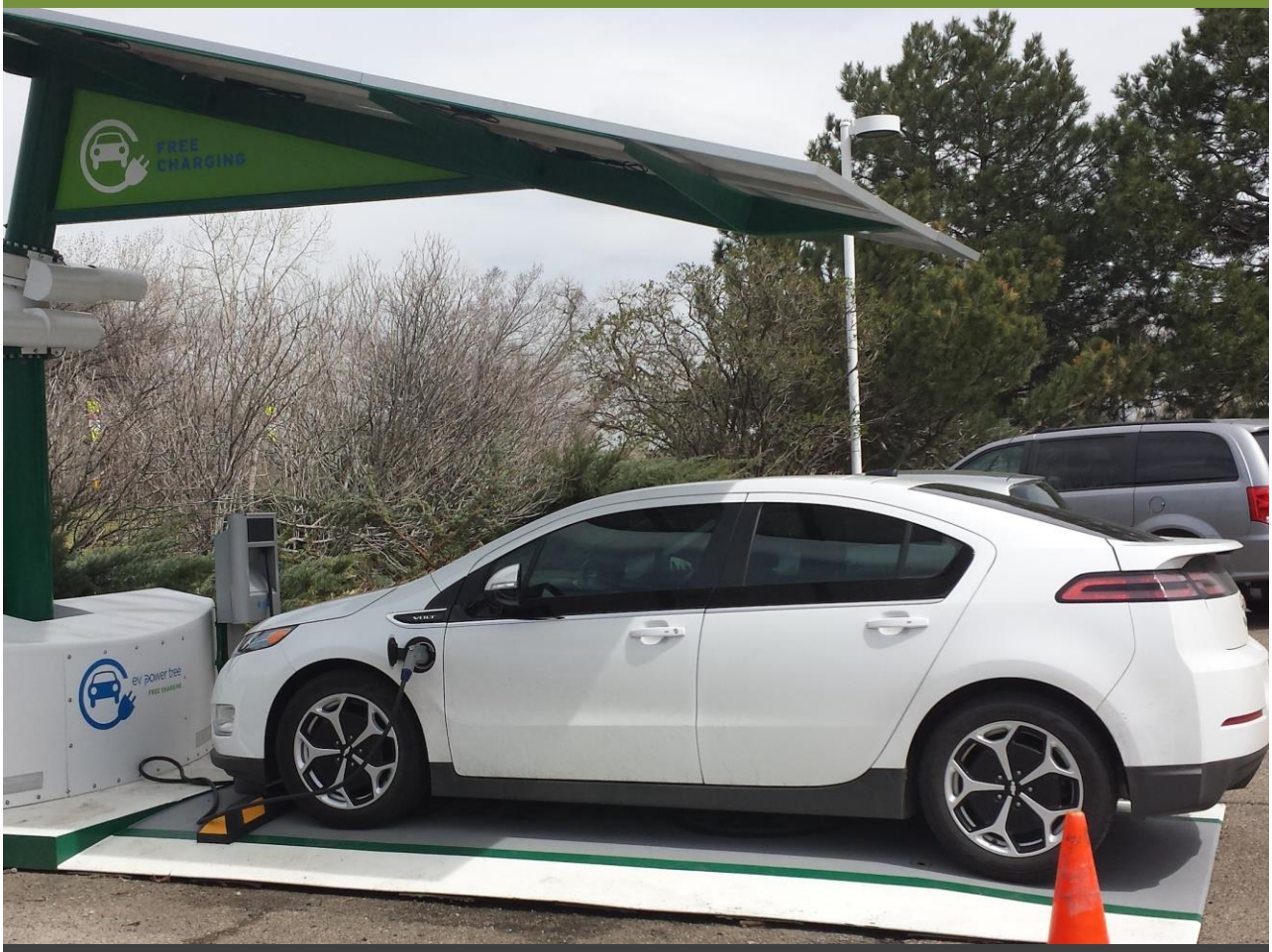

Boulder Electric Vehicle Infrastructure and Adoption Assessment

By Will Toor and Mike Salisbury
Southwest Energy Efficiency Project
April 2015

SWEEP
SOUTHWEST ENERGY EFFICIENCY PROJECT

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The research presented in this report was undertaken to provide recommendations on steps that local governments and other institutions in Boulder County can take to promote electric vehicles among their employees and residents. The report includes summary and discussion of best practices and cutting edge ideas for supporting electric vehicle charging in the workplace, residence and the public.

This research was performed under contract with the City of Boulder. SWEEP would like to thank the City of Boulder, the County of Boulder and the University of Colorado Boulder for their support in providing funding for this research.

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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.

SWEEP's Transportation Program seeks to identify and promote the implementation of policies designed to achieve significant energy savings and reductions in greenhouse gas emissions from the transportation sector. SWEEP's work focuses on two general strategies: reducing vehicle miles traveled and improving vehicle fuel efficiency.

Questions or comments about this report should be directed to Will Toor, Transportation Program Director, wtoor@swenergy.org.

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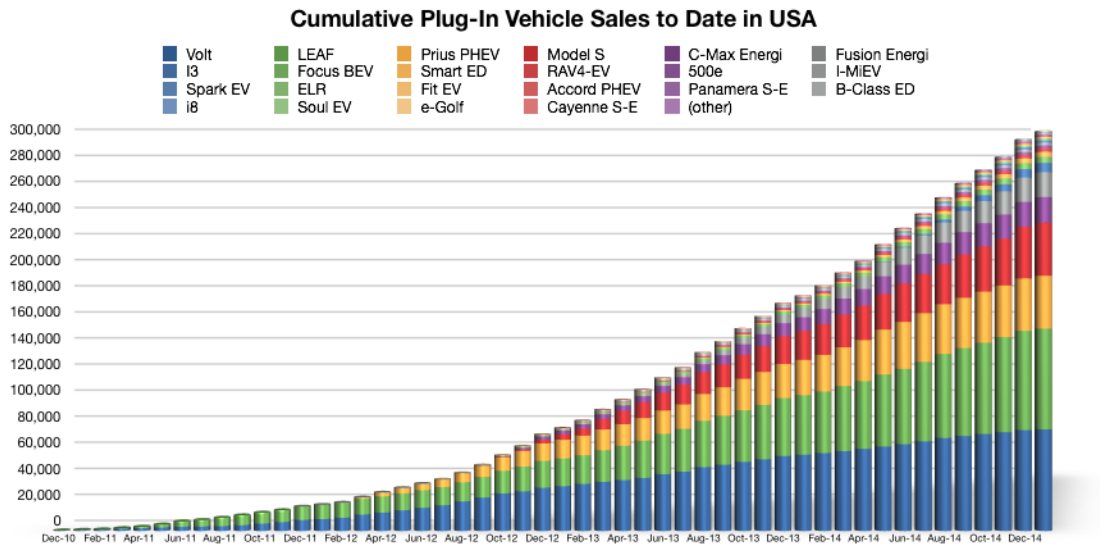
I. INTRODUCTION

Over the last five years, the electric vehicle (EV) market in the United States has gone from a tiny niche market to a growing segment of the automobile market. Nearly every major manufacturer now offers one or more models of battery electric vehicle (BEV) or plug-in hybrid electric vehicle (PHEV). The chart below shows the growth of EV sales since 2010:

Figure 1 | Cumulative Plug-In Vehicle Sales in USA, 2010-2014



Source: Chart reprinted courtesy of Mark Larsen, Inside EVs[1]

The federal government has adopted two major policies that support the growth of the EV market. First, federal fuel efficiency standards give "extra credit" to EVs, encouraging manufacturers to make EVs available. Second, there is a federal income tax credit of up to $7,500 which phases out over time.

The State of Colorado has adopted multiple policies designed to support the EV market. Important milestones include the passage of legislation that:

- deregulates the resale of electricity for EV charging;
- creates a tax credit of up to $6,000 per EV, phasing out in 2021; and
- creates an infrastructure fund to support the installation of EV charging in public locations, workplaces, and multifamily housing.

With these policies in place, Colorado has emerged as one of the top ten EV markets in the country. Figure 2 shows EV sales in Colorado compared to surrounding states.

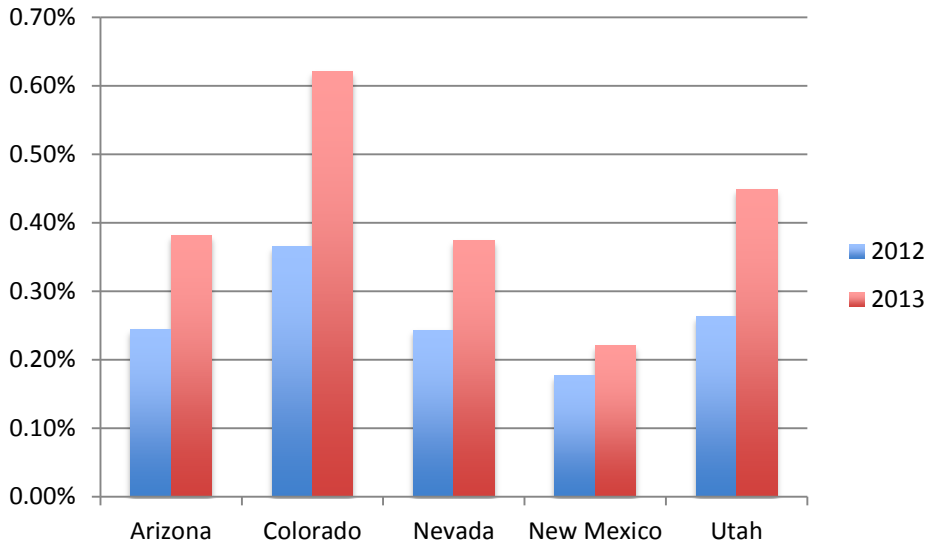
[1] Larsen, M. 2015. The State of United States' Plug-In Vehicles. http://www.casteyanqui.com/ev/usa_sales/index.html.

In the Denver metro region, the Regional Air Quality Council (RAQC) provides grants to public and private vehicle fleets interested in purchasing an EV or installing Level 2 or Level 3 direct current (DC) fast charging stations. RAQC will fund up to:

- $8,260 for the purchase of an EV;
- $6,250 for the purchase and installation of a Level 2 charging station; and
- $16,000 for a Level 3 DC fast charging station.

Organizations which are not eligible for the federal and state tax credits have highest funding priority from RAQC.

Figure 2 | EVs as a percentage of new vehicles sales



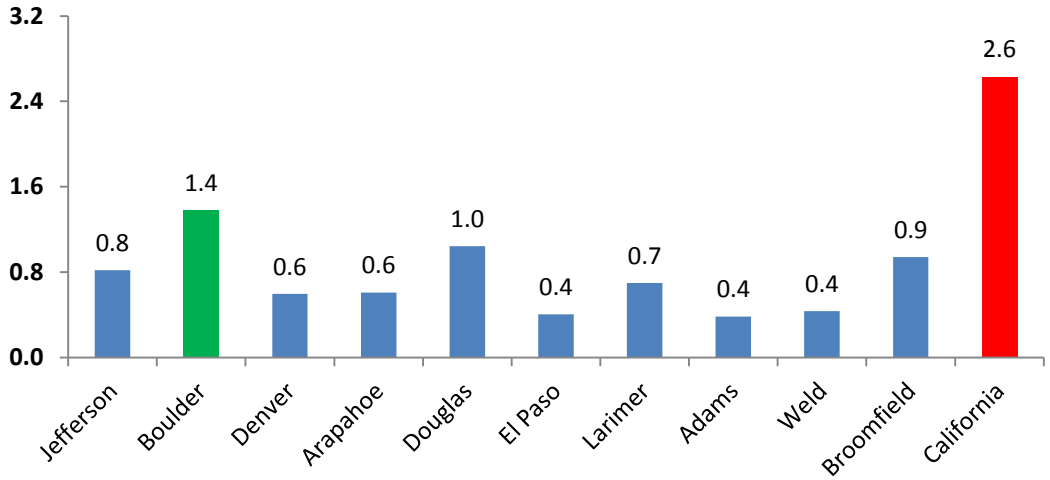
Source: IHS Automotive new vehicle registration data, CYE 2012 and 2013

The Boulder area has emerged as a hotspot for consumer adoption of cleaner vehicles. Boulder residents have purchased hybrids at a rate about five times the national average, and Boulder County has the highest percentage of EVs per capita of any county in Colorado. There are currently slightly over 500 EVs registered within Boulder County, which is about three times higher than the national average market penetration. As noted in the chapter on public charging, a fairly robust public charging network has developed in Boulder County. Figure 3 compares Boulder County to other counties in the Colorado Front Range and to the State of California.

At the same time, however, the most popular vehicle in Boulder is the Subaru Outback, and the percentage of sport utility vehicles (SUVs) and light trucks is higher than the national average, leading to average vehicle efficiency on par with the national average of only 22 mpg. Analysis conducted in 2014 for the City of Boulder Transportation Master Plan (TMP) update demonstrates that, in order to achieve the goal of 80% reduction in greenhouse gas (GHG) emissions from the

transportation sector by 2050, the city will need to both 1) aggressively shift trips to walking, cycling and transit; and 2) reduce the carbon emissions associated with the remaining vehicle trips.

Figure 3 | Registered EVs per 1,000 Residents

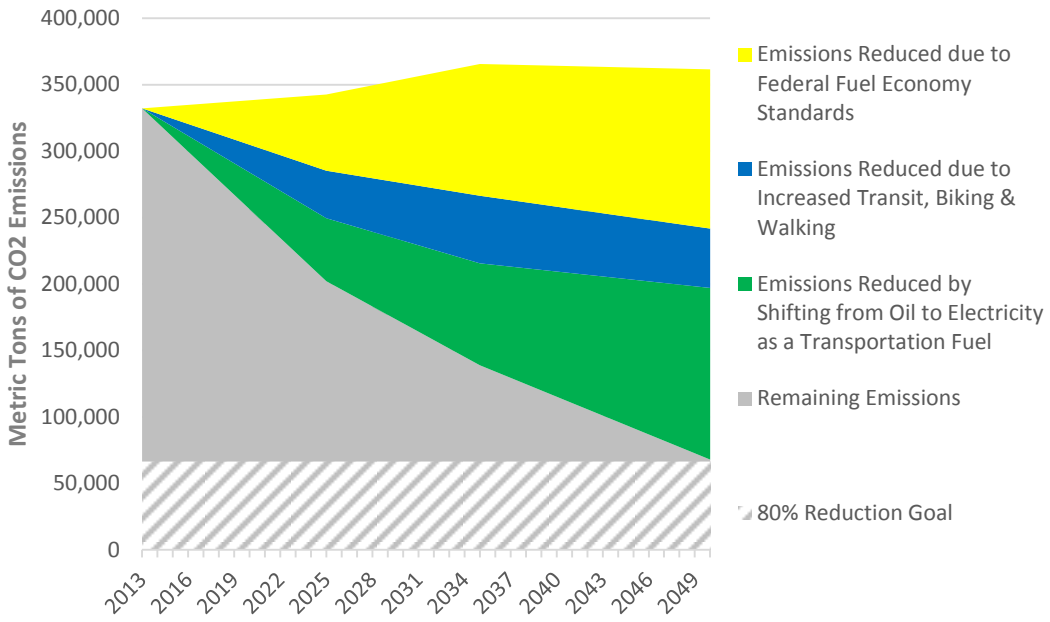


A Toyota Prius and Nissan Leaf parked at 13th & Pine. Scenes like this are not uncommon in Boulder.

Figure 4 shows analysis conducted by SWEEP for the city that shows that – even with the projected reduction in vehicle miles travelled and the expected increase in fuel efficiency due to federal standards – a substantial gap remains. The figure shows the impact on cutting CO_2 emissions that each suite of strategies is expected to have.

