 100 miles per day. PHEVs offer the convenience of making longer trips without the need to charge during the day or the worry about running out of electric range.

However, as the range of BEVs increases, the extended range of PHEVs becomes less important when considering sedans. For example, the 2018 Nissan LEAF is expected to have a range of 140 miles, far exceeding the average daily travel for most of the County's fleet vehicles, and the 2017 Chevy Bolt has a range of 240 miles.

The Denver Metro Clean Cities Coalition performed an analysis for the County in which the group reviewed the suitability of PEVs for County vehicles across many categories of vehicles. Strikingly, this analysis revealed how few miles most County fleet vehicles are driven. Sedans are driven about 7,000 miles per year, or under 30 miles on a typical workday. Without detailed telematics data it is impossible to know how many of these vehicles are occasionally used for much longer distances, but in general this finding supports the notion that BEVs could replace most sedan uses. The table below shows the Clean Cities finding for the average annual and daily vehicles miles traveled (VMT) by vehicle category.

Table 2. Boulder County Fleet Vehicle Travel Profile

Class Description	Avg. Annual VMT/Vehicle	MPG	Miles/day
Mid-Size Sedan	6,860	28.0	27
Mid-Size Hybrid Sedan	7,110	49.5	28
Full-Size Patrol Sedan	1,676	25.5	7
Mid-Size SUV	9,193	19.3	36
Full-Size SUV	8,709	14.2	34
Mid-Size Hybrid SUV	7,600	29.6	30
Compact Pickup	6,938	17.1	27
1/2 Ton Pickup	10,433	15.1	41
3/4 Ton Pickup	6,754	10.9	26
1 Ton Truck	5,634	10.7	22
2 Ton Truck	3,387	9.5	13
Chassis Cab 2 Ton	2,107	6.8	8
Box Truck	5,507	10.4	22
Full-Size Van 12-15 Passenger	2,624	13.5	10
Mini Cargo Van	2,375	22.0	9
Mini Passenger Van	6,055	18.9	24
Full-Size Cargo Van	6,813	15.1	27

Strikingly, this analysis revealed how few miles most County fleet vehicles are driven.

To maximize the emissions benefits, we recommend that the County focus on BEVS for sedans. Shorter-range BEVs cost less and create fewer environmental impacts during their manufacturing, so we recommend that the County evaluate the use for each sedan that is replaced and decide if a shorter-range BEV would fill the need or whether the County needs a longer-range BEV. PHEVs likely will play an important role in replacing larger vehicles such as SUVs, pickups and vans. These larger and heavier vehicles would require much bigger (and more expensive) batteries to provide the same range as sedans like the LEAF and the Chevy Bolt.

The Chevy Bolt, left, can go 240 miles on one charge.
Photo: Chevrolet

For the next few years, PHEVs likely will be the more available and affordable option for the County to replace its heavier vehicles. However, our analysis shows that the average County SUV currently gets driven only 30 to 36 miles per day, a distance that falls within the electric range of existing PHEV SUVs such as a Mitsubishi Outlander. That finding means PHEVs can bring almost the same emissions benefits as a full BEV. For example, the Outlander PHEV has a 32-mile electric range before shifting to gasoline.

While the majority of current plug-in vehicles are sedans, several larger vehicles will hit the market soon. Hyundai, Ford, Tesla, Mercedes, Audi, BMW, VW and Volvo are all expected to produce full electric SUVs by 2020.

Table 3. Current and Future Plug-in Electric SUVs

Make and Model	Vehicle Type	Year Expected	Electric Range
Battery Electric Vehicles			
Toyota RAV4	SUV	Available	103 miles
Hyundai	SUV	2018	200 miles
Ford	SUV	2020	300 miles
Tesla Model X	SUV	Available	237 miles
Tesla Model Y	Compact SUV	2020	Unknown
Mercedes EQ	SUV	2020	310 miles
Jaguar I-PACE	SUV	2018	220 miles
Audi e-tron Quattro	SUV	2018	310 miles
BMW X3	SUV	2020	Unknown
VW ID	SUV	2020	248 miles

Plug-in Hybrid Electric Vehicles			
Audi Q7 e-tron	SUV	Available	35 miles
BMW X5 xDrive40e	SUV	Available	14 miles
Chrysler Pacifica	Minivan	Available	33 miles
Kia Niro	SUV	2018	30-40 miles
Maserati Levante	SUV	2019	30 miles
Mercedes Benz GLC350e	SUV	2018	21 miles
Mercedes Benz GLE550e	SUV	Available	12 miles
Mitsubishi Outlander	SUV	Available	32 miles
Porsche Cayenne S E-Hybrid	SUV	Available	14 miles
Volvo XC40 T5	SUV	2018	31 miles
Volvo XC90 T8	SUV	Available	14 miles
Workhorse W-15	Pickup	2018	80 miles

The Mitsubishi Outlander, left, is among several models of plug-in hybrid electric vehicles now on the market, any of which Boulder County may consider purchasing as it replaces existing County SUVs.

Photo: Mitsubishi

Level 1 and Level 2 Charging Stations

EV charging at Red Rocks.
Photo: iStock/Getty Images

The two main types of charging stations offer different sets of benefits and potential drawbacks.

Level 1 charging stations supply low-levels of electricity (about 1 kW of power). One hour of charging will add approximately 1 kWh or about 3 to 4 miles of electric range. Level 2 charging stations provide a higher wattage, usually between 3 and 6 kW. One hour of charging can add 10 to 20 miles of electric range. Obviously, Level 2 charging stations can re-energize vehicles much faster than a Level 1 station.

Still, Level 1 charging stations offer other benefits. Level 1 charging does not demand as much power as Level 2 charging, so allows more chargers (and more vehicles) to share a given level of electrical service. Lower levels of power demand also may enable more vehicles to be charged without requiring upgrades to electrical service (such as installing new transformers).

Since Level 1 chargers use less energy during peak demand hours, they will create less of an impact on the demand charges paid by the County. Level 1 chargers also provide the convenience of not requiring employees to move vehicles or charging cords during the workday or overnight. A PEV can simply be parked, plugged in, and generally fully charge in eight to twelve hours.

However, Level 1 charging generally is not capable of "smart" charging, or providing data on electricity consumption along with the ability to schedule charging to better manage the load on the grid. This type of data will be important in determining electricity consumption and fuel costs (and how much a department's fleet vehicles should pay for fuel) for PEVs in the fleet.

The County has options, however. Energy monitors can be installed along with Level 1 stations and can provide online information about electrical use for individual chargers. Level 2 charging stations can come with smarter technology that can enable data collection, and the scheduling of charging and peak-load management.

Each of these options, in turn, present the County with additional decisions. If every vehicle has a dedicated charging station or parking spot, the County would have to provide a very large number of parking spaces capable of charging electric vehicles. This scenario may require more retrofitting of parking lots and higher installation costs.

Each of these options, in turn, present the County with additional decisions.

EVs charging in downtown Boulder. *Photo: City of Boulder*

By contrast, Level 2 charging stations could require fewer dedicated parking spaces if multiple vehicles can use the station during a charging period. Level 2 stations might be a better solution at sites with a limited number of parking spaces. However, maximizing the use of Level 2 stations by charging multiple vehicles would require staff time and coordination to move vehicles at the appropriate times. Level 2 stations also clearly make more sense for spaces that may also be used by the public during brief periods of time. Additionally, Level 2 charging is somewhat more energy efficient. The magnitude of the difference depends on charge rate and temperature, and can range from 3 percent to 13 percent.[6]

The capital costs for Level 1 stations are less than for Level 2, but if Level 2 stations are shared among multiple vehicles this will reduce the cost per vehicle charged. A dual-port, Level 2 station, which allows two PEVs to charge simultaneously, will also reduce the cost per vehicle charged. A single-port, Level 2 station costs up to $3,260, while a dual-port, Level 2 stations costs up to $6,260. But some of the cost of a Level 2 charging stations can be funded through the Regional Air Quality Council's (RAQC) Charge Ahead Colorado program, while Level 1 stations are not eligible for funding from the RAQC.

[6] Vermont Energy Investment Corporation. 2014. An Assessment of Level 1 and Level 2 Electric Vehicle Charging Efficiency. https://www.veic.org/resource-library/an-assessment-of-level-1-and-level-2-electric-vehicle-charging-efficiency

Boulder County's Fleet

The County currently has 534 total light- and heavy-duty vehicles in the general and the sheriff's fleets. The general fleet has approximately 285 light-duty vehicles while the sheriff's fleet has 134 light-duty vehicles.

Table 4. Breakdown of Light Duty Fleet Vehicles by Fleet and Vehicle Type

	General Fleet	Sheriff's Fleet	Total
Sedans	37	4	41
SUVs	66	46	112
Pick-Ups	169	33	202
Vans	13	17	30
Interceptors	0	34	34
Total	285	134	419

The tables below provide estimates based on the County's current fleet replacement plan of the number and type of light-duty vehicles that will be replaced between 2019 and 2025.

Table 5. General Fleet Replacement Schedule

	2019	2020	2021	2022	2023	2024	2025
Sedans	1		1	2	5	3	3
SUVs	4	9	3	1	2	2	2
Pickups	12	11	8	7	7	9	9
Vans	4	2	2	2	2	5	4
Total	21	22	14	12	16	19	16

Table 6. Sheriff's Fleet Replacement Schedule

	2019	2020	2021	2022	2023	2024	2025
Sedans	0	0	0	2	0	0	0
SUVs	10	9	2	6	2	6	5
Pickups	1	0	5	5	5	2	4
Vans	0	0	0	4	2	0	1
Interceptor	3	4	7	6	3	4	1
Total	14	13	14	23	12	12	10

The County can reasonably expect that over the next couple years, affordable BEVs or PHEVs suitable for all light-duty use cases will become available on the market, enabling the County to make all its new light-duty vehicles electric. The following table illustrates two scenarios for new light-duty vehicles being electrified. If all new vehicles in the General Fleet were electric starting in 2019, the County would have 120 vehicles or 29 percent of the total light-duty fleet being electric by 2025. A more aggressive scenario would have all new light-duty vehicles from both the General and the Sheriff's Fleet (save for police Interceptors) be electric, resulting in 45 percent of the fleet being electric by 2025.

Table 7. Potential Boulder County Fleet Replacement Schedule

		2019	2020	2021	2022	2023	2024	2025
General	New PEVs	21	22	14	12	16	19	16
	Total PEVs	21	43	57	69	85	104	120
General & Sheriff	New PEVs	32	31	21	29	25	27	26
	Total PEVs	32	63	84	113	138	165	191

Fleet Vehicle Locations

A review of the locations of light-duty vehicles in the County fleet provides insight into where the County might want to first focus resources to electrify its fleet. Note that the listing of vehicles with locations is not always precise and the numbers below are estimates and not exact counts by site and type. Sedans and SUVs are the best candidates for vehicle electrification in the short-term. The electrification of pickups and vans may need to wait a couple years until plug-in versions of these vehicle types become widely available.

Table 8. Light Duty Fleet Vehicles by Location and Vehicle Type

Location	Estimated # of Sedans and SUVs	Estimated # of Pickups	Estimated # of Vans	Total
OSTC	23	68	8	99
Alaska Ave	---	8	23	31
Architects	1	17	3	21
Facilities	---	18	---	18
Kaiser	15	---	---	15
Pine St.	12	---	---	12
Justice Center	8	---	3	11
Courthouse	9	---	---	9
Broadway & Iris	9	---	---	9
Coffman St.	9	---	---	9
Parks	4	4	---	8
Walden Ponds	---	7	---	7
Nederland (RM)	---	6	---	6
Coroner	2	3	1	6
Fairgrounds	---	2	---	2
Resource	---	2	---	2
Sheriff HQ	84*	33	17	134
Jail	2	1	14	17
Total	178	167	68	413[7]

*Includes 38 police Interceptor vehicles, which may not be good candidates for electrification in the short-term.

[7] There is a slight discrepancy between this total number of light duty vehicles (413) and the number indicated earlier (419) because several vehicles did not have an identifiable location.

Top areas for electrification of fleet vehicles in the short term would be vehicles located at the Open Space and Transportation Campus (OSTC), Kaiser, Pine St., the Courthouse, Broadway & Iris and Coffman St.

The Sheriff's Fleet

No electric vehicles now on the market are expressly made to be used as police Interceptors or pursuit-rated cars, but part of the sheriff's fleet still could be well served by plug-in electric vehicles already available on the market.

Of the 134 vehicles in the sheriff's fleet, 34 are Interceptors, leaving 100 other vehicles. Only a small number of these other vehicles are sedans and so can be replaced by electric vehicles now on the market. In the near future, manufacturers likely will offer more SUVs and pickups as plug-in electric vehicles, so the sheriff's department may be able to replenish its fleet of light-duty trucks with PEVs at that time. Even so, the sheriff's fleet presents an additional challenge because about 50 staff who are first responders take their vehicles home at night so that they can be immediately available for an emergency.

Police officers need special qualities in patrol cars, but Boulder County still could replace part of the sheriff's department's current gas-powered fleet with electric cars in the future.

Photo: iStock/ Getty Images

Other communities have addressed this challenge. The Los Angeles police department has ordered 100 BMW i3s (a BEV) that will be used for non-emergency functions. Montgomery County, PA, uses three, PEV Ford Fusion Energi PHEVs for serving civil papers.

While not a plug-in vehicle, Ford is producing a hybrid Fusion that is pursuit-rated and has a fuel economy of 38 mpg, double that of a regular interceptor sedan.

Medium- And Heavy-Duty Vehicles

As noted earlier, to date most PEVs have been light-duty vehicles, but manufacturers are beginning to develop more medium- and heavy-duty electric vehicles. As has happened with the light-duty market, the availability of heavier and larger vehicles likely will increase as battery costs fall.

Earlier in 2017, over 30 municipalities across the United States submitted a Request for Information (RFI) to vehicle manufacturers asking for data on the cost and feasibility of supplying over 100,000 fleet vehicles to the communities.[8] The RFI was intended to show that there is a large interest in, and demand for, electric vehicles. The RFI included requests for information about heavier vehicles, such as trash haulers, street sweepers, fire engines and other heavy-duty trucks.

Some heavier EVs are already available or soon will be. Already, shuttles, school and transit buses are all available in electric models. Tesla released an electric semi-truck in late 2017. Mitsubishi, Daimler, Mercedes Benz, Nikola Motor Company, Cummins and BYD (maker of electric transit buses) also all have announced plans to produce heavy-duty electric trucks.

Photo: Colorado Department of Transportation

Boulder County includes rural areas where only heavy-duty vehicles can handle the job, such snowplowing mountain roads.

Although manufacturers don't currently offer electric versions, some companies plan to introduce electric-powered big trucks in the future.

Greenhouse Gas Emissions Impacts

While electric vehicles are often referred to as zero-emission vehicles, this label only refers to tailpipe emissions. In locations where the electricity source is largely coal, emissions from PEVs are comparable to those from gasoline vehicles.

However, this is not the case in Boulder County. Most of the county is within the service territory of Xcel Energy. SWEEP recently conducted an analysis for the City and County of Denver[9], funded by the

[8] Electrek. 2017. U.S. Cities Massive Electric Vehicle Order Increases to 114,000 vehicles, ~40 Companies Competing. https://electrek.co/2017/03/15/electric-vehicle-order-114000-vehicles-40-companies-competing/

[9] Svitak, T., Salisbury, M. and Toor, W. 2017. Opportunities for Vehicle Electrification in the Denver Metro area and Across Colorado. http://www.swenergy.org/data/sites/1/media/documents/publications/documents/CORRECTED%20Denver%20Electric%20Vehicle%20Report.pdf

Regional Air Quality Council, which quantifies the emissions of an electric vehicle that is charged on Xcel Energy's grid, both in 2016 and as it likely will be in 2025.

In 2016, a light-duty, battery electric vehicle (BEV) reduced emissions of nitrogen oxides (NOx) by 38 percent, volatile organic compounds (VOCs) by 99 percent and greenhouse gas (GHG) emissions by 30 percent compared to a new gasoline vehicle.

Significant changes are being made to Colorado's electricity generation system, due mainly to the *Clean Air, Clean Jobs* bill[10], the Renewable Portfolio Standard, and the additional renewables that Xcel Energy has proposed in its electric resource plan[11], so a new PEV driven in 2025 will offer even greater benefits than it would in 2016.

Boulder County has embraced cleaner energy sources to preserve its clear vistas and clean air, like that enjoyed by these balloonists on a bright morning east of the city of Boulder

Photo: istock/ Getty Images.

Note that the 2025 projections are actually quite conservative. Historically, Xcel has added renewables at a rate that is substantially faster than planned in previous Electricity Resource Plans (ERPs). The company and other stakeholders currently are discussing the potential for adding approximately 1.7 gigawatts of additional renewables prior to the expiration of the production tax credits, and the early retirement of two more coal plants. If these changes take place, the emissions benefits of PEVs will grow even more rapidly as renewable generation will make up over half of the electricity mix in the region.

[10] Colorado House Bill 10-1365. Clean Air, Clean Jobs is expected to result in an 88% reduction in NO_x emissions and a 28% reduction in CO_2 emissions from the electricity generating sector.
[11] Colorado's Renewable Portfolio Standard calls for 30% of investor-owned utility electricity generation to come from renewables and 20% of generation from cooperatives and municipal utilities to come from renewables.

Since the move towards lower percentages of coal generation and higher percentages of renewable generation will likely continue past 2025, emissions from PEVs will continue to decrease over time.

In addition, for vehicles that are charged within the City of Boulder, the city has adopted a goal of 100 percent renewable electricity by 2030.[12] If this goal is met, either through a municipal utility or through a partnership with Xcel, then these vehicles essentially will have zero emissions.

Fewer gas cars will equal cleaner air. *Photo: NRDC*

While new gasoline vehicles will also reduce their emissions (assuming that the Trump Administration does not roll back federal fuel economy standards), the emissions benefits of PEVs will improve at a faster rate. Based on the projected generation mix in Xcel's 2025 Electric Resource Plan, by 2025, a BEV will reduce NOx emissions by 84 percent, VOC emissions by 99 percent and GHG emissions by 49 percent compared to a new gasoline vehicle meeting 2025 federal standards.

And because the fuel source for electric vehicles is what is becoming cleaner, it is not necessary to purchase new PEVs to experience emissions reductions. Existing PEVs will become cleaner every year they are on the road (unlike gasoline vehicles, which have the same emissions profile over their whole lifetime). For example, the GHG emissions from a BEV are the equivalent of a 47 mpg gasoline vehicle in 2016, but will equal a 75 mpg vehicle with the 2025 electricity mix.

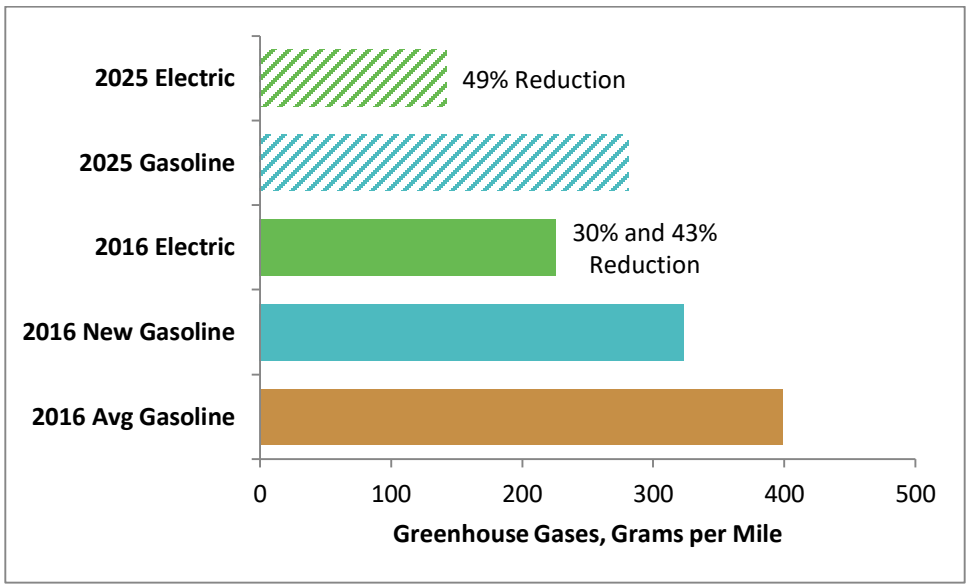
Over the longer term, vehicle electrification is necessary to achieve deep reductions in carbon emissions from the transportation sector. For gas-powered cars, fuel efficiency improvements and reductions in per capita vehicle miles travelled can lead to some reductions. But to reach the goal of an 80 percent (or greater) reduction in carbon emissions by 2050, the County must transform a significant portion of its transportation fleet to electric vehicles, which should be powered by no-carbon or very low-carbon sources of electricity.[13]

[12] City of Boulder. 2017. Energy Future and Climate Commitment https://bouldercolorado.gov/city-council/energy-future-and-climate-commitment

[13] Yang, C., McCollum D., McCarthy, R., Leighty, W.2009. Meeting an 80% reduction in greenhouse gas emissions from transportation by 2050: a case study in California, Transportation Research Part D: Transport and Environment 14.; Melaina, M. Webster, K. 2011.Role of fuel carbon intensity in achieving 2050 greenhouse gas reductions within the light-duty vehicle sector, Environmental Science and Technology 45 *(9)*/; International Energy Agency. 2009. Transport, Energy, and CO_2: Moving Towards Sustainability.

The graph below shows the lifecycle greenhouse gas emissions from gasoline and battery electric vehicles in 2016 and 2025.

Figure 1. Lifecycle GHG Emissions Comparison



The table below compares the total lifecycle emissions from a number of different vehicles over a 10-year period.

Table 9. Lifecycle GHG Emissions Over 10 Years

Vehicle	Total GHG Emissions Over 10 Years (Tons)
BEV Sedan	12.9
PHEV Sedan	14.6
Ford Fusion Sedan Hybrid	17.9
Ford Escape SUV	50.6
Mitsubishi Outlander PHEV SUV	23.9
Ford F-150 Pickup	48.7
Workhorse W-15 Pickup PHEV	29.0

Aggregate GHG Impacts of Fleet Electrification

A very rough estimate of the GHG emissions from all the light-duty vehicles (sedans, SUVs, pickups and vans) in the County' fleet is 1,900 tons annually.

By 2025, the fleet electrification schedules outlined above would result in 120 to 191 light-duty electric vehicles in the County's fleet. The shift to PEVs would cut GHG emissions below current levels by roughly 17 percent, or 330 tons, for 120 vehicles, and by 29 percent, or 550 tons, for 191 vehicles.

If the County converts all its light-duty vehicles (sedans, SUVs, pickups and vans but not including police Interceptors) to plug-in vehicles, it would eliminate approximately 1,075 tons of greenhouse gas emissions, or a 57 percent reduction, from the County's fleet by 2025.

Boulder County could achieve additional reductions from further electrification of its fleet by, for example, replacing plug-in hybrid electric vehicles with full electric vehicles, and from the continued de-carbonization of electricity.

The table below breaks down the emissions reductions by vehicle type.