With no action, the city's annual CO_2 emissions from transportation would be expected to increase from 330,000 tons to 360,000 tons by 2050. The yellow section shows the emissions that are expected to be eliminated due to the federal fuel economy (CAFE) standards. The blue section shows the anticipated reductions in CO_2 emissions from aggressive mode shifting that replaces many vehicle trips with transit, biking and walking trips. The green section shows how much emissions could be reduced by shifting 75 percent of all light and heavy-duty vehicle travel from oil to renewable electricity. The solid grey area shows the remaining CO_2 emissions that would need to be eliminated in order to reach the 80 percent reduction goal before 2050.The dashed grey area at the bottom of the chart shows the levels of CO_2 emissions that the City would need to reach to meet its goal of reducing emissions 80 percent below 2013 levels.

Figure 4 | Transportation GHG Reduction Roadmap, 2013-2050



Note: More aggressive use of pricing and land use strategies to reduce vehicle miles travelled could lead to additional GHG reductions.

One important strategy for reducing emissions from vehicles is to shift towards much broader use of EVs, combined with a shift towards lower carbon electricity sources. The analysis SWEEP conducted for the TMP update looked at multiple scenarios, and the only one which actually met the

target of 80 percent reduction in GHG emissions required that electricity generation approached zero carbon emissions and that EVs make up 75% of the fleet by 2050.

The intent of this study is to examine some of the steps that could lead to faster and deeper penetration of EVs in the Boulder area with a specific focus on concrete actions that could be taken by the City of Boulder, the County of Boulder and the University of Colorado Boulder (CU-Boulder). An earlier analysis by SWEEP (included as Appendix 1) outlined an array of potential policy tools, including efforts targeting fleet adoption of EVs and financial incentives for cleaner vehicles. This analysis focuses primarily on charging infrastructure and employee adoption of EVs.

One issue that needs consideration is how to move this work forward structurally. Currently, there are a number of departments working on energy and on transportation within each of the three agencies named above, but none currently have EVs as a priority. Does action on EVs belong in the transportation departments, the sustainability offices, the planning departments, or in fleet operations? All of these departments play some role, and clearly a collaborative effort will be required to move significant programs or policy initiatives. However, one department in each agency will need to take the leadership role. There is also the possibility of an ongoing collaborative effort involving all three agencies. We believe that conversations among the departments and agencies to determine the appropriate structure for further action are an important step.

II. SUMMARY OF RECOMMENDATIONS

Throughout this document, we propose possible action items for consideration by the study partners. This section provides a brief overview of these recommendations.

Our overarching recommendation is to address the structural question of leadership and where EV policy and programs will be housed and staffed. Individual program areas are listed in Table 1 below.

Table 1 | Summary of Recommendations

Recommendations	Potential Participants		
Public Charging	**City**	**County**	**CU**
Develop pilot DC fast charging at regional attractions	♦	♦	♦
Add public charging in parking structures used for long-term employee parking, and in proposed edge parking locations	♦		
Avoid placing Level 2 public charging in locations where dwell time is less than 3 hours	♦	♦	♦
Consider tiered pricing to drive demand for EV parking spots	♦		♦
Workplace Charging			
Create a local EV Charging Challenge and reach out to large employers	♦	♦	
Have study participants lead the way	♦	♦	♦
Use existing Transportation Management Organizations (TMOs) and Employee Transportation Coordinator (ETC) network for outreach	♦	♦	
Expand EnergySmart for businesses to include advising for workplace charging and EV adoption	♦	♦	
Employee Pilot Program			
Negotiate a purchase discount for employees	♦	♦	♦
Install employee charging at the Public Safety Building and downtown	♦		
Consider financing EV + home charging station + solar PV for employees	♦	♦	♦
Regulatory Actions			
Adopt an EV- friendly building code for new residential and commercial construction	♦		♦
Add EV charging as a factor in discretionary reviews	♦		
Add EV carsharing as a Transportation Demand Management (TDM) option	♦		
Expand EV building code to commercial and multi-family buildings		♦	
Multifamily Housing			
Add charging requirements into SmartRegs for multi-family housing	♦		
Add EV charging into EnergySmart outreach	♦	♦	
Develop partnership with private sector on pilot charging, financing programs	♦		
Transit Stations and Park and Rides[2]			
Add e-bike charging at transit stations and park-n-rides	♦	♦	
Create pilot EV charging program targeting US 36 corridor park-n-rides	♦	♦	
Incorporate EV charging into SH 119 Bus Rapid Transit (BRT) assessment	♦	♦	

[2] While not a study participant, RTD (the transit agency for the metro Denver region) would play a major role in implementation of the Recommendations on Transit Stations and Park and Rides.

Table 1 (continued)

Carshare	City	County	CU
Repurpose underused public charging stations for EV carshare	♦	♦	♦
Build EV carshare into "TDM with teeth" ordinance	♦		
Public Outreach and Education			
Incorporate EVs into EnergySmart residential program	♦	♦	
Incorporate EVs and efficient vehicle messages into ETC network	♦	♦	
Create a program to recognize auto dealers which do the most to champion EVs	♦	♦	
Consider a grant funded pilot providing midstream incentives for EV sales	♦	♦	
Create a visible "electric avenue" with charging and EV education	♦		
Miscellaneous			
Consider an E-Bike Pilot Program	♦	♦	♦

Location-Specific Recommendations

Boulder Junction

Given the presence of major private sector entities (such as Whole Foods and Google) that are friendly to EVs, a demographic that will likely include many singles and couples without children in the housing, and the fact that a large amount of new development is taking place, Boulder Junction is a good location to focus efforts on promoting EVs.

Particular actions we recommend include:

- Place 1-2 electric carshare vehicles in the transit center at Boulder Junction.
- In the review process for large developments, require that charging be provided for employees and residents.
- Ask Google to install EV charging stations and to bring their GFleet corporate EV carsharing program to this campus (Google has over 750 EV charging stations nationwide).[3]

Downtown

- Focus additional City investments in charging for both City employees and for other downtown employees who purchase long-term permits in City lots and garages.
- Incentivize EV purchase by advancing EVs to the front of the waitlist for downtown permits.

[3] US Department of Energy. 2014. Workplace Charging Challenge: Progress Update 2014: Employers Take Charge. http://energy.gov/eere/vehicles/downloads/workplace-charging-challenge-progress-update-2014-employers-take-charge.

- Repurpose some underused public charging stations for EV carsharing; repurpose conduit in Boulder County Courthouse for this purpose.

- Consider creating one very visible EV area as a public outreach effort in the Civic Area, analogous to "Electric Avenue" in Portland, Oregon.

South Boulder

- Develop a pilot charging program at the Table Mesa Park-n-Ride, starting with three charging stations.

- Make the charging station at the South Boulder Recreation Center easier to use (e.g., don't require users to go in and get a key); consider repurposing one space for carshare.

North Boulder

- Consider repurposing space at North Boulder Recreation Center for carsharing.

- Install charging in two to four percent of spaces as part of any edge parking development at the Armory site.

Recreational sites

- Install two or three Level 2 chargers at Eldora Ski Area.

CU-Boulder campus

- Start a pilot e-bike sharing system linking the east and main campus.

- Consider a workplace charging and employee outreach pilot program at the Sustainability, Energy and Environment Complex on the east campus.

County St. Vrain campus

The County is considering an EV fleet project at the St. Vrain campus that would require charging infrastructure that would largely be used at night. This would be a good location to do an employee pilot, since employee cars could use charging available during the day.

Transit stations and park-n-rides

- Add e-bike charging at transit stations and park-n-rides where electricity is available.

- Develop an e-bike sharing pilot as a final mile solution at major transit centers, including Boulder Junction and the Boulder Transit Center downtown.

- Create pilot EV charging program targeting US 36 corridor park-n-rides from Table Mesa to Westminster, with implementation timed for the first quarter 2016 launch of Bus Rapid Transit (BRT) service.

- Include consideration of EV charging into the SH 119 BRT environmental assessment.

DC fast charging at regional attractions

- Work with private sector station developers to add stations to regional attractions– downtown Boulder, CU visitor parking; and to key locations along longer distance corridors: Diagonal Plaza, Gunbarrel Town Center, Longmont, Nederland, and Lyons (for trips to RMNP).

- Make use of the new availability of Fast Charge funding through Charge Ahead Colorado.

Figure 5 | Location-Specific Recommendations, Countywide

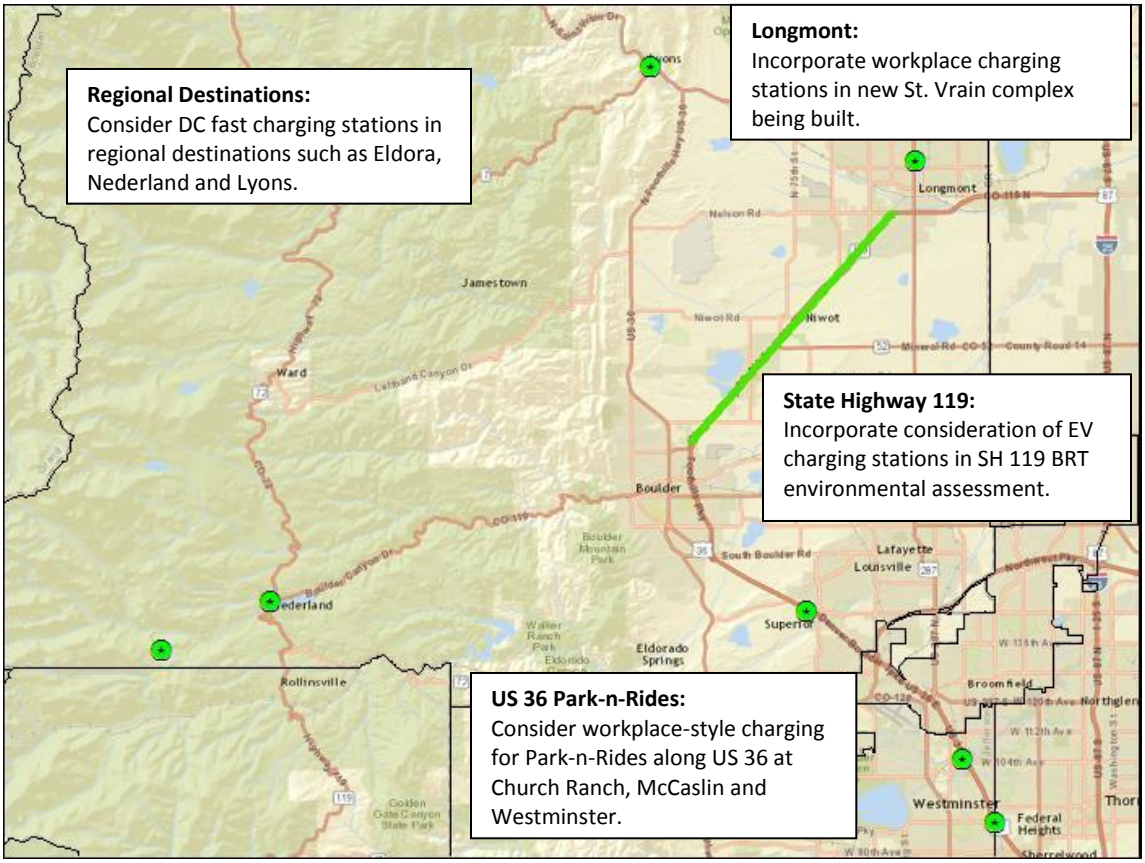
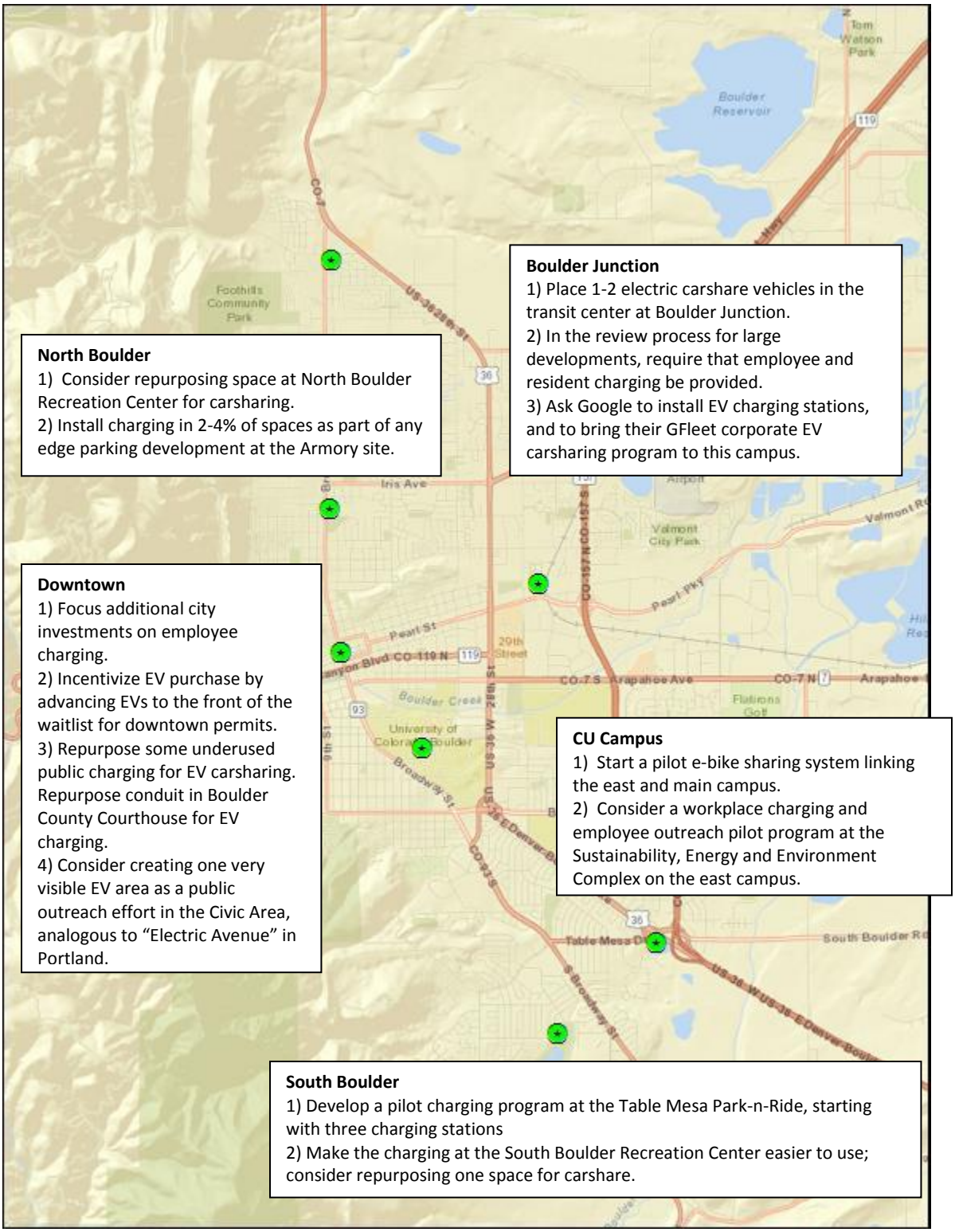


Figure 6 | Location-Specific Recommendations, City of Boulder



III. REVIEW OF PUBLIC CHARGING INFRASTRUCTURE & BEHAVIOR

Summary

Over the last several years, we have begun to gain experience with how EV users charge their vehicles in real world situations. The vast majority of charging takes place at home, or at workplaces, where the vehicles are parked for many hours at a time. Public charging may be an important safety net for users, but tends not to be used very much, unless it is placed at locations where vehicles are parked for many hours, or along major long distance corridors. Our analysis of existing charging stations in Boulder shows very low levels of use for most existing public charging stations. This is consistent with other studies. For example, Xcel conducted a survey of EV drivers in Colorado which concluded that over 75 percent of charging takes place at home, 15 percent at work, and very little at public charging stations.

We do note that this data is focused on Level 2 chargers. There is more limited data on the use of DC fast chargers, and almost no locally available data. Therefore we encourage additional pilot programs focused on deployment of DC fast charging at key regional destinations.

We recommend:

- a primary focus on workplace charging;
- facilitating charging in multifamily housing;
- repurposing low use chargers for carshare and fleet vehicles;
- pilot programs deploying DC fast charging; and
- only very carefully targeted additions of additional public charging.

Analysis

Figure 7 shows all of the destinations for light duty vehicles in Boulder County recorded as part of DRCOG's 2010 Household Travel Survey, excluding people's homes as a destination.[4] The dots in Figures 7-11 represent nearly 5,000 vehicle trips with Boulder County as their destination. As one might expect, destinations are focused in urbanized areas, with the city of Boulder having the highest concentration of destinations.

Figure 8 shows destinations that are not work trips and where the vehicle was parked for at least two hours. These might be good places to provide Level 2 public charging stations.

Figures 9 and 10 show the same destinations as Figure 8, indicating where publicly available charging stations are currently located. One can see that the major population centers (Boulder,

[4] Denver Regional Council of Governments. 2010. Front Range Travel Counts.

Longmont, Superior, Louisville and Lafayette) are already served by a number of public charging stations. (Figure 10 shows the same information as Figure 9, but zooms in on Boulder.)

Finally, Figure 12 shows all non-home destinations (not just those with longer dwell times) around Boulder as well as publicly available charging stations.

Figures 11 and 12 suggest that most areas of the city where vehicles park, both in general and for longer periods of time, are already served by some publicly available charging stations. This appears to apply to the urbanized eastern part of the county as well.

Figure 7 | Boulder County Non-home Destinations

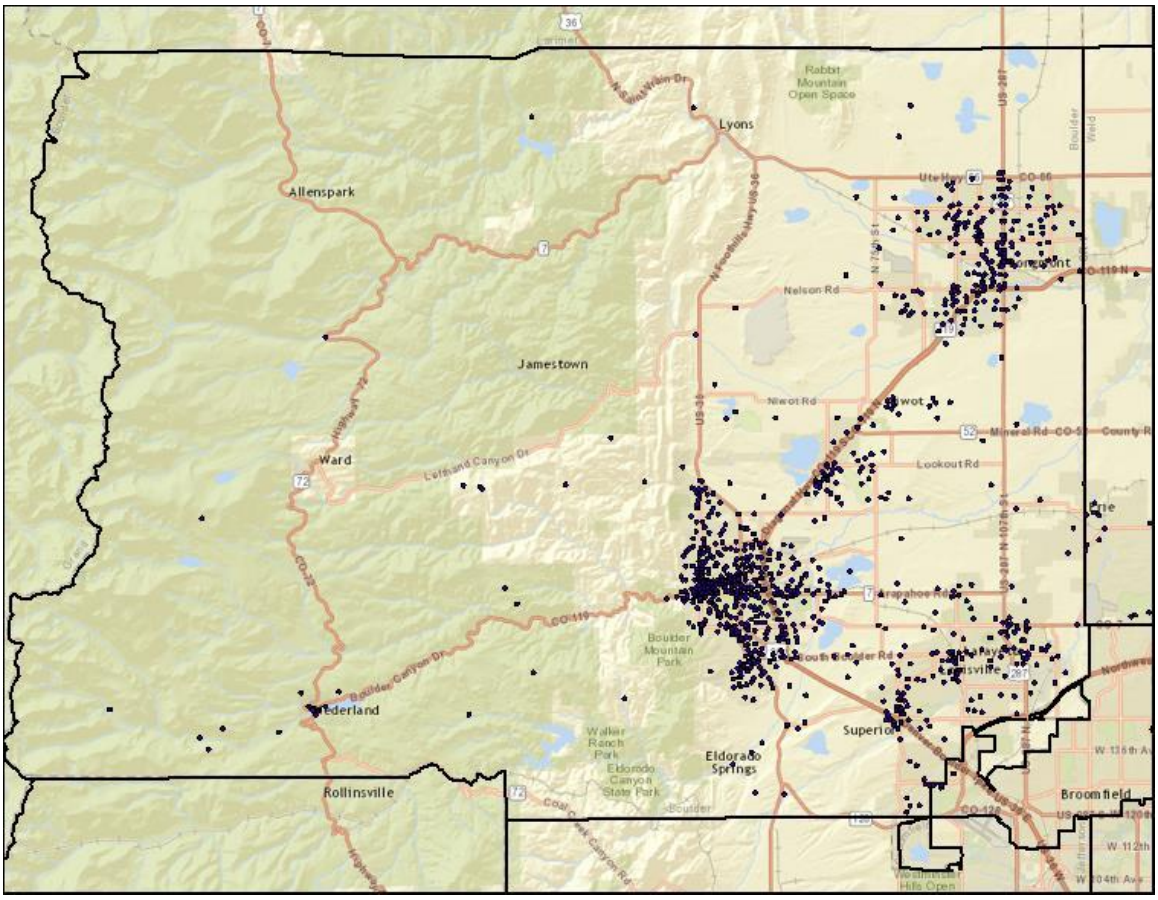


Figure 8 | Non-work destinations where vehicles parked for at least two hours

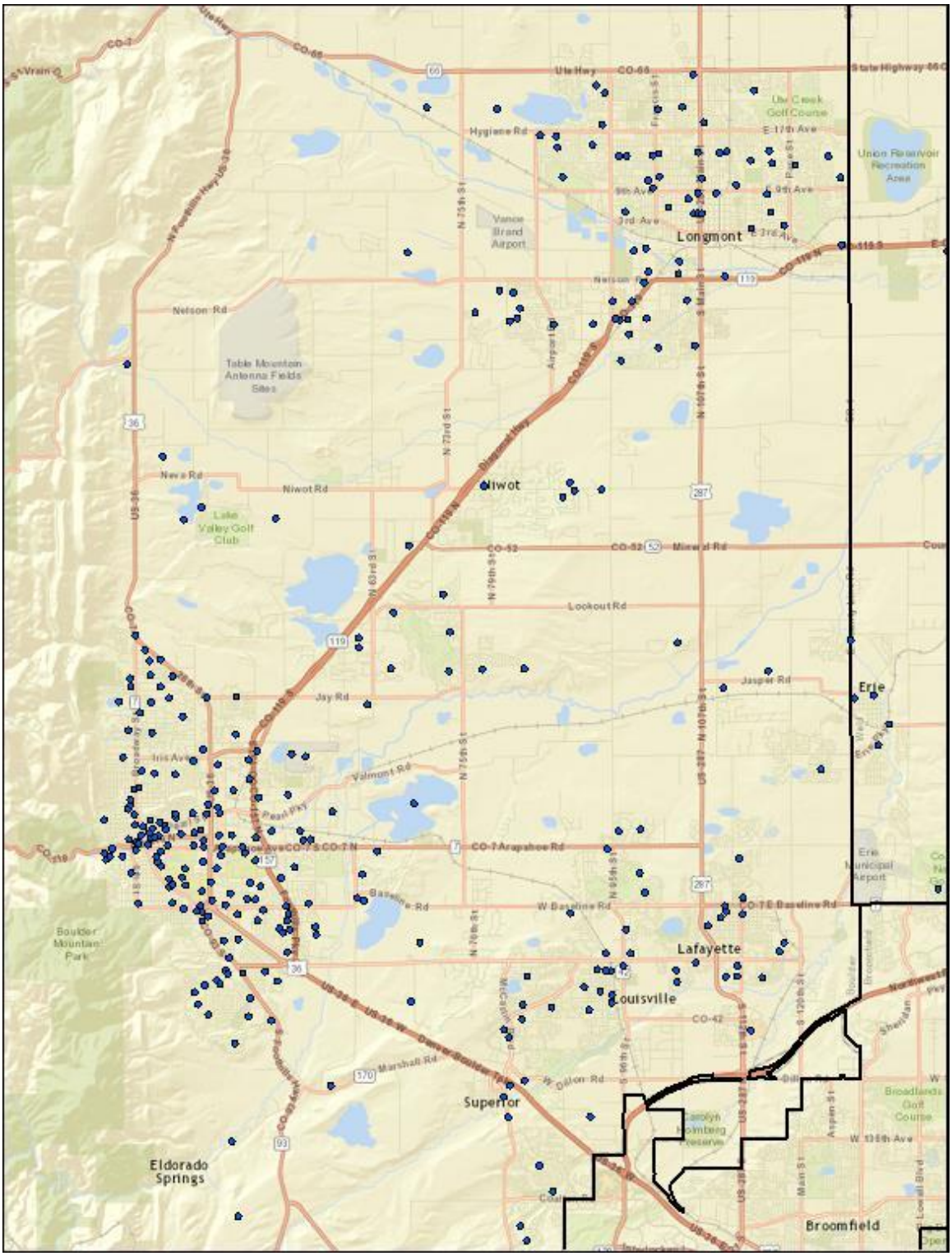


Figure 9 | Non-work destinations in Boulder County where vehicles parked for at least two hours, plus public charging stations

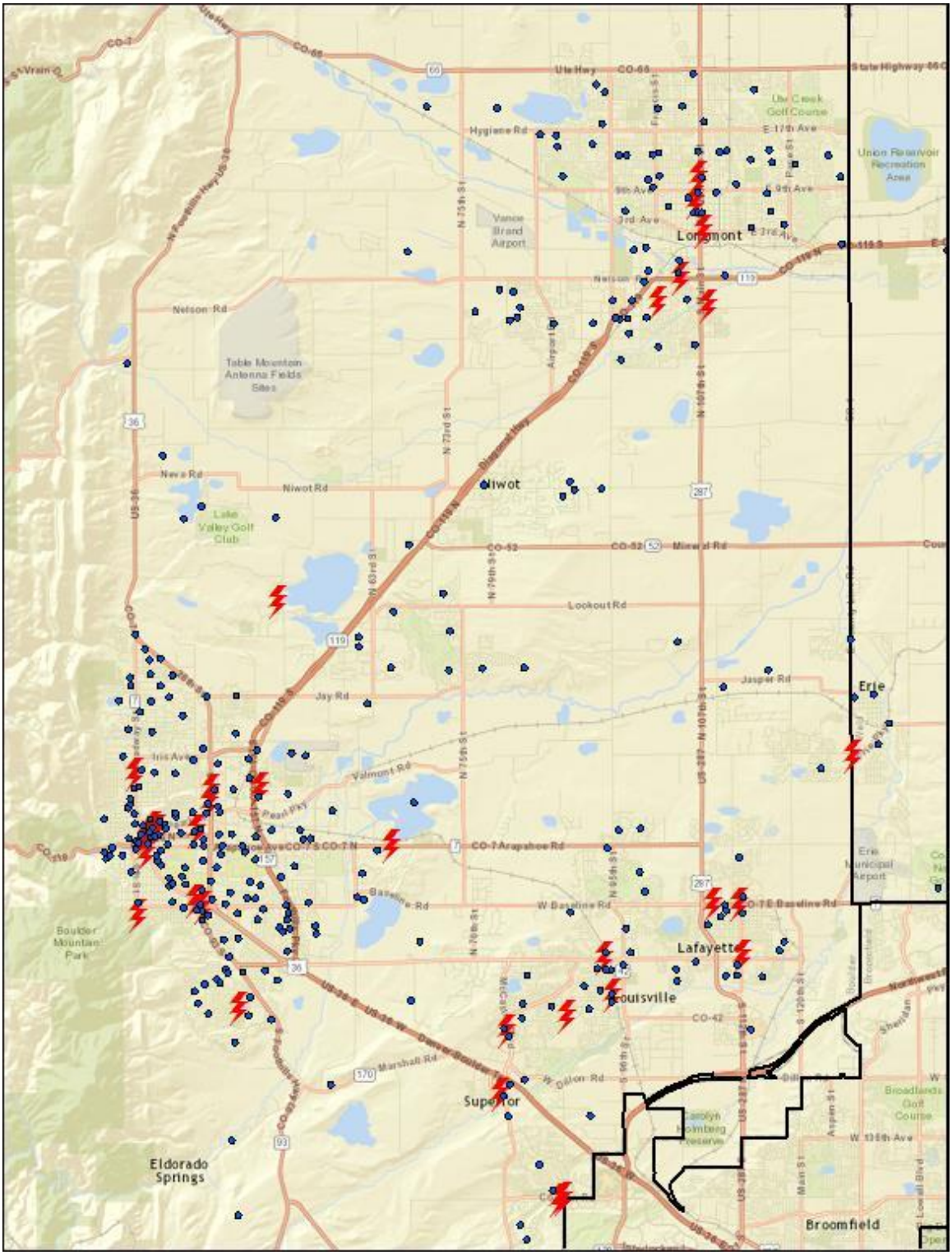


Figure 10 | Non-work destinations in Boulder where vehicles parked for at least two hours, plus public charging stations