Table 10. Potential Tons of GHG Reduction from Electrification of Different Types of Light-Duty Vehicles

Vehicle Type	Total GHG Reductions
All Sedans	39
All SUVs	388
All Pickups	564
All Vans	84
All Light Duty Vehicles	1,075

As appropriate electric technologies come to market, the County also should consider replacing its medium- and heavy-duty vehicles. A very rough estimate of the current GHG emissions from the County's heavy-duty diesel vehicles is 1,100 tons annually, based on the fleet consuming about 98,000 gallons of diesel each year.

In the short- and medium-term, meanwhile, the County should consider using renewable diesel, which can be used as a drop-in fuel by the County's current diesel vehicles. A drop-in fuel can fulfill 100 percent of all fuel needs without the need to modify vehicles or install new refueling infrastructure. Renewable diesel is made from waste vegetable oils or animal fats, which are produced when turning the above into food. Because renewable diesel is processed in the same way as regular diesel fuel, it can be used as a drop-in fuel with no blending, unlike biodiesel, which can only be used up to certain blend levels in most diesel engines. However, renewable diesel may cost between $1.50 to $2.00 more per gallon compared to regular diesel.

The greenhouse gas emissions benefits of renewable diesel depend on the stock used to create the fuel. The California Air Resources Board (CARB) rates three different pathways for renewable diesel for compliance with the state's Low Carbon Fuel Standard.[14] If the County does intend to make use of renewable diesel, it should undertake an accurate accounting of the carbon intensity of the fuel.

If the County does intend to make use of renewable diesel, it should undertake an accurate accounting of the carbon intensity of the fuel.

Table 11. Comparing the Carbon Intensity of Diesel and Renewable Diesel

	Carbon Intensity (grams of CO2e/megajoule)	% Reduction in Carbon Intensity
Regular Diesel		
	98.03	-
Types of Renewable Diesel		
Conversion of Tallow-high energy intensity	39.33	60%
Conversion of Tallow-low energy intensity	19.65	80%
Conversion of Soybeans	82.16	16%

If replacing regular diesel with 100 percent renewable diesel reduced GHG emissions by 60 percent, then a mix of 20 percent renewable diesel and 80 percent regular diesel would reduce emissions by 12 percent per gallon. If all the County's diesel-fueled fleet vehicles used this 20 percent blend, the total emissions reduction would be approximately 140 tons. This level of blending would require approximately 19,500 gallons of renewable diesel a year, resulting in an incremental cost of about $39,000 (assuming an incremental cost of $2 per gallon for renewable diesel).

However, the industry may not be able to scale up production of renewable diesel fast enough to meet higher demand, especially if private owners – not just the County – also want to use more renewable diesel.

But if the industry can quickly scale up the supply of renewable diesel, eventually the County could replace 100 percent of the diesel fuel it uses. That shift would reduce GHG emissions by 60 percent, or approximately 700 tons, at an annual cost of approximately $200,000.

Still, over the long term, electrification of medium- and heavy-duty vehicles offers the best opportunity for a carbon-neutral fleet, so the County should still pursue PEVs as the vehicles become available in this area.

As appropriate electric technologies come to market, the County also should consider replacing its medium- and heavy-duty vehicles.

Economics of Fleet Electrification

Vehicle Costs and Savings

Most PEVs, however, cost more initially than gas-powered cars because of the expense of lithium-ion batteries. But this incremental capital cost has been falling since the first PEV came to market, and manufacturers expect the price to keep dropping until PEVs reach capital cost parity with gasoline vehicles. To help government fleets (which are not eligible for federal and state tax incentives), the Regional Air Quality Council (RAQC) provides funding to offset part of the cost of new electric vehicles and charging stations through its Charge Ahead Colorado (CAC) program. The program offers funding up to 80 percent of the incremental cost of a PEV compared to a gasoline vehicle, with a limit of $8,260. For a Level 2 charging station, RAQC will provide funding for up to 80 percent of the cost, as much as $6,260 for a dual-port charging station and up to $3,260 for a single-port charging station.

To trim the initial capital costs of PEV fleet vehicles, the County should consider an innovative option where the dealership assumes the federal tax credit and passes some or all of the savings on to the County. For example, Alameda County in California recently led a process where it developed a bid asking local dealerships for price quotes for PEVs. The lowest quote came from a dealership that incorporated all of the federal tax credit into the PEV's discounted price.

Ford makes the Fusion hybrid. *Photo: Ford*

This potential opportunity has not been widely used. The federal tax code provides individuals or business purchasers of light-duty electric vehicles a tax credit of up to $7,500. Government agencies and non-profit organizations are not able to take advantage of this provision, at least not directly. However, the tax code contains the following language: "**Exception.** If you are the seller of a qualified plug-in electric drive motor vehicle or qualified two-wheeled plug-in electric vehicle to a tax-exempt organization, governmental unit, or a foreign person or entity, and the use of that vehicle is described in section 50(b)(3) or (4), you can claim the credit, but only if you clearly disclose in writing to the purchaser the amount of the tentative credit allowable for the vehicle.[15]"

That language means local governments can negotiate a deal in which the dealer will get the tax credit and pass on some or all of the value to the government agency. In the Alameda County case, the county

[15] Internal Revenue Service. 2016. Instructions for Form 8936. https://www.irs.gov/pub/irs-pdf/i8936.pdf

bid for 90 electric vehicles, on behalf of several local governments. In the request for proposals (RFP), the county encouraged responding dealers to take advantage of the federal tax credit and pass the savings on to the County. Only one of the responding dealers included the tax credit, but the company passed on the entire $7,500 per vehicle to the county and won the bid.[16]

Even without dealership participation, PEV prices already are in reach for local governments. While PEVs generally have an incremental capital cost compared to a gasoline vehicle, the difference is only a few thousand dollars for several models as shown by the prices from Colorado's state bid. In the case of the Nissan LEAF, the state bid price is below that of a comparable hybrid sedan. If the County received grant funding from the Charge Ahead Colorado program (which is available for vehicles made in the United States), the capital costs of PEVs would be significantly reduced.

Table 12. Current Capital Costs of Plug-in Electric Vehicles that Could Replace County Fleet Vehicles

	Price	Vehicle Type	Incremental Cost Compared to Ford Fusion Hybrid	Incremental Cost After CAC Grant
Ford Fusion Energi	$26,350*	Sedan/PHEV	$3,579	$716
Toyota Prius Prime	$26,064*	Sedan/PHEV	$3,293	$659
Chevy Volt	$29,098*	Sedan/PHEV	$6,327	$1,265
Nissan LEAF	$19,414*	Sedan/BEV	($3,357)	NA
Chevy Bolt	$36,620**	Sedan/BEV	$14,724	$6,464
Mitsubishi Outlander (SUV)	$47,490**	SUV/PHEV	$19,490***	$11,230
Workhorse W-15	$52,000**	Pickup/PHEV	$20,000	$11,740

*Colorado State Bid Price, **MSRP, *** Compared to a Ford Escape SUV/Ford F-150

In fact, if the County can take advantage of both a dealership pass-through of the federal tax credit and a Charge Ahead Colorado grant,[17] the County would not face any remaining incremental cost for all the plug-in electric vehicles (except for purchases of the Mitsubishi Outlander and the Workhorse W-15).

But the County also should consider total ownership costs. PEVs have lower fuel and maintenance costs than purely gasoline fueled vehicles, which enables owners to recover the additional capital costs and, in the long-term, makes PEVs cost-competitive with gasoline vehicles.

[16] EV Smart Fleets. 2017. Capturing the Federal EV Tax Credit for Public Fleets: A Case Study of a Multi-Jurisdictional Electric Vehicle Procurement in Alameda County, California. http://evsmartfleets.com/materials/capturing-the-federal-ev-tax-credit-for-public-fleets/

[17] We assume that the incremental cost funded by Charge Ahead Colorado would reflect the reduced price after taking advantage of the federal tax credit.

Annual fuel savings for PEVs will vary based on the fuel economy of the comparable gasoline vehicle and the number of miles traveled each year. Each vehicle type is estimated to have the following annual mileage based on current County fleet usage: Sedan, 7,000; SUV, 9,000; Pick-up: 10,000. Based on estimates from Argonne National Lab's AFLEET tool[18], the maintenance costs per mile for various types of vehicles are as follows: Gasoline: $0.142; Gasoline Hybrid: $0.137; PHEV: $0.135; BEV: $0.125. The average price of gasoline between 2019 and 2025 is assumed to be $2.75 based on the Energy Information Administration's projections in the Annual Energy Outlook.[19]

Table 13. Comparison of Fuel Costs and Savings

Vehicle Type	Type of Vehicle	Annual Fuel Costs	PEV Fuel Savings	Annual Maintenance Savings	Avg Annual Savings
Ford Fusion Hybrid	Gas Sedan	$458	NA	NA	NA
Chevy Volt	PHEV Sedan	$300	$158	$14	$172
Toyota Prius Prime	PHEV Sedan	$340	$118	$14	$132
Nissan LEAF	BEV Sedan	$256	$202	$84	$286
Chevy Bolt	BEV Sedan	$256	$202	$84	$286
Ford Escape	Gas SUV	$1,331	NA	NA	NA
Mitsubishi Outlander	PHEV SUV	$337	$674	$64	$739
Ford F-150	Gas Pickup	$1,250	NA	NA	NA
Workhorse W-15	PHEV Pickup	$612	$638	$70	$708

Table 14. Current Total Cost of Ownership (Capital, Fuel and Maintenance Costs) of Plug-in Electric Vehicles and Gasoline Vehicles

	Type of Vehicle	Total Cost of Ownership (After 10 years, including CAC grant)
Ford Fusion Hybrid	Gasoline	$37,000
Toyota Prius Prime	PHEV	$36,300
Chevy Volt	PHEV	$36,500
Nissan LEAF	BEV	$30,700
Chevy Bolt	BEV	$40,500
Ford Escape (SUV)	Gasoline	$51,200
Mitsubishi Outlander (SUV)	PHEV	$55,000
Ford F-150	Gasoline	$58,700
Workhorse W-15	PHEV	$63,300

[18] Argonne National Laboratory. 2017. Alternative Fuel Life-Cycle Environmental and Economic Transportation Tool. https://greet.es.anl.gov/afleet

[19] Energy Information Administration. 2017 Annual Energy Outlook. Energy Prices by Sector and Source. https://www.eia.gov/outlooks/aeo/

These data clearly show that the total cost of ownership for plug-in electric vehicles compares favorably with similar gasoline vehicles because of lower fuel and maintenance costs. As electric vehicle prices drop in future years, their total cost of ownership will compare even more favorably with gasoline vehicles.

Aggregate Vehicle Costs Scenarios

We examine two cost scenarios to provide a range of potential incremental capital costs for PEVs. In the high-cost scenario, we assume that the incremental cost of the PEVs is defrayed by the Charge Ahead Colorado program that provides as much as $8,260 off the price of a PEV. In the low-cost scenario, we assume that the County is able to take advantage of both the federal tax credit and the CAC incentive.

Table 15. Incremental Cost of PEVs

	Incremental Cost	With CAC Grant	With CAC Grant & Federal Tax Credit[20]
Nissan LEAF	$0	$0	$0
Chevy Bolt	$14,724	$6,464	$1,444
Mitsubishi Outlander	$19,490	$11,230	$5,430
Workhorse W-15	$20,000	$11,740	$4,240

The incremental cost of electric vehicles is projected to fall each year as battery costs decrease and economies of scale are realized in PEV production. Based on the Energy Information Administration's estimate that the cost of PEVs will fall by $4,000 between 2019 and 2025, we have reduced the incremental cost accordingly each year.

The table below provides estimates of what the annual total incremental capital cost to the County would be if it adopted the goal of having 120 or 191 electric vehicles in its fleet by 2025. For sedans, we assume that the County buys a 50/50 mix of LEAFs and Bolts. We assume that vans will have the same profile as pickups. The estimated annual fuel and maintenance savings are also presented. Importantly, please note that the fuel and maintenance savings from PEVs will continue beyond 2025. If no new PEVs were purchased after 2025, the existing PEVs would provide $800,000 to $1.3 million in fuel and maintenance savings over their total lifetimes.