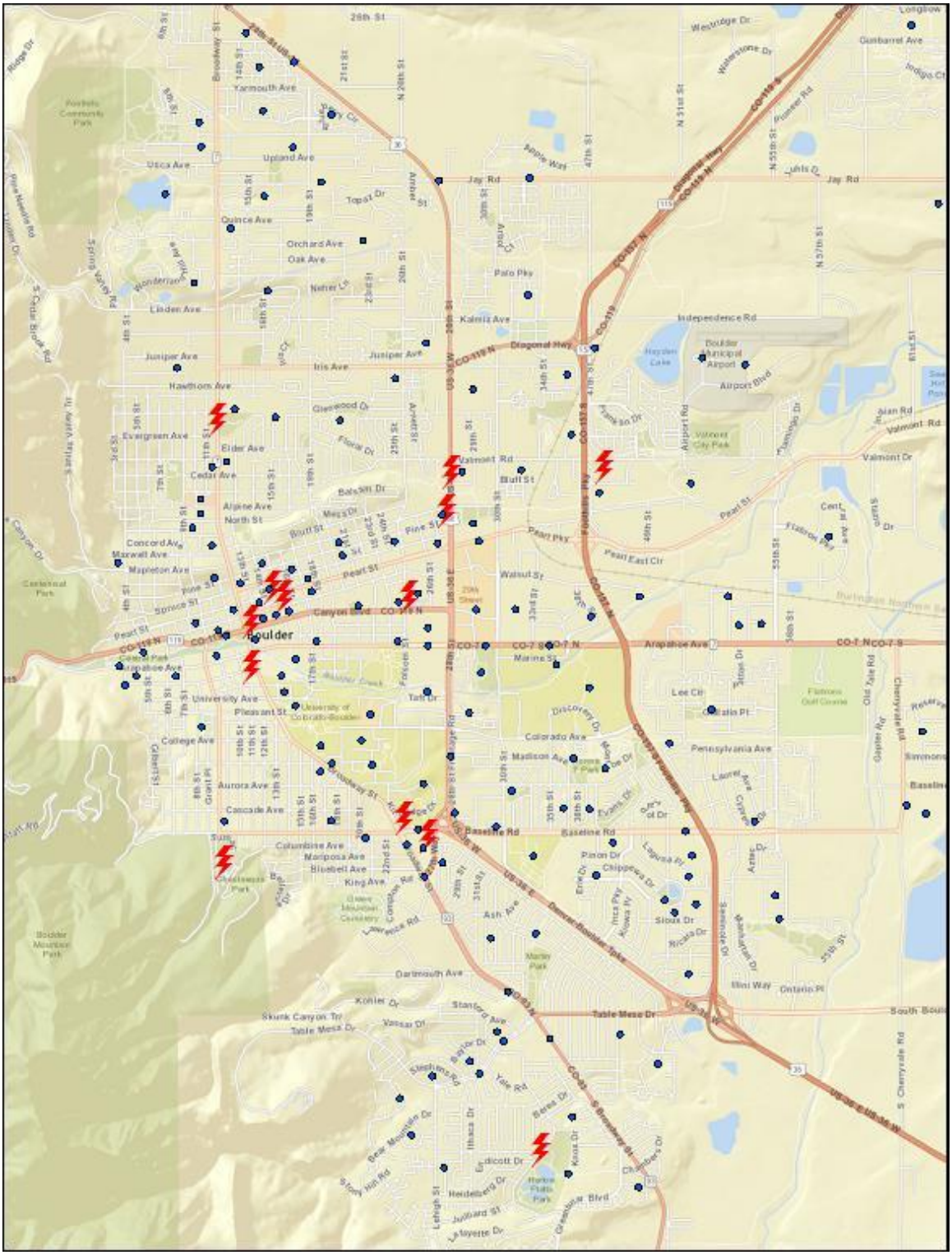
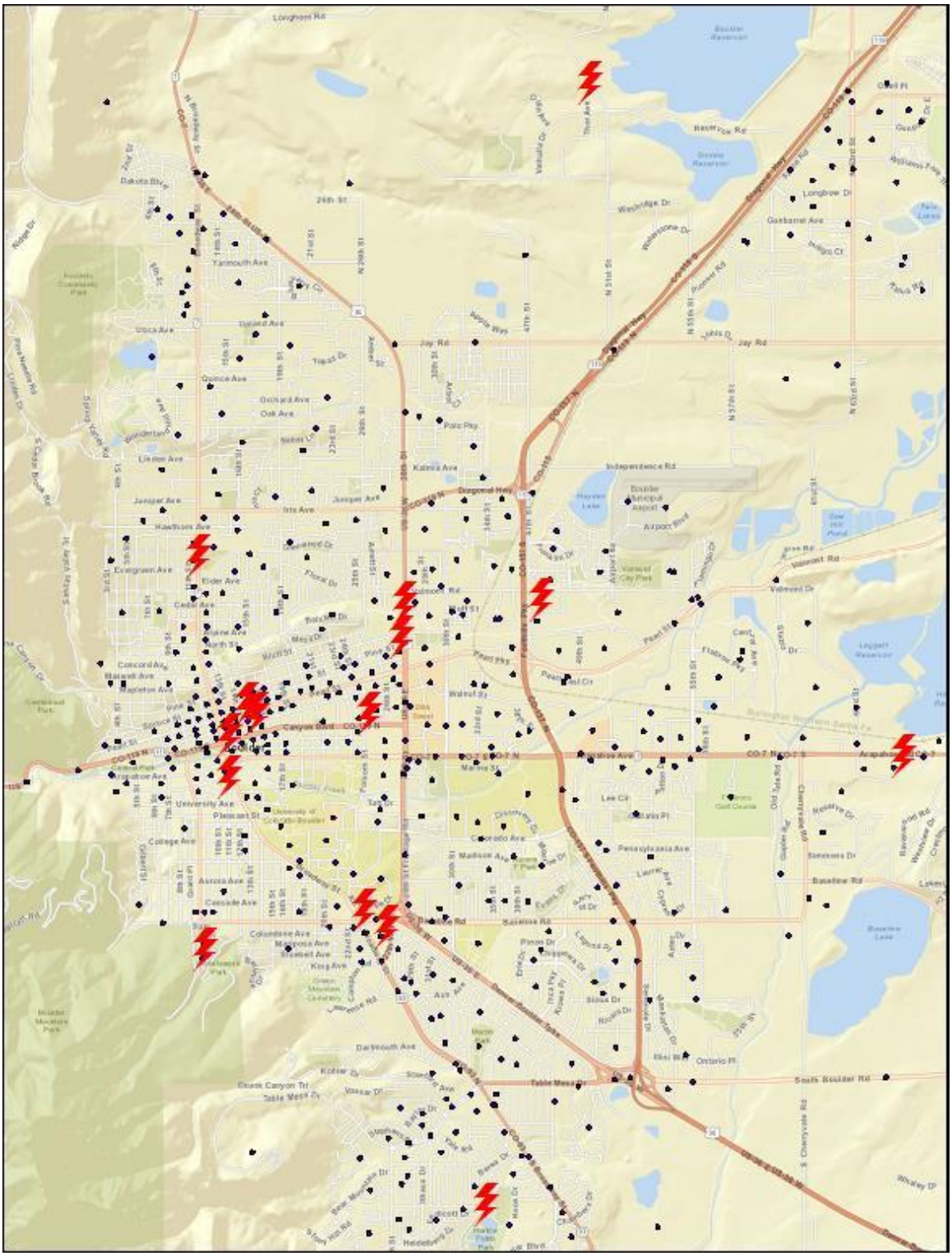

Boulder
Pearl St
Canyon Blvd
Arapahoe Ave
Baseline Rd
Table Mesa Dr
Broadway
Foothills Pkwy
Diagonal Hwy
Valmont Rd
Jay Rd
Iris Ave
Colorado Ave
University Ave
Pleasant St
Walnut St
Spruce St
Dartmouth Ave
Independence Rd
Airport Blvd
Boulder Municipal Airport
Flatirons Golf Course
Boulder Mountain Park
Chautauqua Park
Central Park
Pennsylvania Ave
Lee Cir
Ontario Pl
Mini Way
Ash Ave
Kohler Dr
Skunk Canyon Trl
Table Mesa Dr
Yale Rd
Bear Mountain Dr
Stony Hill Rd
Lehigh St
Juilliard St
Lafayette Dr
Greenbriar Blvd
Hendelberg Dr
Idicott Dr
Kiowa Dr
Chippewa Dr
Sioux Dr
Pinon Dr
Erie Dr
Inca Pkwy
Laurel Ave
Cypress Pl
Aztec Dr
Frank Dr
Madison Ave
Discovery Dr
Marine St
Tate Dr
Foxwood Dr
Pine St
Mesa Dr
Balsam Dr
Floral Dr
Glenwood Dr
Elder Ave
Cedar Ave
Alpine Ave
North St
Concord Ave
Maxwell Ave
Mapleton Ave
Evergreen Ave
Juniper Ave
Hawthorn Ave
Linden Ave
Quince Ave
Orchard Ave
Oak Ave
Nether Ln
Palo Pky
Kalmia Ave
Upland Ave
Topaz Dr
Yarmouth Ave
Usca Ave
Aspen Way
Westridge Dr
Waterstone Dr
Gunbarrel Ave
Longbow
Indigo Ct
Pioneer Rd
Lulls Ct
Alan Rd
Valmont Dr
Airport Rd
Flanagan Dr
Pearl Pky
Pearl East Cir
Flatiron Pky
Cent
Dr
Burlington Northern Sa
Lee Cir
Ontario Pl
Pennsylvania Ave
Laurel Ave
Cypress Pl
Aztec Dr
Frank Dr
Madison Ave
Colorado

Figure 11 | All Destinations and Public Charging Stations near Boulder



SWEEP contacted the owners/operators of all the existing publicly available charging stations in the City of Boulder and Boulder County to try to collect data on how often the stations are used.

From those owners/operators who provided data, the utilization rates of the publicly available charging stations in the City and County indicate that the current supply of public charging stations is underutilized.

Of the eight public charging stations in the city where data was available, only one was used more than once per day on average. For the six stations where there is no dedicated charging, the stations are used on average less than once every five days. This is consistent with experience from around the country, which suggests that the vast majority of vehicle charging will take place at homes or at workplaces – areas where vehicles are parked for many hours at a time, and where users know that charging is consistently available.

Vacant charging station at Broadway and Spruce parking lot

This suggests that additional Level 2 public charging stations may not be a pressing need for EV drivers in Boulder. Therefore, we recommend that additional investments in this area should be limited to particularly strategic locations until a larger number of EVs are on the road in Boulder or until higher utilization rates are seen. We also suggest that when any investments are made in

parking lots or structures, it makes sense to pre-wire these locations so that it will be cheaper and easier to install EVSE in the future if there is demand.

There may be specific locations where providing additional public charging stations would make sense, based on the nature of the use. These would be locations where more of the trips are longer distance, and where vehicles are parked for longer periods of time. Taking data from DRCOG's 2010 Front Range Travel Count, we have classified over 12,000 vehicle trips based on 60 types of destinations.[5] For each type of destination, the median time that a vehicle remained parked at the site (dwell time) was determined. Table 2 shows all the destination types which had median dwell times of 30 minutes or longer. The locations with the longest dwell times are most appropriate for public charging.

This data suggests that the areas in Boulder County that may be most appropriate for additional public charging stations would include the CU-Boulder campus, the Eldora Ski Area, and some of the movie theaters.

In November of 2014, the EV Owners of Colorado conducted a small survey of existing EV owners, asking in which areas they would like to see additional public charging. Areas that were highlighted within Boulder County included the Park-n-Ride at Roosevelt Park in Longmont, the Boulder County fairgrounds, downtown Longmont, Boulder's 29th Street Mall, movie theaters and grocery stores.

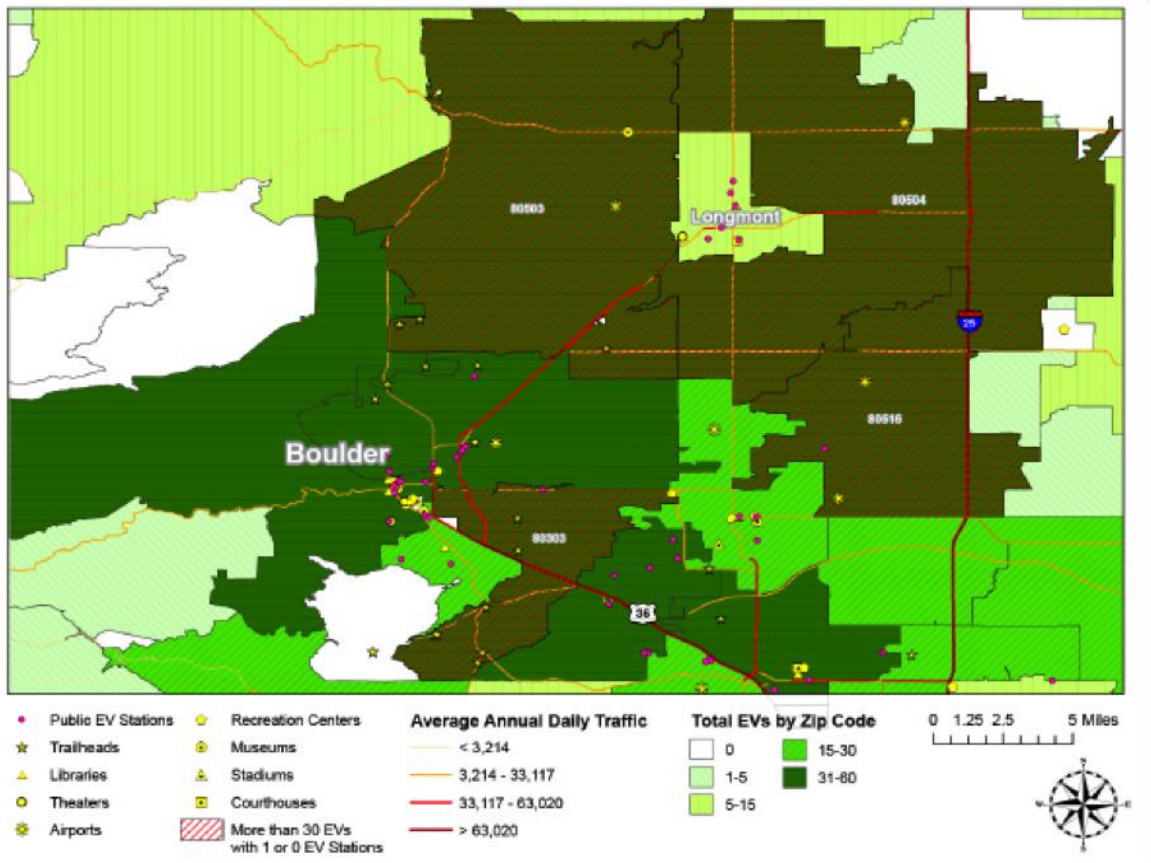
Table 2 | Dwell times destination types in Front Range

Destination	Dwell Time (Minutes)
Skiing	281
Pepsi Center	228
University	174
Outdoor Museum (Zoo, Botanical Garden)	161
Music/Theatre	158
Casino	155
Bowling	154
Movie Theatre	135
Golf/Tennis	131
Museum	112
Ice rink	109
Soccer	103
Church	101
Recreation Center	77
Yoga/Dance/Gymnastics	77
Community/Senior Center	76
Baseball	75
Gym	74
Y's	72
Hike (state or national parks, trailheads)	67
Hospital	65
Martial Arts	65
Swimming	63
Bar	61
Sit Down Restaurant (not fast food)	60
Local Park	60
Health	55
Mall (shopping center, big department store)	50
Grooming (hair, salon, nails)	45
Big Box Grocery (Costco, Sam's Club)	40
Wal-Mart/Target	33
Government Office	32
Bookstore	30

[5] Ibid.

The map below, from the Colorado Energy Office's recent EV Market Implementation Study, shows some of the possible public attractions in the region that may be suitable for future public charging stations.[6]

Figure 12 | Regional Attractions That May be Suitable for EVSE



Also appropriate for public charging are city parking structures and lots where long term permits are offered, including the downtown garages, downtown lots, and University Hill lot. The longer term permits are largely purchased for employee parking, so these are locations where a portion of the spaces function as employee parking. We recommend these as locations for additional public charging at city-owned locations, combined with a communications effort targeting major downtown employers.

In addition, there may be an important role for public charging in certain locations the City is considering for new parking structures. As part of the Access Management and Parking Strategy

[6] For a clearer version of the map please consult the original EV Market Implementation Study at: http://www.colorado.gov/cs/Satellite/GovEnergyOffice/CBON/1251597774824.

(AMPS)[7], the City of Boulder is considering the idea of edge parking and mobility hubs, potentially located at far North Broadway and along east Arapahoe. The idea is that regional commuters would park their vehicles at these edge locations and use public transit or first- and final-mile options for the portion of their commute within Boulder. If these are successful, they would functionally be more similar to employee parking than to public charging. Given this, and that they would be attracting longer distance drivers, these would be appropriate locations for EV charging. It may be appropriate to use differential pricing, offering a lower tier pricing for EVs in these remote parking areas in order to drive demand.

Boulder County Electric Vehicle Registrations

Based on data supplied by the Colorado Department of Revenue to the Regional Air Quality Council (RAQC), Boulder County has the highest number of EV registrations per capita of any county in the state; as of December of 2014, there were 510 EVs registered in the County. This remains a very small portion of the total number of light duty vehicles in the County (about two-tenths of one percent) but if the numbers continue to increase, EVs could make up a more significant portion in coming years.

Two market penetration scenarios are considered: one with EV sales growing linearly and the other with sales growing exponentially over the next six years. The linear scenario has the County adding 160 EVs annually (equivalent to the number added between October 2013 and September 2014). The exponential scenario looks at the sales of EVs increasing by 60 percent each year (as they did between October 2013 and September 2014). In the linear growth scenario, there would be approximately 1,400 EVs in Boulder County by the end of 2020. In the exponential growth scenario, there would be just over 7,000 EVs by the end of 2020. In the higher penetration scenario, we project that charging demand could go up by a factor of 20 over the next five years, which would lead to much higher demand for public charging.

Location of DC Fast Chargers

Direct current (DC) fast chargers (sometimes known as Level 3 chargers) are capable of recharging a vehicle in 15-20 minutes and play a very different role than Level 2 chargers. In 2013, researchers at the University of California-Davis conducted a statewide survey of current EV drivers, and discovered that "the main desire is for quick charging. Fast chargers are wanted at regional attractors such as downtowns, large malls, airports and other regional services."[8] DC fast chargers should be strategically placed to make longer regional trips feasible and convenient for

[7] City of Boulder. 2015. Access Management and Parking Strategy (AMPS). https://bouldercolorado.gov/commercial-districts/access-and-parking-management-strategy.
[8] Nicholas, M., Tal, G., Woodjack, J. 2013. California Statewide Charging Survey: What Do Drivers Want? Presented at the 92nd Annual Meeting of the Transportation Research Board, January 13-17, 2013, Washington, D.C.

EVs. Most installations of DC fast charging stations are along major highway corridors connecting urban areas so that EVs are better able to take longer regional trips which exceed their electric range. The West Coast Electric Highway along Interstate 5 from Southern California to Seattle is perhaps the best example of this type of DC fast charger placement.

Boulder does not fall along a major interstate or highway corridor but is a regional destination. DC fast chargers in Boulder would give EV drivers from Denver and Fort Collins a convenient option to recharge their vehicles and make the round trip without range anxiety. This would be especially important for recreational travelers whose specific destination in Boulder may not be served by Level 2 charging or do not plan to park in one place for several hours.

The planned GoE3 station near 9th and Walnut would be well located to serve EV drivers coming to downtown Boulder, which is a principle destination in the city. There are a number of other regional destinations that may make sense for consideration for DC fast charging, including the CU-Boulder campus and the Eldora Ski area. In addition, as the Boulder Civic Area is redeveloped, this may be an appropriate location for additional fast charging, given the size of this regional attraction.

Another major effort is that led by the NRG eVgo to install "Freedom Stations," which combine a Level 2 charger and a DC fast charger. Under their business model, a site host provides the site, and NRG finances and maintains the charging stations, with customers either purchasing subscriptions or paying per use. They currently have sites at the 29th Street Mall, and several along the US 36 corridor, including at Superior Costco, at Flatirons Crossing, and one in Westminster. Currently their stations are only useable by Nissans, as they use a Chademo plug, but they can easily be retrofitted with an SAE plug to be useable by customers with European and American vehicles. The company also has a deal with Nissan in which Nissan customers get two free years of charging on the eVgo network.

Compared to public Level 2 chargers, we don't yet have enough local experience with DC fast chargers to know how they will be utilized. Given this, it may make sense to focus on developing a few pilot projects, perhaps as public-private partnerships, to learn from the experience before committing to a longer term strategy. There are a number of companies like Goe3 and eVGo which are willing to take the financial risk on developing and operating fast charge stations, so there may be interesting opportunities for the City to partner with the private sector.

Increasing Utilization of Public Chargers

A reasonable argument can be made that placing public chargers has a value, even if the initial utilization is low, by making EVs more visible, reducing range concerns, and helping to spur more people to acquire EVs. However, there are also some downsides, including lower utilization of limited parking in some areas and negative public perceptions associated with people seeing parking spots sitting empty. This is particularly an issue in highly visible locations: the best places

for making EVs visible are the worst places for spots to sit empty. Because of this, we recommend that steps be taken to maximize the use of existing and new stations. Three approaches are described below.

Strategy #1 – Dedicate spaces for fleet and carshare vehicles: Consider dedicating certain underutilized EV spaces for use by either EV fleet vehicles or EV carshare vehicles. SWEEP's survey of existing public charging stations indicates that there are locations that are used an average of less than once every five days; these might be good candidates for such dedication. This might also be appropriate for locations where there are two EV parking spaces adjacent to each other, with relatively low utilization. Karen Worminghaus, executive director of eGo Carshare, stated in an interview that the biggest constraint on their ability to add EVs to their fleet is the availability of dedicated charging locations.[9] Our analysis indicates that this may be an opportunity for partnership.

Strategy #2 – Encourage Shared Parking: Another strategy could focus on shared parking. For example, in the Boulder Junction area, there will be multiple types of uses (housing, transit users and employees) in a relatively compact parking district. This is also an area where the demographics will likely support EVs. It would be worthwhile to explore opportunities for shared EV parking that could be used by employees during the day and residents at night.

Strategy #3 – Make existing chargers easy to use: Steps can be taken to make stations more attractive to potential users. In interviews with EV owners, we received feedback that some of the existing stations are difficult to use. For example, a user described trying to use the station at the South Boulder Recreation Center and having to park the car, go into the building to get a key fob, and come back to the car to plug in. Another user described confusion at the North Boulder Recreation Center, with very slow Level 1 charging available in a well-signed and convenient location, while a more useful Level 2 charger was hard to find in the back of the building.

We recommend an effort to make existing chargers as easy as possible to use. For the public stations, we would also recommend making sure that they are networked, so that potential users can check availability online.

[9] Worminghaus, K. Personal interview with Will Toor. February 10, 2015.

IV. WORKPLACE CHARGING

Experience around the country has shown that workplace charging is a crucial element for EV adoption. While most charging happens at home, workplace charging is the next most important location, accounting for a much higher percentage of charging than public charging. In this section, we begin by discussing what is required for an employer to develop an effective workplace charging program. This would apply to any of the participants: the City, the County, CU Boulder, BVSD and NCAR, as well as any other public or private sector employers in the area. We then discuss some elements of a possible strategy to encourage employers in Boulder and Boulder County to provide workplace charging.

Summary of Key Actions an Employer Can Take to Provide Effective Workplace-Based Charging

1. **Become a partner in the US Department of Energy's Workplace Charging Challenge**
   This will provide access to technical assistance and resources to help guide decisions around setting up workplace charging. It will also increase the visibility of the workplace charging program.

2. **Survey your employees**
   Results from survey will give an idea of:
   - the number of employees who already own or are considering buying an EV (in order to determine the number of stations to install)
   - the distance they commute (in order to better understand EVSE level needs)
   - the best locations to install chargers (if multiple campuses)

3. **Research potential sites (with facilities manager) for EVSE to better understand major cost variables**
   Major variables that will impact the cost of installation are the capacity of the electrical panel serving the parking area and the extent of wiring or conduit around the parking area.

4. **Determine which level of charging to provide**
   The choice between providing Level 1 or Level 2 stations will depend on a number of factors such as the needs of employees and the cost of the installation. The cost of electrical panel and wiring upgrades may make Level 2 cost-prohibitive for some employers, in which case Level 1 may better serve their demand for workplace charging.

5. **Develop policies on workplace charging**
   The employer must develop policies on such issues as how much (if anything) to charge employees to use workplace charging, who can access the stations, and how employees are expected to switch out vehicles if necessary.

6. **Contract with electrician to finalize locations and install stations**
   A licensed electrician will help finalize details such as the location and costs for the stations and will complete the installation.

7. **Install signage**
   Signs should be installed to clearly indicate that the relevant spaces are to be used only for EVs which are actively charging. Painting or striping the pavement can also be helpful in delineating EV spaces from regular spaces.

8. **Begin Employee Outreach and Education Program**
   Once charging is in place, employers must continue outreach and education for their employees to maximize the value of their workplace charging investments. Potential education efforts include the following:
   - Engaging employees who already own EVs to serve as ambassadors to other employees and give short presentations
   - PEVs in fleet that can be used by employees
   - Hosting "Ride and Drive" events with local EV dealers
   - Fleet EV carshare program

Detailed Information on Each of the Key Actions To Provide Effective Workplace-Based Charging

1. Become a Partner in DOE's Workplace Charging Challenge

The US Department of Energy's (DOE) Workplace Charging Challenge program provides employers with resources and technical assistance that will help ensure a successful workplace charging program.[10] Technical assistance and resources are available through the DOE as well as current partners. More than 150 current Challenge Partners include major corporations, small businesses, municipalities and counties, universities and utilities across the United States. Challenge Partners in Colorado include Xcel Energy in Denver, Raytheon in Aurora and Odell Brewing Company in Fort Collins. The Rocky Mountain Institute is listed as a Workplace Charging Ambassador and may be able to provide technical assistance and support.

Becoming a Challenge Partner will also raise the visibility and provide national recognition of the workplace charging program.

[10] More information about becoming a Challenge Partner is available at http://energy.gov/eere/vehicles/ev-everywhere-workplace-charging-challenge.

Partners must pledge to:

- Provide charging access for employees at one or more worksites;
- Assess employee demand for charging and set a minimum goal of providing charging for a portion of EV-driving employees;
- Develop and implement a partner plan based on your organization's workplace charging strategy;
- Publicly announce partnership in the Challenge and highlight workplace charging installations on an ongoing basis; and
- Share workplace charging progress and best practices.

2. Survey your employees

One of the most important first steps an organization should take when considering providing workplace charging is to survey employees. Collecting relevant information will allow the employer to more accurately determine two of the most important points: how many charging stations to provide and what type (level) of stations will best fit the needs of their employees. (See sample employee survey below.)

Results from survey will give an idea of:

- the number of employees who already own or are considering buying an EV (in order to determine the number of stations to install)
- the distance they commute (in order to better understand EVSE level needs)
- the best locations to install chargers (if multiple campuses)

3. Research potential sites for EVSE to get an idea about major variables impacting the cost of installation for Level 1 or Level 2

After using the employee survey to identify which locations (if multiple campuses or sites) might be good locations for employee charging, work with your facilities manager to better understand the electrical characteristics of the potential sites that can impact the cost of installing EVSE.

The two variables that will most influence the cost of installation at each site are:

- the spare capacity of the electrical panel that serves the parking area; and
- the extent of wiring or conduit that is located in or near the parking area.

A new electrical panel or a panel upgrade may be required, depending on the existing panel's spare capacity and the number and type of charging stations you want to install.

If the wiring or conduit currently serving the parking area is not sufficient for the charging stations, or if there is no wiring terminating near the employee parking area, the cost of installation could significantly increase due to the need for trenching or boring to install new wiring.

Sample Employee Survey

Top Questions

- Do you own an EV?
  - Yes/No
    - What brand of EV do you own?
      - Nissan Leaf
      - Chevy Volt
      - Tesla
      - Other (please specify)

- Are you considering a purchase or lease of an EV in the future?
  - Yes/No
    - What type of EV are you considering?
      - Plug-in hybrid electric (PHEV)
      - Battery electric vehicle (BEV)

- Would you be more likely to consider purchasing or leasing an EV if workplace charging were available?
  - Yes/No

- If you drive to work, approximately how far is your trip (one-way)?
  - Less than 10 miles
  - 10-25 miles
  - 26-50 miles
  - More than 50 miles

Supplementary Questions

- How many days a week do you drive to work?
  - I don't / 1 / 2 / 3 / 4 / 5

- If you are considering obtaining a new vehicle, how soon do you plan on buying or leasing your next vehicle (of any type)?
  - I'm considering purchasing in the next 6 months.
  - I'm considering purchasing in 12-24 months.
  - I'm considering purchasing, but I'm not sure when.

- If workplace charging were an option, would you be willing to pay for the service?
  - Yes / No

- Throughout the workday, what is your usual travel pattern?
  - I stay at the worksite and do not move my vehicle.
  - I leave the worksite and move my vehicle once per day.
  - I leave the worksite and move my vehicle more than once per day.

- Do you or would you have the ability to install a charging station at your residence?
  - Yes / No / I don't know

4. Determine which level of charging to provide

There are a number of variables to consider when deciding what level of charging to provide to employees. One major consideration is the average distance that your employees commute to work. If more than 25 percent of employees drive considerable distances (over 25 miles), then some amount of Level 2 charging is probably appropriate to serve these commuters. (In the 2011 Boulder Valley Employee Survey, approximately 21% of car commuters traveled 21 miles or longer to get to work.)[11] Likewise, if a majority of your employees are part-time workers or spend part of their day driving for work purposes, then Level 2 might better serve their needs.

In addition, if you have a number of employees who express interest in an EV but do not have the ability to charge at their residence, supplying Level 2 charging at the workplace will make it much more feasible for them to consider an EV, as they would be able to use the workplace as their primary charging place.

One advantage of installing a greater number Level 1 stations versus fewer Level 2 stations is the simplicity of not having to develop a system for switching the cord or moving vehicles over the course of the day. Having to move one's vehicle during the course of the day could become a distraction to employees and result in lost work time.

Cost is the other major issue when deciding between Level 1 and Level 2 EVSE. Installing and operating a Level 2 station will generally be more expensive than a Level 1 station, although a single Level 2 station can supply more electric miles per dollar invested than a single Level 1 station.

First, the hardware (the actual charging station) costs for Level 2 stations are usually higher than for Level 1. A Level 1 station may cost between $500 and $1,000 while Level 2 hardware varies widely depending on the functionality of the EVSE. A Level 2 station could cost anywhere between $500 (very basic) and $6,000 (most advanced). The higher end systems offer features like credit card payment and wireless communication, which may or may not be of interest for employee charging. If there are existing regular outlets located in the parking area it is even possible that Level 1 charging could be set up with negligible costs (aside from labor costs to dedicate circuits to charging).

If the employer's goal is to maximize the number of EV miles traveled by employees, it makes sense to weigh the costs of the two levels on a per kWh basis. A Level 2 station will cost more upfront, but will provide more kWh over the course of the year. For example, a Level 1 station with capital costs of $500 would provide 2,475 kWh of electricity over the course of the year, resulting in a first-year capital cost of $0.202 per kWh. For a Level 2 station that costs $2,300 and would provide 14,850 kWh over the course of a year, the first-year capital cost per kWh comes to $0.155.

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[11] City of Boulder. 2012. 2011 Boulder Valley Employee Survey for Transportation. https://www-static.bouldercolorado.gov/docs/2011-boulder-valley-employee-survey-for-transportation-report-of-results-1-201305291119.pdf.

The addition of employee charging stations may require upgrades to the electrical panel that will serve the chargers. A panel upgrade may cost around $2,000. As Level 2 stations will have higher electrical use they are more likely to require upgrades than a Level 1 station.

A key variable in the cost of any system is the cost of installation. Ideally, the building would have existing conduit or wiring from an electrical panel that terminates in the employee parking area. If not, it will likely be necessary to trench or bore to run the wiring to the parking area. Both these options tend to increase costs significantly so if at all possible it is ideal to place the charging stations in as close proximity as possible to the existing electrical supply. Between Level 1 and Level 2 there may not be much difference in installation costs, although if you are installing a greater number of Level 1 stations this will require additional trenching and patching of the parking area.

Once the chargers are installed there will be costs for providing electricity. As many employers offer workplace charging for free or a small fee, it is important to understand how much it will cost the employer each year to offer electricity to their employees. Over the course of a year, a Level 1 station would provide an estimated 2,475 kWh[12] at a cost of either $97 or $117 (depending on whether the site is subject to PG or SG tariff).[13] A Level 2 station would deliver approximately 14,580 kWh[14] at a cost of $580 or $700. In addition to kWh costs, charging stations may result in greater demand charges for the site. Because of their higher levels of delivered power, Level 2 stations have more potential to create higher peak loads than a Level 1 station. A single Level 1 station has the potential to add $197 (PG) or $225 (SG) to electricity bills over the course of the year. A single Level 2 station has the potential to add either $1,186 (PG) or $1,350 (SG) over the course of the year.[15] These are maximum values; it is also possible that the addition of charging stations would have no impact on demand charges, especially if the building has an energy management system already in place to help manage peak loads. In addition, the more advanced Level 2 stations may require monthly operating or network access fees.

It may be helpful to provide some context regarding how other employers are deciding between Level 1 and Level 2 EVSE. Approximately three-quarters of the charging stations installed by DOE Workplace Charging Challenge Partners have been Level 2 stations and nearly two-thirds of the stations installed by employers surveyed by the PEV Collaborative are Level 2 stations. The trend seems to moving more towards Level 2, with employers reporting installing an even higher percentage of Level 2 stations over the last year.

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[12] 1.1 kw * 9 hours/day * 250 annual workdays = 2,475 kWh
[13] The PG tariff has a per kWh cost of $0.0472. The SG tariff has a per kWh cost of $0.0391.
[14] 6.6 kw * 9 hours/day * 250 annual workdays = 14,850 kWh.
[15] The PG tariff charges $16.99 per kw during the summer and $13.98 per kw during the winter. The SG tariff charges $19.02 per kw over the summer and $16.06 per kw over the winter.

Table 3 | Comparison of Cost Variables for Level 1 and Level 2 EVSE

Expense Category	Level 1 EVSE	Level 2 EVSE
Hardware[16]	$300-$500	Basic (a simple conduit for electricity): $500-$1,000 Midrange (some features): $1,000-$4,000 Advanced (credit card payment, wireless communication, data tracking, dual ports): $4,000-$6,000
Siting Considerations	Greater number of stations needed; may require more trenching and patching in the parking area	
Upgrade of Electrical Supply		More likely to be necessary. Approximately $2,000 for panel upgrade
Electricity	$100/year	$600-$700/ year
Operating Fees		More advanced stations may result in monthly service and billing charges
Potential Additional Demand Charges	$200/year	$1,200-$1,300/year

To summarize, installing and operating a Level 2 station will generally result in higher capital and operating costs than a Level 1 station. However, a single Level 2 station can provide six times more kWh (and thus electrical miles to your employees) than a Level 1 station and can supply enough electricity to recharge multiple vehicles throughout the day. A fairer comparison would be between four Level 1 stations and one Level 2 station, which would bring their capital and operating costs much closer to parity. Employers may also provide a mixture with a larger number of Level 1 stations supplemented by a few Level 2 stations.