These data clearly show that the total cost of ownership for plug-in electric vehicles compares favorably with similar gasoline vehicles because of lower fuel and maintenance costs.

[20] When both the federal tax credit and the CAC grant are used, the federal tax credit is taken first and the CAC grant is applied to the remaining incremental cost.

Table 16. Potential Boulder County Fleet Electric Vehicle Adoption Schedule and Incremental Cost

	2019	2020	2021	2022	2023	2024	2025	Total
General Fleet								
Low Estimate	$82,139	$87,058	$45,049	$30,116	$31,463	$40,730	$36,218	$352,772
High Estimate	$218,261	$219,826	$124,152	$90,630	$93,204	$127,839	$115,556	$989,468
Savings	$14,611	$30,457	$40,083	$47,859	$57,375	$69,761	$81,440	$341,584
General and Sheriff Fleets								
Low Estimate	$136,035	$129,001	$69,566	$80,565	$57,638	$67,044	$64,726	$604,576
High Estimate	$333,014	$307,042	$190,227	$223,776	$169,114	$189,209	$190,723	$1,603,104
Savings	$22,703	$45,196	$59,838	$79,081	$95,028	$113,261	$132,170	$547,277

To put these cost numbers in perspective, the annual budget for replacement of fleet vehicles is an average of $3.9 million over the same time period, and the total budget from 2019 to 2025 is $27.4 million.

Charging Station Costs

Based on the analysis done by Clean Cities, the average light-duty fleet vehicle travels between 25 to 30 miles each day, with some vehicle classes (mid- and full-sized SUVs and half-ton trucks) traveling closer to 40 miles per day on average. While the average is important, more detailed information on daily vehicle travel will be critical for the County to decide which vehicles to electrify. While the average vehicle may travel 25 to 30 miles a day, certain vehicles, especially in departments like Parks and Road Maintenance, may easily travel over 100 miles in a day.

The County could take several approaches in providing the charging stations necessary to support the electrification of the fleet. Two levels of charging are most practical for fleet charging, Level 1 and Level 2. Based on an average daily usage of 25 to 30 miles, refilling an EV's battery would take about seven to eight hours at a Level 1 charging station and about one to three hours at a Level 2 station.

One approach to recharging fleet vehicles would be to provide each PEV with a dedicated Level 1 station that its driver would plug in every night to refill the battery. Assuming that the vehicle would be plugged in from 5 p.m. to 8 p.m., those 15 hours of charging would be enough to add about 45-60 miles of range each night (enough to satisfy the charging need for most County fleet vehicles).

For plug-in hybrids, a nightly charge would provide sufficient time to fill up the battery, allowing for the maximization of electric miles the following day. But almost all PHEV today, and expected on the market in the next few years, will offer less than 45 to 60 miles of range on an electric charge alone, so some gasoline use might still occur with County cars driven longer distances. For battery electric vehicles, only vehicles that consistently travel over 60 miles a day, or spend fewer hours parked overnight, would be unable to maintain a fully charged battery. With some BEVs like the Chevy Bolt,

that driving distance may not be an obstacle if the vehicle is left to charge during the entire weekend, too, so it would be ready Monday morning with a fully charged battery.

However, Level 1 charging generally is not capable of "smart" charging, or providing data on electricity consumption along with the ability to schedule charging to better manage the local grid's load. This smart charging can be critical, because it allows the fuel consumption of each fleet vehicle to be monitored accurately and easily.

While Level 2 stations can offer smart charging abilities and enable vehicles to refill at a much faster rate, those facilities also present a logistical challenge and so will make it difficult for the County to take advantage of them. It won't be feasible for County workers to move vehicles or charging cords after regular work hours or on weekends. Instead, to efficiently and consistently make use of Level 2 chargers, we recommend that the County have a set of vehicles that access a single dedicated charger where just one vehicle is fully charged each night. Here is one example of how such a system would work.

The 2018 LEAF travels 140 miles per charge. *Photo: Nissan*

Remember that most of the County's fleet sedans travel an average daily distance of just 25 miles.

That statistic means a set of Nissan LEAFs easily could share four parking spaces that surround a Level 2 charger. A pre-determined schedule would let drivers know who should plug in their County car each evening.

Nissan estimates that its 2018 LEAF can travel 140 miles per charge, so even after four days of use and traveling 100 miles, the County car still should have about 40 miles of range remaining in its battery. So, a vehicle could be re-charged on a Thursday night, have a full battery by the next morning, and still could be driven through most of the next week without running out of juice.

For fleet vehicles traveling longer distances of around 50 miles per day, a set of four Chevy Bolts would meet the demands while using the same schedule of recharging every fourth night. After four days, the Bolt would have traveled about 200 miles and have about 40 miles of range remaining. Again on the fourth night, the County staffer would plug in the vehicle, which would be fully charged by morning.

Managing the charging of these vehicles would be as straightforward as having one employee at the location responsible for making sure the correct vehicle was plugged in at the end of each work day. There would be no need to move vehicles as they would always be parked in the same space.

Installing a dual-port station in the middle of a parking lot would enable four vehicles to easily re-charge, but might be cost-prohibitive because the lot would need to be trenched (to bury the electrical cables)

and then repaved. A similar but less expensive option would be to install one Level 2 station at the edge of a lot, then park four vehicles nearby in a row; a 25-foot cord should reach all four EVs' charging ports

Level 2 charging can also better serve vehicles that can charge during the day, allowing PHEVs to quickly refill between trips and maximize electric-powered mileage. Additionally, if some BEVs can charge during the day, they will reduce the demand for chargers overnight.

Given these possibilities, we designed the cost analysis below by assuming that Level 2 charging will be used for fleet vehicles and that each Level 2 station can serve four vehicles.

The installed cost of charging stations will likely vary by site, with some sites requiring extensive trenching and longer runs of wire, both of which will increase costs. The table below provides estimates of the costs to purchase and install Level 2 charging stations.

Table 17. Level 2 Station Costs[21]

Single Port Station[22]	Dual Port Station	Installation Costs (per unit)
$5,500	$7,200	$5,000-$10,000

Estimates of the cost of retrofitting a parking space to install a Level 2 charger range between $5,000 and $10,000.[23] A smart, Level 2 charging station will cost an estimated $5,000 to $7,000.[24] The County could drive costs to the lower end of the estimate if it plans ahead and installs multiple stations at one time. We therefore assume that the total costs to purchase and install a Level 2 station will be between $10,000 and $14,000. Charge Ahead Colorado provides funding of up to $6,260 for each charger, so this would bring the cost down to between $3,740 and $7,740. The draft plan for allocating Colorado's share

[21] Svitak, T., Salisbury, M. and Toor, W. 2017. Opportunities for Vehicle Electrification in the Denver Metro area and Across Colorado.
http://www.swenergy.org/data/sites/1/media/documents/publications/documents/CORRECTED%20Denver%20Electric%20Vehicle%20Report.pdf

[22] US Department of Energy. 2015. Costs Associated With Non-Residential Electric Vehicle Supply Equipment.
https://www.afdc.energy.gov/uploads/publication/evse_cost_report_2015.pdf

[23] TecHome Builder. 2014. EV Charging: What do Homebuilders Need to Know?
http://techomebuilder.com/emagazine-articles-1/energy-and-water/ev-charging-what-do-homebuilders-need-to-know;
California Building Standards Commissions. 2015. EV Charging Infrastructure Provisions.
https://www.documents.dgs.ca.gov/bsc/2015TriCycle/CAC/GREEN/Exhibit-B-CARB-Cost-Analysis-and-Technical-Report.pdf;
Agenbroad, J. and Holland, B. 2014. Pulling Back the Veil on EV Charging Station Costs.
https://rmi.org/news/pulling-back-veil-ev-charging-station-costs/;
$5,200 is the average costs for commercial installations from RAQC's Charge Ahead Colorado program.

[24] National Car Charging. 2017. ChargePoint CT4021 Dual Plug Bollard Add-On Charging Station.
https://www.nationalcarcharging.com/products/chargepoint-ct4021;
Amazon. 2017. CharePointCT4023Level 2 Electric Vehicle Charging Station Double Port Wall Mount.
https://www.amazon.com/ChargePoint-Electric-Vehicle-Charging-Non-Gateway/dp/B01A5YEH3Q;
$5,500 is the average cost for commercial stations from RAQC's Charge Ahead Colorado program.

of VW Settlement funds would increase the funding levels to $9,000 for a dual-port, Level 2 charging stations, and would make the costs to provide electrical service eligible expenses. If the state adopts the draft plan, the County's net costs of installing charging stations should come down.

Service Upgrades

The County buildings generally do not have enough spare electrical capacity to serve multiple charging stations. Therefore, the addition of new charging stations and their additional electrical load will require the provision of new electrical service. The cost to set up a new electrical service will vary by site, depending on the distance between existing service and the new charging stations, how much retrofitting a site will have to undergo, and the price of a new transformer.

Tesla home charger. *Photo: Jim Meyers, SWEEP*

New electric service costs from $15,000 to $25,000, so we assume an average price of $20,000 for the cost analysis. One way to reduce the number of new services required would be to consider the possibility of installing lower-amperage Level 2 stations. Many Level 2 stations require the dedication of 40 amps of electrical service, but others (which supply lower levels of power and slower charging) are rated at 25 amps. If vehicles were able to fully charge using only a 25-amp station, the County could install more charging sites for each electrical service upgrade it makes.

In Boulder, the maximum power for each new electrical service is 320 amps. This level of power could serve up to eight, 40-amp, Level 2 charging stations, or twelve, 25-amp stations. In Longmont, the maximum power for each new service is 200 amps, which could serve up to five, 40-amp Level 2 stations, or eight, 25-amp stations.

The table below provides a range of costs for supplying charging stations to County fleet vehicles under the two PEV adoption scenarios discussed earlier. Under each scenario, we give a low- and high-cost estimate for all Level 2 stations to charge the vehicles, thus providing an idea of the infrastructure costs.

Table 18. Charging Stations Cost for General Fleet Scenario

	2019	2020	2021	2022	2023	2024	2025	Total
New Level 2 Stations	6	6	4	3	4	5	4	32
Low Cost	$22,440	$22,440	$14,960	$11,220	$14,960	$18,700	$14,960	$119,680
High Cost	$46,440	$46,440	$30,960	$23,220	$30,960	$38,700	$30,960	$247,680
Service Cost	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$140,000

Table 19. Charging Stations Cost for General and Sheriff Fleets Scenario

	2019	2020	2021	2022	2023	2024	2025	Total
New Level 2 Stations	8	8	6	8	7	7	7	51
Low Cost	$29,920	$29,920	$22,440	$29,920	$26,180	$26,180	$26,180	$190,740
High Cost	$61,920	$61,920	$46,440	$61,920	$54,180	$54,180	$54,180	$394,740
Service Cost	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$140,000

Cost and Savings Summary

The table below provides a summary of the estimated vehicle, charging stations and electrical infrastructure costs under the two scenarios, along with the expected fuel and maintenance savings.

Table 20. Cost and Savings Summary

	2019	2020	2021	2022	2023	2024	2025	Cumulative
General Fleet								
Low Cost	$124,579	$129,498	$80,009	$61,336	$66,423	$79,430	$71,178	$612,452
High Cost	$284,701	$286,266	$175,112	$133,850	$144,164	$186,539	$166,516	$1,377,148
Savings	$14,611	$30,457	$40,083	$47,859	$57,375	$69,761	$81,440	$341,584
General and Sheriff Fleets								
Low Cost	$185,955	$178,921	$112,006	$130,485	$103,818	$113,224	$110,906	$935,316
High Cost	$414,934	$388,962	$256,667	$305,696	$243,294	$263,389	$264,903	$2,137,844
Savings	$22,703	$45,196	$59,838	$79,081	$95,028	$113,261	$132,170	$547,277

Other Potential Funding Sources

Appendix D of the state's recently released draft plan for use of the VW settlement funding indicates that there may be higher levels of funding available for workplace charging. Charge Ahead Colorado offers up to $6,260 for a Level 2 dual-port charging station, while the draft plan sets the maximum funding levels for the same type of equipment at $9,000.