5. Develop policies on workplace charging issues

Cost of charging

The employer must decide if they want to charge their employees a fee to use the workplace charging stations. Many employers offer free workplace charging to their employees; for example, 80 percent of DOE Workplace Challenge Partners offer free charging. However, collecting a fee from employees can help defray some of the ongoing costs of providing workplace charging and possibly recoup some of the capital costs of the stations.

[16] Calstart. 2013. Best Practices for Workplace Charging. http://evworkplace.org/wp-content/uploads/2013/10/Best-Practices-for-Workplace-Charging-CALSTART.pdf.

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

The basic pros and cons of free workplace charging summarized in Table 4 below are outlined in greater detail in a UC Davis paper on this topic.[17]

Table 4 | Pros and Cons of Free Workplace Charging

Pros of free workplace charging	Cons of free workplace charging
• Potentially increases plug-in electric vehicle sales • Simplifies charger installation and setup for workplace • Avoids administrative hassle of collecting revenue • Avoids impression of pettiness of employer • Provides employees a workplace benefit	• Switches charging from home to work • Switches charging from off-peak to peak electricity demand times • Does not appreciably increase electric VMT over a priced charging scenario • Creates congestion at chargers more quickly than a priced charging scenario, making the availability of charging less dependable • Decreases dependability for BEVs, discouraging certain trips • Potentially requires expensive panel upgrades to keep up with demand • Demand for free chargers may outpace practical installation rates

If the employer decides to charge for the use of stations, a good price level would be one that is slightly higher than the regular residential rates that employees would pay when charging at home. By pricing above residential rates, the employer ensures that only employees who really need the extra electric miles offered by workplace charging will be motivated to plug in during the day.

[17] Nicholas, M., and Tal, G. 2013. Charging for Charging: The Paradox of Free Charging and Its Detrimental Effect on the Use of Electric Vehicles. http://www.its.ucdavis.edu/research/publications/publication-detail/?pub_id=1919.

Access

The employer needs to decide whether the charging stations are to be used exclusively by employees or they will be made available to the employer's fleet vehicles or the general public. If access to the stations is managed via a third party, it may be feasible to allow public access to the stations outside of normal work hours. If access is not controlled, then it makes sense to restrict use to employees.

An additional question around access regards compliance with the Americans with Disabilities Act (ADA). The DOE has put together a summary of the requirements around charging station parking spots and ADA compliance.[18] Generally, for every twenty-five parking spaces, one space needs to be accessible and for every six accessible parking spaces, one needs to be van accessible. There are no explicit guidelines on EV charging spaces and ADA compliance but at the least EV parking spaces will need to follow the guidelines for regular parking spaces.

Management

Policies need to be developed around how long any individual vehicle can charge during the day (especially if using Level 2 stations) and how employees should switch out vehicles over the course of the day.

The employer may also wish to limit charging during the building's peak electricity use (often late afternoons during the summer) to avoid higher demand charges.

A workplace charging policy template developed by Capital District Clean Communities is available as part of a larger report on workplace charging.[19]

6. Contract with electrician to finalize locations and install charging stations

When doing the installation you should plan and prepare for the addition of more stations in the future by pre-wiring or installing conduit.

7. Install signage

Signs should be installed to clearly indicate that the relevant spaces are only to be used for EVs which are actively charging. Painting or striping of the spaces' pavement can also be helpful in delineating EV spaces from regular spaces.

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[18] US Department of Energy. 2014. ADA Requirements for Workplace Charging Installations. http://energy.gov/eere/vehicles/downloads/ada-requirements-workplace-charging-installation.

[19] Capital District Clean Communities. 2014. Workplace Charging Toolkit. http://www.nycapitalregionev.com/uploads/2/0/3/1/20310469/workplace_charging_kit.pdf.

8. Implement employee outreach and education program

Below are some best practices around engaging and educating your employees about workplace charging.[20]

- Engage employees who already own EVs to serve as ambassadors to other employees and give short presentations.
- Post flyers on EV benefits and workplace charging availability in common areas.
- EVs in City fleet that can be used by employees.
- Offer reserved parking spaces (not charging stations) in prime spots as an added incentive.
- Host "Ride and Drive" events with local EV dealers.[21]
- Offer a workplace charging Tour to show interested employees workplace EVSE and give info about charging procedures.
- Provide employee testimonials and info on EV benefits with employee. newsletter or other communications.
- Include EV info with new employee information.

Promoting Adoption of Electric Vehicles in Workplaces Across the County

Boulder County leads the state in EV adoption. High EV sales rates in Boulder County are complemented by over 30 publicly available charging stations, making it convenient for EV drivers to recharge their vehicles when away from home. To maintain its strong record on EVs, the City and County should seek ways to promote workplace charging among the major employers.

After their homes, employees are generally parked at work for the most time each day, which makes the workplace an ideal place to provide charging stations. Workplace charging provides additional confidence to EV drivers and opens up the possibility of EV ownership to residents who do not have the ability to charge their vehicles at their residences. DOE research has shown that employees who have access to workplace charging are much more likely to purchase an EV, and has identified workplace charging as a key component to increased adoption of EVs.[22]

Providing workplace charging provides the following benefits to employers:

- Improves employee recruitment and retention
- Helps to meet sustainability goals
- Enhances public perception of the company

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[20] This list is adapted from DOE's PEV Outreach Resources for Your Employees. http://energy.gov/eere/vehicles/downloads/pev-outreach-resources-your-employees.

[21] A Ride and Drive Toolkit, developed by Advanced Energy, is available at www.advancedenergy.org/portal/ncpev/resources/RideandDriveKit.pdf.

[22] US Department of Energy. 2014. Workplace Charging Challenge, Progress Update 2014: Employers Take Charge. http://energy.gov/eere/vehicles/downloads/workplace-charging-challenge-progress-update-2014-employers-take-charge.

There are four steps the City and County could take to promote adoption of EVs by employees in workplaces:

1. ***Use existing transportation management organizations (TMOs) to reach employers and employees.*** The City and the County have two TMOs (36 Commuting Solutions and Boulder Transportation Connections) which have an existing relationship with many employers. We recommend working with both TMOs to broaden their outreach efforts with employers, and to include information on workplace charging, joining the workplace charging challenge, and setting up Ride and Drive events.

2. ***Use the existing network of Employee Transportation Coordinators (ETCs).*** In the city, this is coordinated between GO Boulder and Boulder Transportation Connections. The ETC network hosts four events each year which bring ETCs together and provide support to ETCs on issues such as setting up transit pass programs. In addition, ETCs can identify individual employees for personal travel planning assistance. We recommend that this be broadened to include education on EVs at ETC events.

3. ***Use the EnergySmart Program to reach businesses***. EnergySmart has offered energy advising to more than 3,000 businesses to date. We recommend building two new elements into the energy advising: a quick review of any passenger vehicles in the company fleet and a review of the potential for workplace charging. EnergySmart advisors could also help businesses apply for the Charge Ahead grants that are available through the RAQC to support charging at businesses.

4. To encourage major employers to provide workplace charging for their employees, the City and the County could ***sponsor a Workplace Charging Challenge***. This would provide recognition to employers who commit to workplace charging and could further highlight the employers who are the most successful in their promotion of workplace charging. This would build on the DOE Workplace Charging Challenge program, a voluntary program in which employers can participate to gain recognition and support.[23] Drive Electric Northern Colorado (www.DriveElectricNoCo.org) has developed a regional version of this program. Boulder and Boulder County could develop such a program.

[23] US Department of Energy. 2015. EV Everywhere Workplace Charging Challenge. http://energy.gov/eere/vehicles/ev-everywhere-workplace-charging-challenge.

V. PILOT PROJECT FOR INCENTIVIZING EMPLOYEES TO USE ELECTRIC VEHICLES

In this section, we discuss the potential for a pilot project focused on City of Boulder employees. A similar approach could be considered for Boulder County, CU, and other public sector employers.

The fundamental concept is to combine a workplace charging program with:

- targeted outreach to employees;
- negotiated purchase price discounts on one or more EV models;
- free energy advising (including both home and transportation advising);
- discounted solar photovoltaic (PV); and
- a program to provide bridge financing until employees can get tax credits.

Background Information for Pilot Program

Employee commute patterns

A substantial number of employees commute from outside of Boulder city limits and the majority of these employees drive by themselves. Based on past trends, the percentage of public employees living out of the city and commuting in is likely to continue to grow over time, as is the average commute length. The data below show a snapshot of City and CU employees over the last two years.

Table 5 | Average One-Way Commute Distance for Employees

Employer	Miles
City of Boulder	14.1
Boulder County	12.5
CU-Boulder	13.2

For City of Boulder employees living outside of the city, the average commute is even longer at 18.2 miles. For CU employees, 29% have a commute between 11 and 20 miles and 20% have a commute over 20 miles.

We note that these commute lengths are well within the range of any EV on the market.

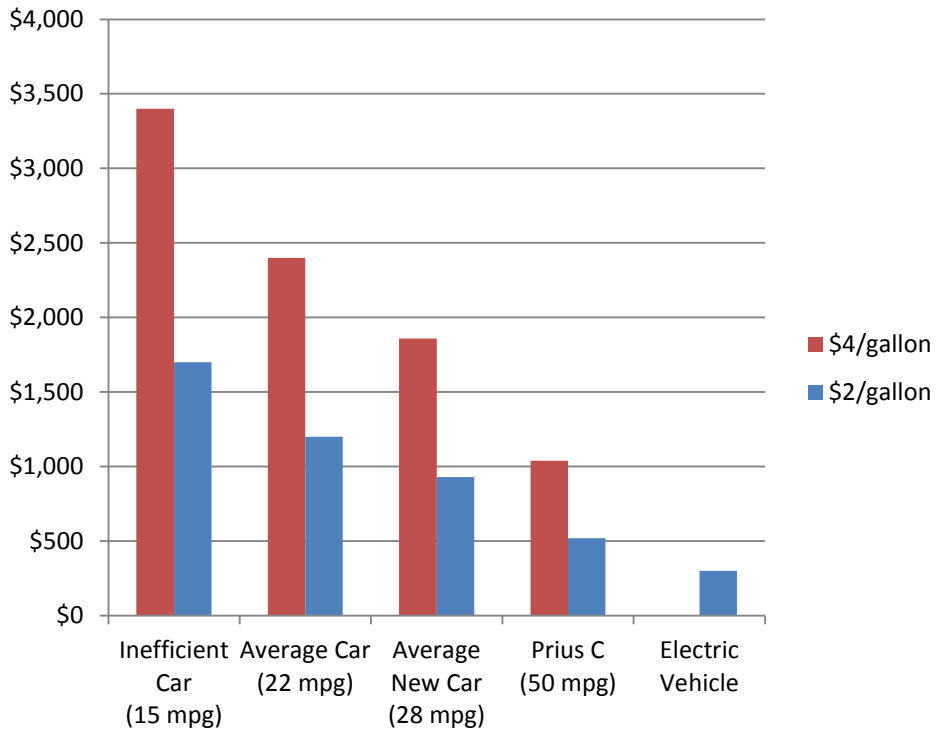
The economic case for employee EV

Table 6 below compares estimated fuel costs for a typical employee driving 13,000 miles per year. A typical EV will use about 3,000 kWh to travel 13,000 miles, so can be expected to cost about $300 for fueling at 10 cents/kwh. Compared to driving an inefficient vehicle, driving an EV will save the owner between $1,500 and $3,100 annually in fuel costs. Even compared to the most efficient gasoline vehicle, an EV will still provide fuel cost savings of up to $740 a year.

Table 6 | Comparison of Fuel Cost for Different Types of Vehicles

Vehicle Type	MPG	Annual Fuel Consumption (gallons)	Fuel Cost (at $2/gallon)	Fuel Cost (at $4/gallon)
Inefficient car	15	870	$1,700	$3,400
Average car	22	590	$1,200	$2,400
Average new car	28	464	$930	$1,860
Prius C	50	260	$520	$1,040

Figure 13 | Annual Fuel Expense for Different Vehicles



Two sample scenarios

Figures 14 and 15 below show how much a new vehicle owner might expect to pay in car payments and fuel costs every month, comparing two of the most popular vehicles in Boulder (the Subaru Outback and Subaru Legacy) to a Nissan Leaf. The two scenarios make a compelling case that EVs can offer a financial advantage over gasoline vehicles and at little additional cost, a solar photovoltaic (PV) system can be installed to provide carbon-free transportation. Due to tax credits that reduce the upfront cost of a Leaf and its lower fuel costs, it is actually much less expensive to buy/lease and operate a Nissan Leaf than either of the Subarus. In addition, the cost to a

homeowner to add solar panels that would meet the new electricity demand for a Leaf would only be $3 more per month than the cost of purchasing the electricity from Xcel. And after paying off the PV system in 10 years, the homeowner would have "free" electricity for the remaining life of the panels.

Thus, there is a case to be made that, for many employees, there can be a lowered monthly cost by transitioning from a conventional vehicle to an EV for commuting, while at the same time acquiring PV so that their commute is close to zero emission. Clearly, if gasoline prices increase from their current low rate of $2 per gallon, the economic case for EVs becomes even stronger. Furthermore, the average turnover time for vehicles is more than 10 years, so a vehicle acquired today is likely to be owned for many more years than the current very low fuel prices.

Figure 14 | Monthly Costs to Purchase and Fuel a New Vehicle

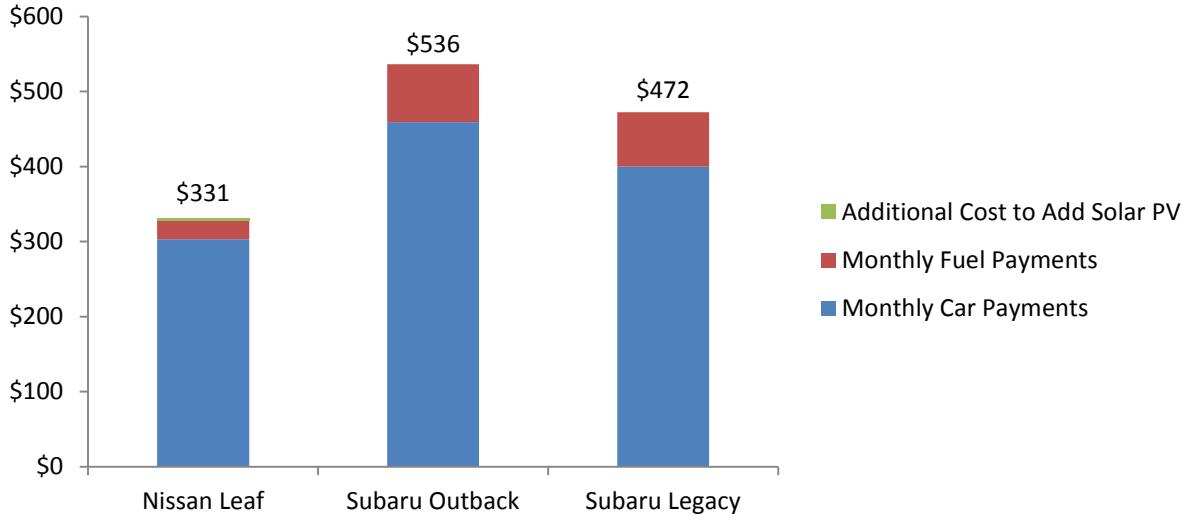


Figure 15| Monthly Costs to Lease and Fuel a New Vehicle

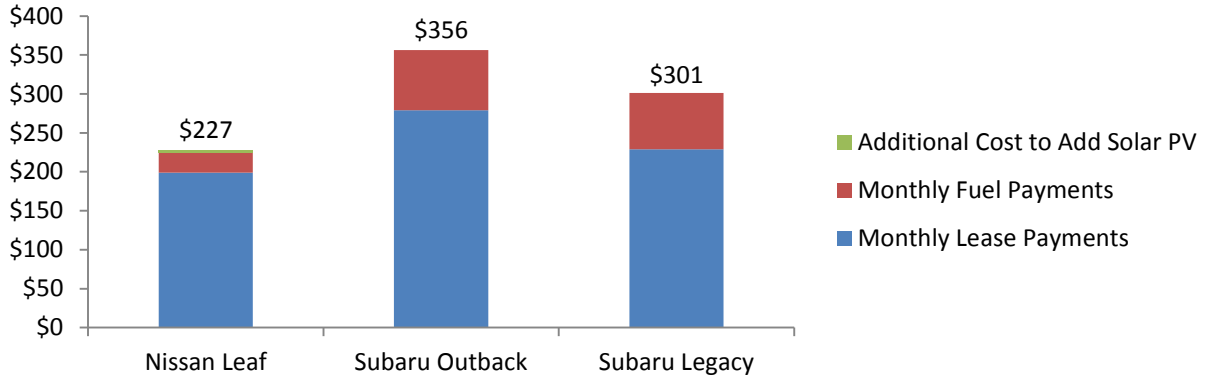


Table 7 | Assumptions

Vehicle	MSRP	Incentives	Base Price	Monthly Payment*	Monthly Lease Payment	Monthly Fuel Costs
Leaf	$29,000	$12,600	$16,400	$303	$199	$25
Outback	$24,895	NA	$24,895	$459	$279	$77
Legacy	$21,695	NA	$21,695	$400	$229	$72

**Monthly payment estimated using tool on Subaru website*

Additional assumptions:

- $2/gallon gasoline
- 4% financing for 5 years with zero down payment
- Outback with 28 mpg, Legacy with 30 mpg
- Incremental Cost to Add PV (compared to Excel rates): $3/month. $28 per month to lease 1.5 kW system compared to $25/month at Xcel residential rates of $0.10/kWh

Top locations for workplace charging

Based on the numbers in Table 8, the downtown campus and the Public Safety building may be the best locations for an initial pilot program, targeting these relatively large clusters of employees. In addition, the new location on Center Green, where a number of charging stations have been installed, may also be a good location. As part of this program, the City would commit to providing workplace charging at both the downtown campus and Public Safety Building, with the number of charging stations determined by the level of employee participation. While the North and South Recreation Centers have a large number of employees, about half of them are part time or occasional employees such as lifeguards or class instructors, making them less ideal for targeted workplace charging.

For the CU-Boulder campus, the Sustainability, Energy and Environment Complex (SEEC) would be an ideal location for a pilot program that combines workplace charging with a targeted employee outreach and incentive program. It would be relatively easy to incorporate, since the complex is not yet complete and the faculty and staff who will be located at this complex are likely to be highly motivated. The University Center for Atmospheric Research (UCAR), which has a similar demographic profile to SEEC, conducted a survey of 100 employees in fall of 2014. Ten percent of respondents stated that they already owned an EV, 11 percent were considering purchasing an EV in the next two years, and 69 percent responded that the availability of workplace charging would make them more likely to purchase an EV.

For Boulder County, there are several locations that might make sense for employee pilots, including the Courthouse, North Broadway, and St. Vrain locations. St. Vrain may offer particular opportunities if the County develops an EV fleet at this location. Boulder County is currently considering a program in which several fleet EVs would be located at this site, for use largely by caseworkers. This would require that charging infrastructure be installed, but the vehicles would

be used during the day and largely charged at night, creating the opportunity for a shared use arrangement where the stations could be used for employee charging during the day.

Table 8 | City of Boulder Locations with more than 50 Employees

List of Locations	Total # of Employees
Downtown Campus (Total)	437
• *Park Central Building*	*137*
• *Library - Main Branch*	*114*
• *Municipal Building*	*100*
• *Streets & Utilities Maintenance*	*86*
Public Safety Building	291
South Boulder Recreation Center	239
North Boulder Recreation Center	196
Park Central Building	137
Cherryvale Open Space Operations Center	117
Library - Main Branch	114
East Boulder Community Center – Recreation & Senior	101
Municipal Building	100
Streets And Utilities Maintenance	86
Center Green	83
Boulder Reservoir	70
Park Maintenance and Forestry	60

Employee Survey

We recommend conducting a survey at these locations, as described in the chapter on workplace charging.

Energy Advising

We recommend offering free home energy assessments to employees on these campuses, buying down the costs of the EnergySmart residential energy advisor program. We recommend offering this over a limited time horizon, perhaps a 90-day window, to encourage employees to get involved promptly. Transportation advising would be built into the energy advising sessions.

Discounted Purchases of EVs

It is not clear that this is broadly possible, but Nissan has developed a program that can offer $1,000 discounts to employees of large employers who participate in their workplace programs.

Financing Program

One of the barriers to EV purchases is the upfront cost of acquisition. While up to $13,500 combined federal and state incentives are available, these are income tax credits that are the purchaser does not benefit from until the next tax year. The City and County of Boulder could consider a program that would essentially finance the tax credits, turning them into an upfront incentive. This would be a variant of the Home Energy Affordability Loan approach, developed by the Clinton Global Initiative, which has been piloted by a number of governments. The basic concept would be to offer a low interest loan for the anticipated amount of the tax credits, paid back through a payroll deduction, and potentially to structure payments to begin at the point when tax credits would be anticipated. This could allow participating employees to be cash flow positive from day one of the program, which could substantially increase uptake rates.

Estimated Costs of Pilot Program

We describe a hypothetical initial employee pilot program that includes EV/PV/EVSE financing for 20 employees. This initial pilot would give valuable experience in understanding how such a program worked in practice and give program administrators the opportunity to iron out any kinks prior to expanding it to a larger pool of employees.

The federal tax credit is up to a maximum of $7,500, with the majority of EVs sold (Leaf, Volt, Tesla) receiving the maximum credit. The Colorado state tax credit is up to a maximum of $6,000 ($4,300 for a Volt; $5100 for a Leaf; the more expensive EVs like the Tesla, Cadillac ELR and BMW i3 qualify for the maximum). It may be reasonable to assume that the average state tax credit will be around $5,000. So to provide upfront financing for federal and state EV tax credits would require about $250,000 in upfront capital.

To provide Level 1 workplace charging to these 20 employees would cost approximately $2,500 per charger (this is a very rough estimate and not at all site specific).[24] It is unlikely that all the participants will require access to workplace charging (if they're driving EVs and have a Level 2 home charger they shouldn't have much need to top off at work unless they live over 25 miles away). So perhaps an additional $50,000 in capital costs to install 20 Level 1 charging stations for the participants. The ongoing electricity costs would be approximately $600 per year per station which would come to an additional $12,000 per year. Some of this could be recovered if the EV owners were charged a fee for at work charging. To finance Level 2 home chargers for participants would cost about $1,200 per system.[25]

[24] Inside EVs. 2014. How Much Do Public and Home EV Charging Stations Really Cost? http://insideevs.com/how-much-do-public-and-home-ev-charging-stations-really-cost/.
[25] Ibid.

To finance home PV installations to match EV use (about a 1.5 kW system) would cost about $6,000 per system.

To extend the program to five percent of city employees (which would be about 100 employees) the costs identified above would need to be multiplied by 5, which would bring the total cost (not accounting for repayments) to $2.2 million.

There would be additional costs for energy advising for program participants and the cost associated with some staff from the City to oversee the program.

Table 9 | Cost Estimates for Pilot Program

Program Elements	Per Employee	For 20 Employees
Electric Vehicle (loan)	$12,500	$250,000
Level 2 Home Charger (loan)	$1,200	$24,000
1.5 kW Solar PV System (loan)	$6,000	$120,000
Workplace Charging	$2,500	$50,000
Total	**$19,700**	**$444,000**
Amount Returned within One Year from Tax Credits	$14,300 *($12,500 + $1,800 Federal tax credit for home PV)*	$286,000 *(64% of total)*

Greenhouse Gas Emissions Benefits of Program

One EV powered by solar PV would save 590 gallons of gasoline compared to the average car in Boulder (22 mpg). This would save 19.64 pounds of CO_2/gallon * 590 = 11,587 pounds of CO2 or 5.25 tons. The pilot project could therefore reduce CO_2 emissions by 105 tons annually.

Note that this is a scenario in which we're switching out an "average" vehicle with a pure EV powered exclusively by solar PV.

To put that in perspective, all the light duty vehicle travel within the City generated approximately 246,000 tons of GHG emissions in 2013. About 30 percent of that can be attributed to non-resident employees commuting to work. To achieve a one percent reduction in citywide transportation GHG emissions this program would need to be scaled up to about 450 vehicles. To achieve a one percent reduction in non-resident employee GHG emissions would require about 140 vehicles.

VI. INCORPORATING EV CHARGING INTO BUILDING CODE & PLANNING REQUIREMENTS

There are a number of regulatory areas where local governments exercise authority that can have an impact on EV adoption. These are largely in the arena of minimizing obstacles, incentivizing, or requiring the installation of charging infrastructure.

Removing Obstacles to Permitting

Both the City and County appear to have implemented effective and user-friendly permitting processes for residential EV charging stations. The City offers an over-the-counter permit that covers the installation of most residential home charging stations. The County offers an Easy Building Permit (EZBP) that is issued either over the counter or within 24 hours.

Best Practices Around Other Local Government Regulations: Incentivizing or Requiring Charging

There are multiple strategies that other local governments have taken to try to get more charging infrastructure installed in their communities. A few jurisdictions have enacted requirements in their zoning codes; a larger number have enacted them in building codes. Most have focused on requiring pre-wiring to make new parking areas EV ready; a smaller number require the actual installation of charging stations. We present brief summaries of some of these examples below.

Discretionary review

The City of Redmond, Washington allows builders/developers the possibility of receiving different incentives such as height bonuses, floor area ratio bonuses and building setback flexibility for commercial properties that incorporate certain green building and green infrastructure.[26] Two ways for a commercial property to receive a point towards the incentive are to install two EV charging stations on-site or to reserve five percent of required parking spaces for low-emission vehicles.

The City of Boulder could incorporate EV charging as a factor in site plan review or as an element of the "Transportation Demand Management (TDM) with teeth" requirements under development. This would allow for a site-specific examination of what makes sense for EV charging, given the particular uses and travel patterns at the site.

[26] Encodeplus. 2014. Green Building and Green Infrastructure Incentive Program. http://www.zoningplus.com/regs/redmond/acc/doc-view.aspx?tocid=005.004.

Requiring EV charging through zoning

The City of Grand Rapids, Michigan allows the provision of one reserved, signed and enforced EV parking space – complete with charging outlet – to count for the provision of four regular parking spaces with regards to off-street parking requirements.[27]

This novel approach, which combines an incentive for EV adoption with a reduction in the total number of parking spaces, fits well with Boulder's broader policy goals around reducing VMT.

For major expansions and all new buildings over 5,000 square feet, the City of Salt Lake City, Utah requires that for every 25 parking spaces provided, at least one parking space have an EV charging station. This applies to both multi-family residential and commercial developments.[28]

This is a relatively unusual provision, in that it is enacted as a zoning requirement rather than as a building code requirement, and that it requires an actual charging station rather than simply pre-wiring to allow easy installation of charging in the future. It was adopted with little controversy, but has received some pushback since it began being enforced, and the City is considering whether to reduce the requirement from four percent of spaces to two percent.

Avoiding zoning restrictions on EV charging

For zoning it may be an advantage for the code to define what types of EV charging stations are allowable or appropriate for each type of land use. It is important to ensure that charging stations are not prohibited or grouped with a more restrictive use such as a gas station. An example of clarifying language include New York City defining "EV charging in conjunction with parking facilities" as an accessory use. Another example is the City of Methuen, Massachusetts making Levels 1 and 2 chargers permissible as accessory uses to parking facilities in all areas and DC fast chargers permissible as a principal use in commercial or industrial zones or as a conditional use in general. In Boulder this has not been explicitly addressed, but so far it does not seem to have caused any issues.

Building codes

Local governments can have a significant impact on the ease and cost of installing EV charging stations by modifying their building codes.

A significant barrier to widespread adoption of EVs is the higher incremental cost, which can be exacerbated by the need to install a new electric panel and wiring for a home charging station.

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[27] City of Grand Rapids, Michigan. 2010. Zoning Ordinance. http://grcity.us/design-and-development-services/Planning-Department/Documents/13873_ZONING%20ORDINANCE%20TEXT%20last%20amended%20September%2028,%202010%20FOR%20WEB.pdf.

[28] Sterling Codifiers. 2013. Salt Lake City Ordinance No. 62 or 2013. http://www.sterlingcodifiers.com/codebook/getBookData.php?pending_id=14925.

Retrofitting a home to install a charging station can cost significantly more than preparing the home for EVSE during new construction. Owners of multi-family housing, which makes up 46 percent of Boulder's residential building stock, may be unable to install a station at the property. Providing residents of multi-family housing an option to charge vehicles overnight at home is an important step toward opening up larger populations to the potential of owning an EV.

Another barrier is the lack of adequate charging infrastructure away from home (either at workplaces or in public parking areas) which limits the range of EVs. Requiring new commercial parking areas to be EVSE-ready will increase the amount of available charging stations at a fraction of the cost of retrofitting a similar number of existing parking lots. EV charger readiness at commercial parking lots will also make it easier for employers to offer employees the option of workplace charging. Due to the long periods of time employees are generally parked at work, workplace charging can allow EV drivers to double their electric range and provides EV owners without access to home charging a reliable option for charging their vehicles.

Modifying the building code is an effective mechanism to address these barriers because incorporating EVSE or prewiring during initial construction is much less expensive than retrofitting the property at a later date. Retrofitting may require significantly more expensive upgrades to the electrical panel and trenching and cutting to run additional wiring to the garage or parking area.

A number of jurisdictions have adopted codes that address EV charging readiness in their residential and commercial building codes.

Table 10 | Jurisdictions with EV-friendly building codes

Jurisdiction	Single Family	Multi Family	Commercial
Boulder County, CO	♦		
New York, NY			♦
Los Angeles, CA	♦	♦	♦
City of Lancaster, CA	♦	♦	♦
Mountlake Terrace, WA	♦	♦	♦
Palo Alto, CA	♦	♦	♦
Rolling Hills Estates, CA	♦		
Santa Clara, CA	♦	♦	♦
Sunnyvale, CA	♦	♦	♦
Vancouver, British Columbia	♦	♦	

The examples below show possible language that could be incorporated into the City of Boulder's Building Code to expand EV charging requirements beyond single family residential requirements currently in the County code. Likewise, CU Boulder could adopt a similar policy regarding new construction on their campuses.

Residential

For one- or two- family dwellings and townhouses, where off street parking is provided, provide a minimum of:

a) One 208/240 V 40 amp, grounded AC outlet, for each dwelling unit; or
b) Panel capacity and conduit for the future installation of a 208/240 V 40 amp, grounded AC outlet, for each dwelling unit.

The electrical outlet or conduit termination shall be located adjacent to the parking area.

For residential occupancies where there is a common parking area, provide one of the following:

a) A minimum number of 208/240 V 40 amp, grounded AC outlets equal to five percent of the total number of parking spaces. The outlets shall be located within the parking area; or
b) Panel capacity and conduit for future installation of electrical outlets. The panel capacity and conduit size shall be designed to accommodate the future installation, and allow the simultaneous charging, of a minimum number of 208/240 V 40 amp, grounded AC outlets, that is equal to five percent of the total number of parking spaces. The conduit shall terminate within the parking area. When the application of the five percent results in a fractional space, round up to the next whole number. (Exception: If the electric panel is located in the parking area, conduit does not need to be installed.)

Commercial

For new commercial buildings with more than 50 parking spaces, provide one of the following options:

a) A minimum number of 208/240 V 40 amp, grounded AC outlet(s), that is equal to five percent of the total number of parking spaces, rounded up to the next whole number. The outlet(s) shall be located in the parking area and allow simultaneous charging.
b) Additional service capacity and conduit for future installation of electrical outlets. The service capacity and conduit size shall be designed to accommodate the future installation, and allow the simultaneous charging, of a minimum number of 208/240 V 40 amp, grounded AC outlets, that is equal to five percent of the total number of parking spaces. The conduit shall terminate within the parking area.