Eighty-five percent of the funding from the VW settlement is focused on medium- and heavy- duty diesel vehicles. The draft settlement plan proposes that $18 million be used to replace "medium and heavy duty trucks, school and shuttle buses… with alternative fuel or electric vehicles"[25] This Alternative Fuel Vehicle Replacement program will provide incentives for public and private fleets to scrap older

[25] Colorado Department of Public Health and Environment. Proposed Beneficiary Mitigation Plan. https://www.colorado.gov/pacific/sites/default/files/AP_VW_Beneficiary_Mitigation_Plan.pdf

vehicles (from between 1992 and 2009) and replace them with new vehicles. Public fleets will be eligible for grants that cover up to 40 percent of cost of the new vehicle and its associated charging infrastructure, up to the caps outlined below.

Table 21. Maximum Vehicle Incentives from VW Settlement

Vehicle Type	Class 4-8 School/Shuttle Bus	Class 4-7 Local Freight	Class 8 Local Freight
Incentive Level	$200,000	$100,000	$200,000

This incentive should go a long way to making medium- and heavy-duty electric vehicles more affordable from a capital cost perspective.

Another potential source that could further defray the costs of installing charging stations would be Xcel Energy. Potentially, Xcel Energy could take on the role of providing supporting electrical infrastructure to charging stations such as transformers, wiring and new electrical service to serve the new load demands from the charging stations. This support could be for both the fleet and workplace charging stations.

The state's settlement plan proposes that $18 million be used to replace "medium and heavy duty trucks, school and shuttle buses… with alternative fuel or electric vehicles"

For additional details on the state's detailed January 24, 2018 electric vehicle plan, please see SWEEP's newsroom page.

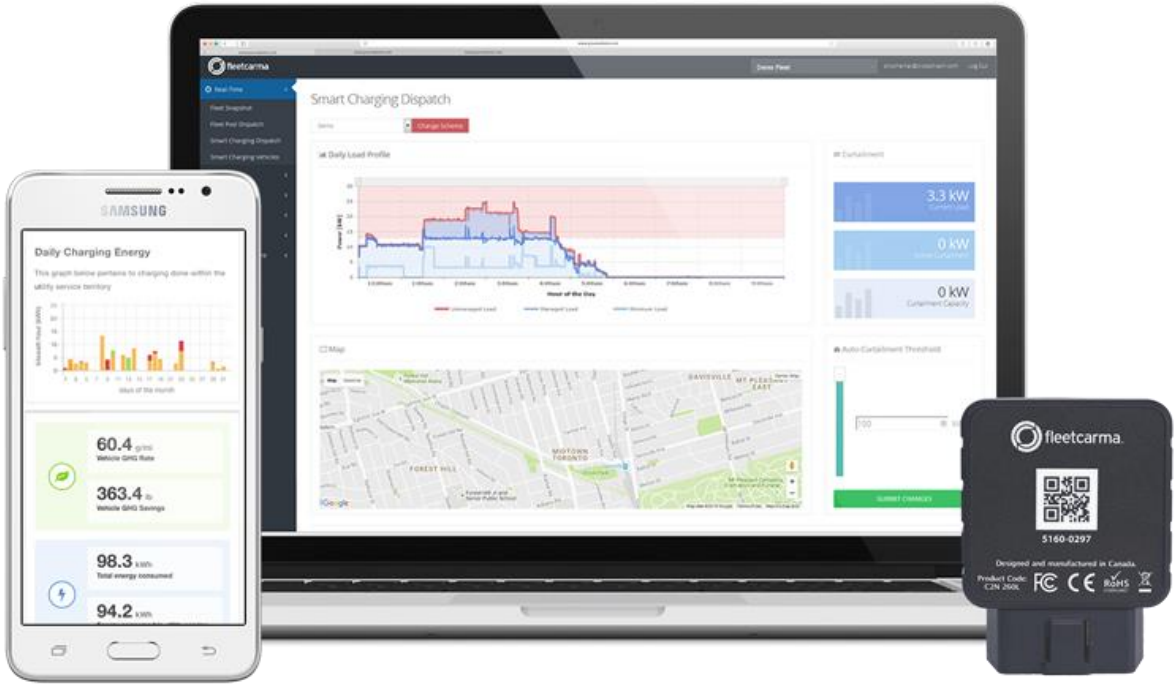
Telematics

Telematics offer the opportunity to get data on the usage of fleet vehicles to identify which vehicles are best suited for electrification.

Using on board devices, a vehicle's location, fuel usage and mileage can be monitored in real-time and analyzed over the course of six months to a year. With this data, fleet managers can see which vehicles have daily ranges that can be met by PHEVs or BEVs. Along with the data, analysis is done on the potential charging needs to support electric vehicles and the economic impact of fleet electrification.

The County is currently considering entering into a partnership with FleetCarma to provide this type of information. While we have not evaluated the proposal, we do agree that collection of this type of data is a best practice that allows fleet transitions to be made in the most strategic and financially beneficial fashion.

An example of FleetCarma's infographics. *Courtesy of FleetCarma.*



Charging for Employees

SWEEP reviewed the current parking facilities at County government locations across the County to determine where it makes sense for the County to invest in charging infrastructure for its employees.

The table below lists all the locations where information was available for the number of parking spaces, the number of employees and the dedicated employee parking at a given site.

Table 22. Boulder County Employee Parking Locations

Site	# of Employees	Total Parking Spaces	# of Dedicated Employee Spaces
North Broadway	385	368	250
St. Vrain	334	243	145
Boulder Courthouse (Main, Annex & Pine St.)	319	113	91
OSTC	267	211	0
Sheriff & Coroner	195	201	105
Jail	165	311	0?
Justice Center	102	538	304
Kaiser[26]	83	96	96
Clerk & Recorder (33rd)	74	203	0
Longmont Courthouse	25	157	0
Recycling	23	126	0

Most of these County sites appear to have enough additional parking that they could add dedicated EV spaces. The clear exceptions include the Boulder Courthouse, which has a very limited amount of parking, almost all of it already dedicated to specific uses. This limitation is true, too, of the Pine St. parking lot, which also serves the Courthouse. The Transportation and Housing Department, housed at the Kaiser building, also does not appear to have additional parking capacity as all the existing spaces are dedicated to specific uses.

Of those employees who own a PEV already or have some interest in purchasing a PEV, 44 percent indicated that they do not have access to charging at their homes.

[26] Many of the spaces at the Kaiser building are used by Courthouse employees, not employees at the actual Kaiser site.

The historic Boulder County courthouse in downtown Boulder has employee parking in the back, where additional EV charging stations could be installed.

Photo: iStock/Getty Images

Forecast of Future Employee PEV Adoption

The County recently conducted a survey of 605 of its employees to better understand current levels of PEV ownership and what level of interest exists among employees for a future PEV purchase.

The survey found that 5 percent of County employees already own a PEV and 19 percent have plans to purchase one in the next two years. The availability of charging at the workplace would influence 37 percent of employees to consider a PEV. This 37 percent may serve as a medium-term indication of potential PEV adoption by employees. As PEVs increase their range, come down in cost, and as more public charging stations become available, this percentage of interested employees is likely to increase.

Of those employees who own a PEV already or have some interest in purchasing a PEV, 44 percent indicated that they do not have access to charging at their homes.

Future PEVs are expected to have longer ranges, making workplace charging less of a need for PEV owners. The vast majority of PEV owners who have access to home charging will not require workplace charging to meet their commuting needs. Rather, workplace charging will be critical for PEV owners (and potential PEV owners) who do not have access to any kind of charging at their homes, a large portion of whom are likely to be residents of multi-family dwellings. Workplace charging can also play a role in increasing the number of electric miles driven by plug-in hybrid owners.

These figures indicate that over the long-term, workplace charging may be necessary for the approximately 16 percent (44 percent of 37 percent) of employees who are interested in an PEV but who do not have access to charging at home. Additionally, to give PHEV drivers the ability to increase their electric miles traveled, the County could provide charging access to 20 percent of employees.

The County could set a reasonable short-term goal of providing access to PEV chargers at 10 percent of existing employee parking spots at a given workplace, with infrastructure in place to expand to up to 20 percent. This plan would give 10 percent of the County's employees access to workplace charging in the short-term, and make it easy to expand charging to provide access to 20 percent of employees in the medium-term.

Of the employees who cannot charge at home, their round-trip commute length is broken down in the following table, along with the capacity of different levels of charging to facilitate their round-trip commute.

Table 23. Boulder County Employee Commuting Distances and Charging Requirements

		Could be fully served by:		
Roundtrip Commute	**% of Employees**	**8 hours of Level 1?**	**4 hours of Level 2?**	**8 hours of Level 2?**
Less than 10 miles	23%	Yes	Yes	Yes
11 to 30 miles	42%	Yes	Yes	Yes
31 to 60 miles	28%	No	Yes	Yes
61 to 90 miles	5%	No	Mostly	Yes
90+ miles	2%	No	No	Yes

Less than 10 percent of these employees would require more than four hours of charging at a Level 2 station to be able to make their round-trip commute. For these employees, they may need access to a charging station for most of the work day.

For the remaining 90 percent or more of employees, a mix of Level 1 and Level 2 stations should meet their needs. About 65 percent of employees would be able to complete their roundtrip commute with eight hours of Level 1 charging.

For those employees who require more charging than is possible with Level 1 stations, the County can design a system that allows for Level 2 stations to be shared over the course of the workday, both to maximize the stations' utilization and allow the charging site to serve a greater number of employees.

Policies that other employers have used to encourage sharing of stations include:

- Limiting the amount of time any one vehicle can charge.
- Assessing fees for vehicles that are plugged in for more than a period of time (such as four hours).
- Requiring charging to stop once a vehicle is fully charged.
- Having employees set up their own charging schedule via Outlook or apps.
- Siting of stations between two-to-four parking spaces, so that only the cords need to be moved, not the vehicles.

This last point would be the most desirable option if Level 2 chargers are being shared: put the charging stations between two or four parking spaces, so that only the cord needs to be moved between vehicles, rather than relocating the vehicles themselves. This arrangement will minimize the disruption and inconvenience to employees. As long as all the employees have an agreed-upon charging etiquette (only unplug a vehicle after four hours or when a vehicle is full), this setup would only require one or two employees to switch the charging cord during the day. One downside of this approach would be that a larger number of spaces would need to be dedicated to charging, compared to a model where employees move their vehicles during the day.

EV charging at Alfalfa's, Boulder. Photo: Alfalfa's

There may be the potential for more employees to make use of charging stations during the day because many employee vehicles are not parked for the entire work day. The St. Vrain parking study found that only 40 percent of employee vehicles were parked for longer than four hours at that location. If this figure is indicative of employee parking across the County, the same number of charging stations may serve a much larger number of PEV owners, though the coordination of when employees charge may pose a logistical challenge.

Based on the advantages and disadvantages of Level 1 and Level 2 charging, logically the County may consider a mix of these types of stations, depending on what makes sense at each location.

But if we assume that vehicles are not moved during the day (either the spaces are Level 1 or multiple spaces are served by one Level 2 station) then providing 10 percent of the employees with access to charging would require that 10 percent of employee spaces have access to PEV charging.

Should employees have to pay for charging?

One important consideration is whether employees should be billed for access to charging at work. Employers have come to a variety of conclusions on this issue. Many employers offer free workplace charging to their employees; for example, 80 percent of DOE Workplace Challenge Partners offer free charging.

The biggest advantage to having a cost for charging is that the fee can help to manage the use of the limited number of charging stations. Ultimately, the goal is that workplace charging should be used by those who need it (primarily people without access to home charging, and PHEV drivers who need additional electric range) while most people should be charging at night at home. Thus, over the long term the County logically should set a price for charging at work that is slightly higher than the cost of home charging. However, this approach would require setting up appropriate billing systems.

Payment could be collected from employees in several ways. The more sophisticated Level 2 charging stations can track an individual vehicle's usage, enabling employers to charge the employees based on how much electricity they used. If more basic chargers are in use, employers can ask employees to pay a flat monthly fee for access to the stations. If the station is managed by a third party provider, such as ChargePoint, then the contractor would collect the fees.

There are some concerns about whether or not offering free charging to employees would require that value to be considered taxable income by the Internal Revenue Service (IRS). This is a gray area as the IRS has not made a clear declaration as to whether free charging would qualify or not qualify as a taxable fringe benefit. Currently, transit passes (like the EcoPass) and parking subsidies are considered a qualified transportation benefit and are exempt from being considered taxable income. In addition, there is an exemption for *de minimus* benefits. If workplace charging is considered part of a parking benefit, then it would likely be covered under the allowable parking subsidy.

Potential Workplace Charging Locations

Of the employees without access to charging at their homes who have also expressed interest in purchasing a PEV (95 responded to this survey question), the following table breaks down where they work. Note that these percentages correspond well with where all employees work who have an interest in purchasing a PEV.

Table 24. Percentage of Employees Interested in PEVs

Site	% of PEV Interested Employees at Site
North Broadway	29%
Courthouse	18%
St. Vrain	14%
OSTC Campus	11%
Justice Center	8%
Kaiser	6%
Sheriff/Coroner	3%
Clerk & Recorder at 33rd	3%
Jail Complex	3%
Other	4%

The next table shows the number of employees at each site and calculates the number of parking spaces and charging stations that would be needed to provide 10 percent of employees with access to PEV charging at work. We assume that there is fifty/fifty mix of Level 1 and Level 2 stations serving these parking spaces. One Level 1 station would serve one vehicle, and one, dual-port Level 2 station could serve up to four vehicles.

The biggest advantage to having a cost for charging is that the fee can help to manage the use of the limited number of charging stations.

Table 25. Number of Charging Stations Needed to Serve Interested Employees

Site	# of Employees	10% of Employees & # of Dedicated EV Spaces Needed	# of Level 1 Stations	# of Dual Port Level 2 Chargers	Existing Level 2 Dual Port Stations
North Broadway	385	39	20	5	1
Courthouse & Annex	319	32	16	4	1
St. Vrain	334	33	16	5	1[27]
OSTC Campus	267	27	13	4	1
Justice Center	102	10	5	3	-
Kaiser	83	8	4	1	1
Sheriff/Coroner	195	20	10	3	-
Clerk & Recorder at 33rd	74	7	3	1	-
Jail	165 (3 shifts)	6	3	1	-
Longmont Courthouse	25	3	1	1	-
Recycling	23	2	1	1	-
Total	1,862	187	92	29	4

As per the previous analysis on the costs of providing charging stations to support fleet electrification, Level 2 stations cost between $3,740 and $7,740 to purchase and install.

For a low-end estimate of the costs of a Level 1 station, we assume that only a dedicated outlet and not an actual charging station would be required. In this situation, we assume an average cost of $500 per outlet (the cost could be $0 if there is a dedicated outlet already located at the parking space but that is unlikely to be the case for the majority of spaces). At the high end, we assume that capital and installation costs to put in a Level 1 pedestal or wall mount would be $3,000 (approximately the midpoint of the ranges given in the table above). [28]

It would cost between $108,000 and $224,000 to install the 29 Level 2 chargers identified in the table above. The 92 Level 1 chargers would cost between $46,000 and $276,000. Approximately nine to ten new electrical services would need to be provided to serve these new charging stations, adding $180,000 to $200,000 in costs.

[27] The St. Vrain site has conduit and service set up for one more Level 2 station.
[28] U.S. Department of Energy. 2016. Level 1 Electric Vehicle Charging Stations at the Workplace. https://www.afdc.energy.gov/uploads/publication/WPCC_L1ChargingAtTheWorkplace_0716.pdf

Does providing charging discourage getting to work by walking, biking, carpooling or transit?

County transportation staff raised concerns of whether providing EV charging for employees will tend to encourage commuting by single-occupant vehicle and discourage the use of other modes of transportation. There is certainly substantial evidence that parking availability and cost are major factors in "drive alone" rates. So any approach that provided EV charging by increasing the number of parking spaces available would be expected to lead to more driving. However, an approach that relies on adding charging to existing spaces would not be expected to have any impact on drive-alone rates, since the total parking supply is unchanged.

Other impacts of PEV adoption may not be directly connected to workplace charging. For example, the operating costs of PEVs are lower than for gasoline vehicles. In general, when energy efficiency increases, the lower costs can lead to a "rebound effect," (where lower costs lead to greater consumption) thus partially offsetting the savings from greater efficiency. We are not aware of any specific analyses of this problem in the context of PEVs, but the issue has been extensively analyzed in the context of energy efficiency standards for lighting, appliances, and CAFE standards for cars.

People power: B Cycles ready for rental Photo: Boulder B Cycle Program

The general result has been that the effect is very modest, and does not significantly reduce the benefits of the standards[29]. The Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) assumed a 10 percent rebound effect when calculating the emissions benefits of the new fuel economy standards during the Obama administration.[30] So, it is possible that a shift to vehicles with lower operating costs could lead to a small increase in total VMT, but there is very little empirical evidence. Studies by Idaho National Lab of actual PEV use by early adopters show BEV drivers having lower annual VMT than the average vehicle.

The general result has been that the "rebound" effect is very modest

[29] Nature. 2013. Energy Policy: The Rebound Effect is Overplayed. http://www.nature.com/nature/journal/v493/n7433/full/493475a.html

[30] Environmental Protection Agency. 2010. Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule. https://www.regulations.gov/document?D=EPA-HQ-OAR-2009-0472-11424

Shared Charging

Since the County is interested in increasing adoption of electric vehicles in both its fleet and among its employees, it makes sense to examine the possibility of having these two group share charging stations.

The main advantage of shared charging is that fewer charging stations would be needed, which would reduce the costs for installing stations. Rather than adding one set of charging stations for fleet vehicles and a separate set of stations for employees, the same set of stations would serve both groups.

Logistically, however, there are pros and cons to this approach. Generally, these two groups would be charging their vehicles at different times of the day so there should not be a lot of competition for charging stations. Employees would usually charge during work hours, between 8 a.m. and 5 p.m., while they are parked at their workplaces. Fleet vehicles would generally be used during the day and then would be able to charge overnight.

One logistical concern is that fleet users would need to move the vehicles in the morning before employees arrive and then at the end of the day when employees leave.

Combining fleet and employee charging may also require a shift in where fleet vehicles are located. Generally, the County's fleet vehicles are parked and refueled in a separate area, often sealed off or demarcated from other vehicles. Given this practice, it is probably not feasible to consider shared charging in most locations.

It is probably not feasible to consider shared charging in most locations.

Public Adoption

Actions to Increase Public Adoption of PEVs

Boulder County currently leads the state in public electric vehicle adoption, but adoption will need to scale up dramatically to realize the benefits of improved air quality, decreased GHG emissions, and fuel-cost savings that can come from widespread transportation electrification.

This table provides a brief overview of the potential actions Boulder County could take to promote PEV adoption in the general population and identifies potential partners the County could work with to take the action.

Table 26. Potential Actions and Partners

Action	Potential Partners
Set an EV Goal	Cities
Low Income Access	Cities, Xcel, Housing Agencies
Multi-Family Access	Cities, Xcel
EV Rideshare/Carshare	Cities, eGo CarShare, Zipcar, TNCs
Curbside Charging Stations	Cities
Streetlight Charging	Cities, Xcel
Review of County's Existing Chargers	County
DCFC Station Support	Cities
Improve Model Availability	Cities, Dealers, Manufacturers
Bus Electrification	RTD, Via Mobility, Utilities, School Districts
Group Purchase Program	Manufacturers, Dealers
Public Education	TMOs, ETCs
L2 Stations at Recreational Destinations	Land management agencies; Eldora Ski Area
EV Showcase	City of Boulder
Charging Stations at Park and Rides	RTD
Vehicle Feebate	State Legislature

Set an EV Market Goal

One important way to signal the importance of PEVs to the County is to develop an aggressive goal for EV adoption. Ideally, this would be coordinated with the major cities in the County.

At the end of 2016, there were 8,600 electric vehicles in Colorado, and 1,600, or 18.6 percent, were in Boulder County. With approximately 241,000 registered light-duty vehicles in the County in 2016, PEVs made up about 0.66 percent of all light-duty vehicles in the County. Statewide, at the end of 2016 PEVs made up approximately 0.19 percent of all vehicles. The state of Colorado has just proposed a goal of 940,000 PEVs (about 17 percent of vehicles) on the road in 2030 as part of its statewide Electric Vehicle Plan.

As the state's leading County for PEV adoption, Boulder County should set more aggressive goals than the state and could aim for at least doubling the statewide goals. In addition, the County should also set short-term goals to build towards a 2030 goal. Some potential goals for the County could be:

- 2 percent of vehicles by 2020 (~4,800 PEVs);
- 7.5 percent of vehicles by 2025 (~18,100 PEVs);
- 35 percent of vehicles by 2030 (~80,000 PEVs).

Alternatively, the County and the cities in the County could set far more ambitious aspirational goals. Many cities (including Boulder and Longmont in Boulder County) have adopted 100 percent renewable energy goals for the electricity sector, often in a context where they do not have precise plans on how to achieve these goals. However, setting the goals can then create political will for actions that greatly

advance renewable energy adoption. For example, here is a potential set of targets for the market share of new vehicle acquisition:

1. Public buses: 100 percent transit buses by 2020; 100 percent school buses by 2025;
2. Public or publically contracted medium-duty vehicles (such as trash trucks): 70 percent by 2025, >95% by 2040;
3. Private light-duty vehicles 50 percent by 2030, >95% by 2040.

Multi-family and Low Income

One area of particular focus in leading PEV states and municipalities is how to increase PEV adoption for lower-income residents and those who live in multi-family housing. These areas have relatively low access to charging at people's residences, which makes PEV adoption much more challenging. For example, when SWEEP surveyed participants in Boulder County's first group purchase program, we found that 95 percent of participants who acquired a PEV lived in single family homes.[31]

A first step in solving this problem would be to develop a clearer understanding of the current availability of charging in these sectors. This task could be done by mapping areas with high concentrations of multi-family and low-income populations, and contrasting that with current public and private charging stations.

This issue has been difficult to address across the country. The most successful programs make adding charging to existing multi-family housing very easy, with little effort and money required from landlords, tenants or owners. For example, San Diego Gas and Electric's Power Your Drive program allows the utility to install, own and operate chargers in multi-family units, and has had very high uptake.

A first step in solving this problem would be to develop a clearer understanding of the current availability of charging in these sectors.

Potential programs to improve access to multi-family and low-income populations include:

- Develop a pilot program that partners access to charging at low-income and multi-family properties with a program to encourage purchase of used PEVs (perhaps with a Cash for Clunkers component). Potentially, the County could collaborate with Boulder Housing Partners, the Boulder County Housing Authority, Thistle Community Housing and the Mobility for All program.

[31] Southwest Energy Efficiency Project. 2016. Evaluation of Colorado Electric Vehicle Group Purchase Programs http://www.swenergy.org/data/sites/1/media/documents/publications/documents/Colorado_EV_Group_Purchase_Programs_Mar-2016.pdf

- Locate charging hubs near areas with high concentrations of low-income/multi-family residents. These charging stations could be from Level 1, Level 2 or Direct Current fast charging (DCFC) depending on the situation.
- Provide County and/or city financial support specifically for stations at these locations, similar to the additional incentives offered by the City and County of Boulder to supplement the Charge Ahead Colorado funding.
- Work with city governments to adopt PEV-Ready building codes so that new or remodeled multi-family buildings are set up for easy and inexpensive charging station installation. The City of Boulder and Boulder County have already adopted code requirements, but other municipalities have not.
- Partner with utilities including Xcel and Longmont Power and Communications to develop pilot programs for utility-owned and -operated chargers in multi-family housing.
- The County could consider using a portion of sustainability funds as rebates towards the purchase of PEVs by lower-income residents.
- It may also make sense to target higher-income, multi-family residents who may not have access to charging at their residences. There is likely to be some latent demand for PEV charging in this area, so this sector would probably have high levels of utilization in the short term.

EV Carshare/Rideshare

Carshare and ridesharing programs can expose large numbers of people to electric vehicles without their needing to purchase them. In addition, electrified ridesharing may be a step towards a broadly adopted, electrified Transportation as a Service (TaaS) model, which could be a precursor to shared electrified autonomous vehicles, potentially leading to much lower levels of vehicle ownership, and significant emissions reductions.

An electrified rideshare program could be supported with hubs of fast chargers located across the County, likely in the larger cities. A charging hub would consist of several co-located, fast-charge stations. The hub concept would allow for reduced installation costs per charger and, with a large number of stations in one area, would provide transportation network company (TNC) drivers high levels of confidence that charging would always be available. Preliminary experience in California has found that fast-charging hubs that are used by TNC drivers get high enough use that they generate adequate revenue to cover their operating costs. To supplement, rather than compete with, transit service, a ridesharing program could also focus on first- and final-mile service.

These hubs could be developed by the private sector, potentially with some public sector support. For example, the City of Boulder recently considered a proposal for an EV charging hub for Commutifi, which intended to operate a fleet of Tesla Model Xs as part of a ridesharing program in the community. While the proposed program would have started with human drivers, the company intends to transition to autonomous vehicles as that technology becomes mainstream. Consideration for future autonomous vehicles should be a factor in the placement and development of any charging hubs for ridesharing.

GM, which is currently deciding where it will operate its fleets of autonomous Bolts, offers another opportunity in the autonomous carsharing space.

Furthermore, eGo CarShare already operates in Boulder and offers Nissan LEAFs as part of its fleet. The County and cities could partner with eGo CarShare by supporting the installation of dedicated Level 2 charging stations for carshare vehicles, which would allow more PEVs to be incorporated into the carshare fleet.

Zipcar, which serves the CU Boulder campus population, offers amenities such as the ability to make one-way trips, but does not currently offer any electric vehicles.

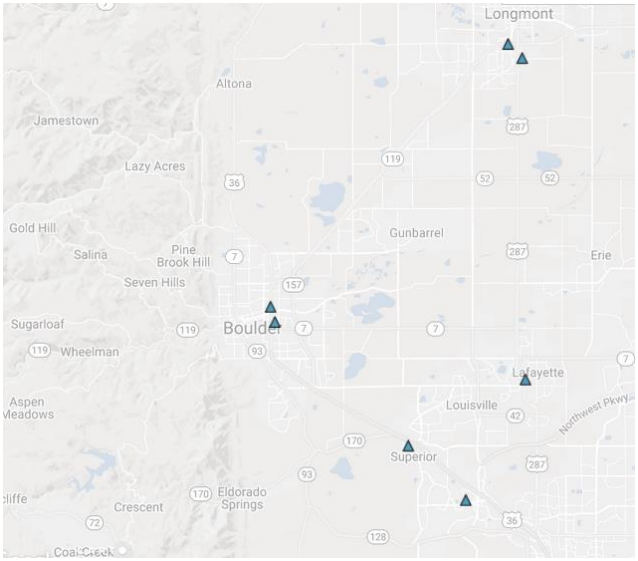
Carshare programs could be targeted to serve low-income populations. In Sacramento, the Metropolitan Air Quality Management District launched a carshare program designed for low-income residents; the city is supplying two charging stations to support the program and working with Zipcar to manage the program.

Seattle's carshare program, ReachNow, has plans to add 20 fast-charging stations to serve the PEVs in its carshare fleet.

High-Priority Sites for DC Fast Charging Stations

Municipalities are taking a more active role in supporting not only Level 2 charging, but direct-current, fast-charging (DCFC) stations as well. Vancouver, British Columbia, plans to spend $2 million to install groups of DCFC stations throughout the city. Portland, Oregon, plans to double the number of Level 2 and DCFC available to the public by 2020. The city of Santa Monica, California, plans to add ten DCFC stations over the next three years.

Current DCFC Stations in Boulder County



Currently, Boulder County has six, publically available DCFC stations: two in Boulder, two in Longmont, and one each in Lafayette and Superior (there is another DCFC station in Broomfield by the southeast corner of Boulder County). In Boulder, fast-charging stations are available at Boulder Nissan and at the 29th St. Mall, neither of which are convenient to downtown Boulder. Downtown Boulder should be the first focus for the installation of new DCFC stations in the County, as this is both a top local and regional destination.

Another potential location for DCFC would be in the town of Lyons, which serves as the County's gateway to Rocky Mountain National Park. As there is currently no publically available fast-charging in Estes Park (although there is a Tesla station), a DCFC

stations in Lyons could be an important location to provide access to one of the region's key recreation destinations.

DC fast-charging stations can also provide convenient charging to those without access to charging at their homes. The County could create a pilot program to develop a DCFC hub to serve an area of high-multi-family density, and see how well this type of service provides charging access to residents who otherwise could not charge their EVs at home.

Curbside Charging

To expand charging opportunities in denser areas, municipalities are examining the potential for curbside, or on-street, charging in both residential and commercial areas. This plan may be especially useful in areas without large amounts of off-street parking, and with high concentrations of multi-family housing. The first step would be to see if this type of charging is allowed under current regulations. An evaluation of curbside charging may be focused more in cities than the County.

A number of municipalities have developed curbside charging pilot programs including Seattle[32], Berkeley, California[33] and Burbank, California.[34] Generally, the pilots have focused on allowing someone to install a charging station in the public right-of-way, and the individual is responsible for all the installation costs. For example, the City and County of Denver, Colorado, just installed its first curbside charging station in downtown.

Streetlight Charging

A potential way to install charging infrastructure without the need for expensive electrical upgrades is to take advantage of the potential electrical capacity savings from conversion of streetlights. If existing, low-efficiency street light bulbs are replaced by high-efficiency LEDs, the additional electrical capacity could be used to support Level 1 or Level 2 charging stations. It may be possible to use the cost savings from lower electricity to pay for the charging stations.

[32] Seattle Department of Transportation. 2017. Electric Vehicle Charging in the Public Right of Way (EVCROW) Program. https://www.seattle.gov/Documents/Departments/SDOT/NewMobilityProgram/EVCROW_Program.pdf
[33] City of Berkeley. 2017. Residential Curbside Electric Vehicle Charging Pilot. https://www.cityofberkeley.info/EVcurbside/
[34] City of Burbank Water and Power. 2016. Burbank Water and Power Electric Vehicle Charging Program. http://docketpublic.energy.ca.gov/PublicDocuments/15-MISC-04/TN211161_20160420T113312_Burbank_Water_and_Power_Presentation.pdf

The City of Los Angeles has installed over 80, Level 2 charging stations using electrical capacity freed up by upgrading streetlights to LEDs.[35] Lancaster, California has launched a demonstration project to install charging stations in a number of streetlights in the downtown area.[36]

If existing, low-efficiency street light bulbs are replaced by high-efficiency LEDs, the additional electrical capacity could be used to support Level 1 or Level 2 charging stations.

Review of County-Owned (Public) Charging Stations

The County should review utilization and other available data from the publicly available charging stations owned by the County. This will give the County an idea of how well the stations are serving the public and inform decisions about additional infrastructure or upgrades of current infrastructure at the current sites.

Improve PEV Model Availability

Availability of PEV models is a key factor in PEV adoption rates, but unfortunately many EV models are not available for sale in Colorado. A 2015 study found only seven models available in Colorado, while 25 were available in California. This is particularly striking given the high level of PEV adoption in Boulder County. For example, studies by the International Council on Clean Transportation have found that the city of Boulder has the highest new vehicle market share of any city outside of California (3 percent in 2015, 4 percent in 2016), so this area should be a market where manufacturers and dealers would make models available. To try to address this, Boulder County could coordinate an effort among local government officials in the County to reach out to both local dealerships and vehicle manufacturers to ask that more PEV models be made available at vehicle dealerships in the County.

Moreover, so far only Nissan has taken advantage of the 2016 legislation making state PEV tax credits assignable. Boulder County could work with other automakers to encourage them to offer this benefit in their financing packages – essentially reducing the upfront purchase price by $5,000 per vehicle.

[35] Wired. 2016. LA's Using Energy Savings from LED Streetlights to Charge Electric Vehicles. https://www.wired.com/2016/06/las-using-energy-savings-led-streetlights-charge-electric-vehicles/
[36] Ludlow, M. 2017. Lancaster, California, a city with a vision for the post petrol future. http://www.cityoflancasterca.org/Home/ShowDocument?id=35311

Bus Electrification

While most of the public adoption efforts focus on light-duty vehicles, transit buses currently offer the best opportunity for the electrification of larger and heavier vehicles.

RTD has electrified some bus routes, including Denver's 16th Street Mall ride, at left. Photo: RTD.

The County should advocate that RTD electrify transit routes in the County as soon as possible. Via Mobility, which operates the HOP and serves the disabled population in Boulder County, recently announced it would begin to electrify the HOP route and plans to electrify its entire fleet over time.

Napa Valley, CA, has EV school buses. Photo: Clean4Kids.

Furthermore, the County could seize an important opportunity from Colorado's VW settlement, which is expected to dedicate 26 percent of its funding ($18 million) toward transit bus electrification and charging. The state's draft plan would cover 110 percent of the incremental cost of an electric bus and accompanying charging equipment. There is likely to be significant demand for this funding, so it will be important to work with agencies to file applications during 2018, as it is possible that all of these funds may be allocated in the first year. In addition, there is a $12 million "flex fund" that will be allocated after the first year depending on market demand; by showing very strong demand for transit electrification, Boulder County can make it more likely that these flex funds will go to transit.

The VW funds will also support school bus electrification. Colorado's draft plan will set aside another $18 million for alternative fuel trucks, shuttle buses and school buses. This set-aside will pay 110 percent of the incremental costs of electric school buses and associated charging infrastructure, up to a cap of $200,000 per vehicle. School buses also are parked during many hours of the day, so offer the potential for using the batteries for grid services and resiliency services. The County could partner with both the Boulder Valley School District and the Saint Vrain Valley School District to create such a program.

Finally, interesting new models emerging for financing electric buses are emerging. The bus company Proterra has developed a financing product that offers capital leases for electric bus batteries. Electric transit buses have a lower total cost of ownership, due to fuel and maintenance savings, but a much higher upfront capital cost. Converting the capital cost to an ongoing lease expense could let transit

agencies acquire electric buses at a capital cost comparable to a diesel bus, while offering immediate cash-flow savings. In addition, Clean Energy Works[37] has begun developing a new model for utility financing of electric buses that the County should explore with local utilities.

Group Purchase Programs

The County should continue to pursue opportunities such as its very successful group purchase programs for both electric vehicles and electric bikes. This continued promotion makes sense as long as manufacturers and dealers continue to express interest and are able to offer deals.

Public Awareness and Education

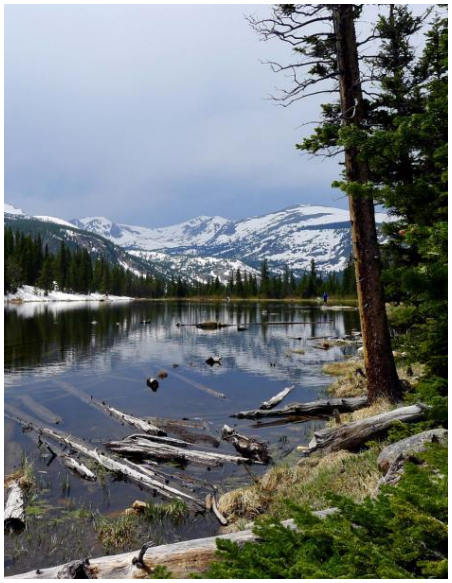
The County also should continue to build on its existing public outreach efforts to residential and commercial customers through Property Assessed Clean Energy (PACE) financing and Energy Smart regarding PEVs and charging. Other entities that could play a part in expanding public knowledge and awareness of PEVs are the transportation management organizations (TMOs), 36 Commuting Solutions, Boulder Transportation Connections and the Employee Transportation Coordinators (ETCs).

Workplace Charging

Other than their residences, people park their vehicles the most hours at their job. That makes the workplaces ideal locations for lower-level chargers, which also can serve as a main source of charging for PEVs or provide plug-in hybrids the opportunity to maximize their electric miles. To promote workplace charging, the County should partner with the Boulder Chamber of Commerce to encourage businesses to install charging at workplaces. In addition, the County can work with ETCs and TMOs to provide more information on charging to employers and employees. The PACE program can also continue to provide support for commercial entities interested in charging for their employees.

[37] Clean Energy Works. 2017. About Us. http://cleanenergyworks.org/about/

Level 2 Stations at Long-Dwell County Recreational Sites



Outside of the County's urban areas, recreational sites are important destinations for County residents and may be good locations to provide charging stations.

Some of the top recreational destinations in the County might be: Brainard Lake, Eldorado Canyon, Long's Peak trailhead, the Eldora Ski area and the Hessie trailhead outside Nederland. Some locations also offer the potential for partnership with private business or the U.S. National Park or Forest Service.

Lost Lake is a popular destination from the heavily-used Hessie Trailhead in Boulder County's national forest.

Photo: U.S. Forest Service

Importantly, the County and its partners should evaluate the level of electrical service available at the access points. The rural nature of many of these sites means they may lack a sufficient service to provide charging stations without expensive infrastructure upgrades. Since very popular recreation destinations already experience parking space shortages during peak usage, the County could work with its partners to provide shuttle service from a nearby location where it would be easier and less expensive to add charging stations. An example of this type of service is the shuttle that serves the Hessie trailhead west of Nederland, but leaves from the Nederland Park and Ride and Nederland High School in town. Additional research may be useful to collect data on the most visited sites, to better understand the infrastructure situation (both parking availability and electrical capacity) at these sites.

Electric Charging Stations at Park and Rides

The County also could partner with RTD to install charging stations at major Park and Rides in Boulder County, especially along US-36. The project also could include charging for e-bikes and an e-bike sharing pilot project.

Create A Public Electric Vehicle Showcase

The County also should consider creating a very visible location that combines PEV charging with educational outreach. Portland, Oregon, has developed such an area: known as "Electric Avenue," it combines public DCFC and high-powered Level 2 stations, parking for PEV carshare vehicles, e-bike parking, and educational displays. The Boulder County could site also include a DCFC hub or a next-generation, higher-capacity DCFC station.

Vehicle Feebate

A "feebate" enables the City or the County to assess a fee on new vehicles that achieve less than average fuel efficiency, and then use that revenue to offer incentives for purchase or lease of a new high-efficiency vehicle. This program is designed to pay for itself by providing rebates for efficient vehicles (minus administrative costs, which do not exceed the impact fees collected from the purchase of new inefficient vehicles). This approach imposes no barriers to the freedom of consumers to purchase any vehicle for sale, so does not trigger federal pre-emption. However, it would require purchasers of the least-efficient vehicles to bear an additional cost to help reduce the burden they place on all consumers, because their vehicles increase the overall demand for motor fuels, emit more pollution, drive the price of fuels higher, and reduce our energy security.

This program is designed to pay for itself by providing rebates for efficient vehicles.

Denmark, France, the Netherlands and Norway implemented "feebates" to incentivize the purchase of high-efficiency vehicles. Similar policies have been discussed at both the federal level and in a number of states, but have not been implemented anywhere in the United States. However, it may be more politically feasible to start such a program at the local level, although doing so might require state lawmakers to approve legislation allowing cities or counties to begin a feebate program.

Potential Funding Sources

The VW settlement offers funding opportunities to support the installation of charging stations, while the state's draft plan describes how these funds will be allocated.[38] Fifteen percent of the funding ($10.3 million) will likely go to support charging stations for light-duty vehicles. The plan proposes funding levels for non-highway charging stations at $9,000 for a dual-port, Level 2 station and at $22,000 for a DCFC station. These funding levels are higher than what is available through the Charge Ahead Colorado program ($6,260 for a dual-port, Level 2 station and $16,000 for a DCFC station). The state anticipates incentives of $110,000 to $165,000 for fast-charge stations that are located along the state's interstates and major highways.

[38] Colorado Department of Public Health and Environment. 2017. Proposed Beneficiary Mitigation Plan. https://www.colorado.gov/pacific/sites/default/files/AP_VW_Beneficiary_Mitigation_Plan.pdf

Boulder County Emissions Benefits from PEVs

Currently, approximately 240,000 light-duty vehicles are registered in Boulder County, and they contribute significantly both to local air pollution and to greenhouse gas emissions.

Based on EPA inventories[39], light-duty gasoline vehicles in Boulder County account for approximately 24 percent of all NOx and 14 percent of all VOC emissions (the two precursors of ground-level ozone emitted by vehicles). The County's 2012 Greenhouse Gas Inventory identified gasoline vehicles as contributing 19 percent of Countywide GHG emissions. Decreases of the electricity sector's carbon intensity over the last several years[40] means that transportation and light-duty vehicles now make up a larger share of GHG emissions than in past years.

Electric vehicles, however, offer an opportunity to reduce all three of these pollutants compared to gasoline vehicles, especially as the electricity mix is expected to reduce its carbon intensity even more in future years. The table below provides an estimate of the emissions benefits from the light-duty vehicle sector that could be realized if BEVs replace different levels of gasoline vehicles in the County.[41]

Electric vehicles, however, offer an opportunity to reduce all three of these pollutants compared to gasoline vehicles, especially as the electricity mix is expected to reduce its carbon intensity even more in future years.

Table 27. Percent Reduction in Overall Light Duty Vehicle Emissions from Different Levels of BEV Penetration[42]

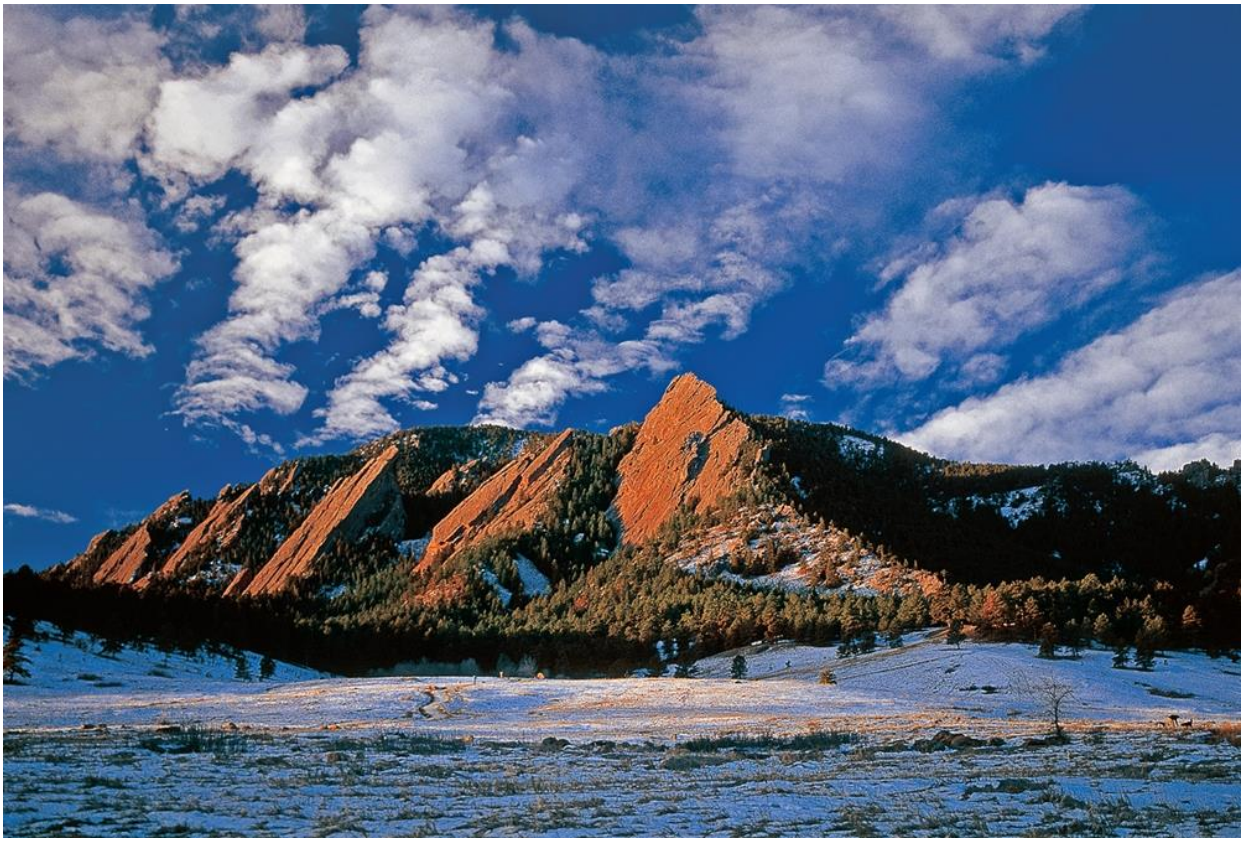
Percentage of PEVs in County	NOx	VOC	GHG
10%	-9.0%	-9.9%	-6.3%
15%	-13.5%	-14.9%	-9.5%
20%	-18.0%	-19.8%	-12.7%

[39] Environmental Protection Agency. 2017. Where You Live. https://www.epa.gov/air-emissions-inventories/where-you-live

[40] Xcel Energy in Colorado's CO2 emission rate decreased fifteen percent, from 1,545 to 1,308 pounds/MWh between 2012 and 2016. Xcel Energy. 2017. Energy and Carbon Emissions Reporting. https://www.xcelenergy.com/staticfiles/xe-responsive/Environment/Carbon/Carbon-Reduction-2016-Energy-and-Carbon-Summary.pdf

[41] This analysis assumes the emissions benefits of a BEV operating in 2026 compared to the average gasoline vehicle in that year, which is estimated to be from 2016.

[42] The emissions reductions in this table are based on Xcel Energy's proposed ERP which would lead to an electricity mix of 55% renewables, 23% coal and 22% natural gas by 2026. While exact numbers are not available, Longmont Power is hoping to move to 25% natural gas and 75% renewables by 2030 but this is not yet a concrete proposal.



Boulder County's stunning beauty helps motivate its County Commissioners to improve air quality and reduce greenhouse gas emissions. This report shows how embracing electric vehicles can help the communities achieve their goals. *Photo: iStock/Getty Images*