We would note that it may be helpful to distinguish between types of commercial facilities. Experience across the country is showing that most charging takes place at homes or at workplaces, with public charging in areas where people are parked for short time periods getting little use. Given this, code or zoning requirements should focus on charging in homes, in multifamily residential areas, and on employee charging at workplaces, rather than on parking for customers or the general public.

Rental licensing

In our review, we have not found rental licensing in other cities. However, given the City of Boulder's history in developing the SmartRegs program, it may be interesting to consider addressing EV charging in this context. Throughout the country, multifamily housing has been one of the most difficult arenas for EV charging. While building code or zoning requirements can ensure that new multifamily housing provides EV charging, they do not address the existing housing stock.

One way to encourage the installation of EV chargers in existing multi-family developments would be to allow property owners to receive points towards meeting SmartRegs requirements for each charging station installed. While SmartRegs is focused on CO_2 emissions from the residential sector rather than transportation, it makes sense to encourage multi-family units to offer EV charging as part of SmartRegs because the most convenient place for most EV owners to charge is at their residence.

The LEED rating system developed by the US Green Building Council recognizes that EV charging stations play a role in making residences sustainable and offers points towards LEED certification if chargers are installed at multi-family properties. Under current rules, the City could give points to multi-family units that install EV charging under the "Innovative Practice" measure, which is a discretionary category. It would be ideal to assign a specific number of points for each percentage of parking spaces or units that are equipped with a charging station.

Other multi-family models

In California several different companies have developed models to bring charging stations to multi-family dwellings.

In San Diego, a partnership was developed between Chargepoint, the City, the California Energy Commission and local groups that allows owners of multi-family units to apply for free charging stations. The owners then only bear the cost of the station's installation.[29]

The City of San Francisco used state grant money to install charging stations at 36 multi-family units in the City. The grant paid for the chargers (from Chargepoint) and the installation.[30]

NRG Energy, Inc., a major utility, has developed eVgo as an EV charging subsidiary. They have developed a private sector model in which they provide stations at multi-family units. NRG eVgoworks with property owners and managers to determine potential sites for charging and gets an estimate from an electrician about the costs to install a charging station. The property

[29] Chargepoint. 2013. New Program Will Offer Free Electric Car Charging Stations for San Diego Residents Living in Apartments and Condos. http://www.chargepoint.com/press-releases/2013/1017.
[30] San Francisco Apartment Association. 2013. Supercharged Amenities. http://www.sfaa.org/may2013/1305_landes.shtml.

owners/managers and NRG then promote the site as "Ready for EV" to help attract residents interested in charging. Once a resident requests the installation of a charging station, the installation process begins immediately based on the pre-determined plans. Stations are only set up when residents request them, so there is no concern about over- or under-supply of charging stations. If the resident moves elsewhere, NRG eVgo removes the charging station from the property.[31]

Another innovative model comes from Powertree Services, which is working with multi-family properties to develop integrated solar PV, energy storage and EV charging systems. Powertree covers all installation and operations costs for the system; no capital costs are incurred by the property owner. EV owners pay a flat monthly rate for unlimited charging. There is a ten year minimum agreement.[32]

It may be possible for the City of Boulder to partner with Chargepoint , NRG eVgo or another EVSE provider to set up a similar program. The City could provide some grant money to multi-family properties and Chargepoint could perhaps "donate" the stations in order to receive more customers, which could help bring down the cost of installation for property owners. The grant wouldn't need to cover all the costs of installation, but would need to be sufficient (several thousand dollars perhaps) to make them more attractive. The City could also reach out to NRG eVgo and Powertree Services to see if they would be interested in working with the City to expand their private sector initiatives in Boulder.

[31] NRG. 2014. Host NRG eVgo Stations at a Multi-Family Community or Condo. http://www.nrgevgo.com/own-or-manage-multi-family-communities/.
[32] San Francisco Apartment Association. 2013. Supercharged Amenities.

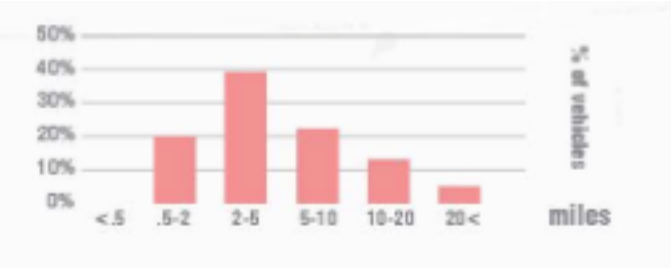
VII. PUBLIC TRANSIT, BIKESHARE AND CARSHARE

EV Charging at Transit Stations

There are two different potential roles for EVSE at transit stations and park-n-rides. The first is EV charging for drivers who drive an EV to a park-n-ride, then take a bus to their destination. The second is any potential role for EVs or e-bikes as part of a last mile solution for people taking transit to a park-n-ride.

There are six park-n-rides in Boulder, with a total of 1,543 spaces. The average occupancy is 66 percent. The largest location is the Table Mesa Park-n-Ride, which has 824 spaces and is typically about 60% full. RTD surveys license plates to determine how far people are driving to these sites. For Table Mesa, the distribution is shown below:

Figure 16 | Driving Distances for Cars Parked at Table Mesa Park-n-Ride[33]



RTD does not have good data on the dwell time. However, it is a reasonable assumption that many users are commuting to work, so that a significant number of the spaces used are used for multiple hours.

There are two groups of EV users who could be best served by EV charging at a park-n-ride. One group is EV owners who live in multifamily housing with limited or no access to home charging. The other group is those who live further away. For Table Mesa, about 12 percent of users live 10-20 miles away, and about five percent live over 20 miles away. If we aimed for making charging available for two to four percent of these customers, the total number of spaces with chargers would be 0.3-0.6 percent. With about 500 vehicles parked there on a typical day, this amounts to one to three spaces.

RTD does allow users to pay to reserve spaces. If the reserved space is not occupied by 10:00 AM, it becomes available for other drivers.

[33] US 36 Commuting Solutions First and Final Mile Study, conducted by Fehr and Peers. 2013. http://36commutingsolutions.org/36cs/wp-content/uploads/US36FFM_Final.pdf.

Other large park-n-rides along the US 36 corridor include McCaslin with 466 spaces, Broomfield with 940 spaces, and Westminster with 1,310 spaces.

We recommend a pilot project to provide three EV charging spaces at the Table Mesa Park-n-Ride and two spaces at the US 36 & McCaslin Park-n-Ride. We recommend that these spaces be eligible for reservation, so that they can be relied on by regular commuters who purchase an EV, and also that the chargers should be networked with online information on availability. RTD currently has no plans to install EV charging at these locations, so this would require the local governments to initiate a partnership effort with RTD. Given the planned launch of US 36 Bus Rapid Transit (BRT) service in first quarter of 2016, we would encourage that this happen over the next year, so that the availability of EV charging could be built into the opening day branding and marketing of the service.

There are a number of smaller park-n-rides within Boulder, but these have a smaller number of vehicles coming from far away and may be less well suited for EV charging. The other park-n-rides in the county (such as those located along US 287 and in Niwot, Longmont and Lafayette) are also quite small and likely not the best choices for an initial pilot. However, we recommend that EV charging be considered as a potential element along the Diagonal Highway as the SH 119 BRT environmental assessment effort moves forward.

E-bike Parking

Electric-assist bicycles, or e-bikes, are pedal bicycles with an electric motor that can assist with climbing hills or can be used to increase speed. They remove a number of potential barriers to the use of bicycles by non-cyclists, including concerns about getting sweaty going up hills and concerns about the impact of cycling on the knees. By speeding up cycling, they also potentially extend the range of bicycle trips.

E-bike parking in downtown Portland, Oregon

Because the batteries are so much smaller than for electric cars, e-bikes can easily be charged with regular 110 volt outlets. Thus, it is very straightforward and cheap to install e-bike charging in locations where there is electricity. We would recommend adding e-bike charging to transit stations, to park-n-rides where electricity is available, and at the Bike-then-Bus shelters being installed at selected transit stops in Boulder County and along the US 36 corridor.

Bikeshare

The use of e-bikes as a first- and final-mile solution is another interesting potential connection to the transit system. E-bikes lower the barrier to bicycle use by non-cyclists. A number of cities in Europe, including Madrid and Copenhagen, have begun to incorporate e-bikes in their bikeshare programs. In the United States, City CarShare in San Francisco began a pilot with a small number of electric bicycles. The University of Tennessee launched cycleUshare, a pilot e-bike sharing program in 2013.

There is limited experience with these systems, but they are a promising idea. We recommend that a pilot e-bike share program be considered. The CU-Boulder campus could be a good pilot location, given its location on a hill above downtown, the grade differences with east campus, and the challenges with connectivity between the main and east campus.

Carshare

EVs can be a good fit for carshare. Since carshare members have the ability to choose vehicles the meet the particular needs for an individual trip, the issues that may deter purchasers – such as range anxiety or the occasional need for a larger vehicle than most EVs on the market – do not come into play in the same way. In addition, since research shows that once someone drives an EV they are much more likely to buy one in the future, carshare may increase EV market penetration by giving many people exposure to EVs.

There is limited data on the actual impacts of EV carsharing. Susan Shaheen, at UC Berkeley, has launched a study that is starting to gather data on the use of EVs in carshare programs, but no results are available yet.

Karen Worminghaus, executive director of eGo CarShare, stated in an interview that the major limitation on eGo CarShare's ability to expand their fleet of EVs is the availability of dedicated parking. They currently have one dedicated space at Alfalfa's and one near the Teahouse. Given their users, they believe that they could place EVs at CU, in Boulder Junction, in south Boulder, and more in the downtown, if charging were available.

Table 11 | User Statistics for eGo CarShare

Vehicle	Date range	Total # Unique Users	Total # Trips
Nissan Leaf	8/2012 – 1/2015 (42 months)	263	1100
Chevy Volt	7/2014 – 1/2015 (6 months)	87	250

There is another model of carshare program, known as one-way carshare, in which the user does not need to return the vehicle to a specific location. Instead, the user simply parks it anywhere within a defined service area. Other users then use their smartphones to find the vehicle. This is the model used by Car2Go, which has a large presence in Denver and is interested in entering the Boulder market. Car2Go has developed large-scale EV fleets in San Diego and Amsterdam.

Recommendations

1. ***We recommend repurposing underutilized public charging stations to EV carshare vehicles.*** In locations where two chargers sit side by side, one could be dedicated to carshare, while one would be available to the public.

   Potential locations include:
   - Wolf Law School (CU);
   - Broadway/Spruce (City); and
   - North and South Boulder Recreation Centers (City).

   In addition to making use of an existing underutilized asset and promoting electric carsharing, this approach also will help avoid negative public perceptions associated with visibly empty spaces.

   In addition, the Boulder County Courthouse has four parking spaces which had conduit installed for a PHEV pilot several years ago. While the original charging outlets have been removed, the conduit is still present. One of these spaces could be repurposed for an electric carshare vehicle.

   The agreements could be for a limited period of time, to allow for repurposing to open public charging in the future as demand grows.

2. ***We recommended in the previous section on building codes and planning requirements that the City consider adding support for EVs into the discretionary review process.*** In particular, we suggest incentivizing the provision of EV carsharing as an element of "TDM with teeth."

Conduit in the parking lot at the Boulder County Courthouse

VIII. OUTREACH AND EDUCATION

Opportunities and potential objectives for EV outreach and education include:

- enhancing public understanding of EVs;
- helping drivers understand how EVs may be able to meet their needs; and
- educating policy-makers on the role that EVs can play as an important part of making our transportation system more sustainable.

There are a number of steps that the City and the County can take toward meeting these objectives.

We acknowledge that there is a delicate balance here, given the current emphasis on VMT reduction to meet City, County and University goals. Some constituent groups are concerned that public efforts to promote EVs may detract from the focus on reducing VMT, and could be confusing to the public. It is very important to develop a consistent message that VMT reduction strategies are complementary to efforts to electrify the transportation system.

One opportunity to ensure this consistency in messaging is to leverage existing outreach programs that communicate about other aspects of transportation. In particular, we would recommend developing consistent EV messaging and incorporating it into the work of the employee transportation coordinator network, GO Boulder, Boulder Transportation Connections, 36 Commuting Solutions, CU Parking and Transportation Services, and the CU Environmental Center.

We also recommend incorporating EVs into the business and residential EnergySmart program – including the free phone advising, home energy assessments, and business advising, as well as follow-up on grants and tax credits. This is also an ideal place to communicate the benefits of combining EVs with solar PV. In addition, we recommend experimenting with small rebates for EV charging as part of the package of EnergySmart rebates.

Another area to consider is outreach to automobile dealers. Studies by the University of California – Davis and by Consumer Reports have shown that some auto dealers are inept at or actively hostile to selling EVs.[34, 35] This is certainly not universal – for example, the Boulder Nissan dealership is one of the top locations in the nation for Nissan Leaf sales – but efforts aimed at encouraging dealerships to actively market EVs could be a very effective tool. There is not much experience to draw upon directly, but there may be lessons that can be learned from past experience with energy efficiency programs.

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[34] Cahill. E. 2014. Selling Plug-in Vehicles: Lessons from the California Market. http://phev.ucdavis.edu/project/dealer-study/.

[35] Consumer Reports. 2014. Dealers not always plugged in about electric cars, Consumer Reports' study reveals. http://www.consumerreports.org/cro/news/2014/04/dealers-not-always-plugged-in-about-electric-cars-secret-shopper-study-reveals/index.htm.

For example, so-called "midstream incentives" are often used in programs encouraging the adoption of energy efficient consumer electronics.[36] The concept is that, given the relatively small profit margin on many products, a fairly small incentive to the retailer may provide a significant motivation for sales. A similar logic holds for car sales, where the salesperson at a dealership may make only a few hundred dollars per sale. Thus, a midstream incentive of a few hundred dollars could have a major impact on the dealers, while a few hundred additional dollars on top of the existing federal and state tax credits might have little impact on the end buyers.

Politically, it is challenging to use tax revenues for this purpose. Many midstream incentive programs are funded through utility demand-side management programs.

We would propose a pilot program, potentially in partnership with the RAQC, to test the impact of dealer incentives along with a public recognition program for dealers who do an excellent job selling EVs.

Another idea to consider is the creation of a very visible location which combines EV charging with educational outreach. This could, for example, be considered as an element of the Boulder Civic Area plan. The City of Portland, Oregon has developed an area known as "Electric Avenue" which combines public EV charging, parking for EV carshare vehicles, e-bike parking, DC fast charging and educational displays.

Scenes from Electric Avenue in Portland, Oregon

[36] US Environmental Protection Agency. 2013. How to Use Midstream Incentives to Promote ENERGY STAR CERTIFIED Consumer Electronics. http://www.energystar.gov/ia/partners/downloads/CE_Guide.pdf.

APPENDIX 1: POLICY OPTIONS FOR EXPANDING THE USE OF ELECTRIC AND EFFICIENT VEHICLES

Achieving deep reductions in greenhouse gas (GHG) emissions will require efforts in three areas:

1. demand reduction strategies to reduce VMT;
2. significant improvements to fuel economy; and
3. a move towards much lower carbon fuels.

This section will focus on the latter two strategies.

As discussed in the accompanying analysis, the light duty fuel economy standards that have been adopted by the federal government will be a significant driver towards greater fuel economy, and to a lesser extent towards vehicle electrification. We will explore additional strategies that could be employed at a local level, focusing on efficiency and on electrification.

There are other potentially effective approaches. For example, it is possible that truly low carbon biofuels will be developed and available at scale. This could make biofuels a very important tool, especially in the heavy duty vehicle sector where electrification is more challenging. It is also possible that fuel cell technologies will become affordable and practical on a large scale, and that low carbon sources of hydrogen will become available, making hydrogen an important fuel. However, both of these are speculative enough that we do not further discuss them at this point.

One challenge for any local effort aimed at increasing the efficiency of the vehicle fleet is federal pre-emption: the Energy Policy and Efficiency Act and the Clean Air Act prevent state or local governments from setting fuel efficiency standards and GHG emission standards different than those set by the federal government. The one exception is the State of California, which does have the ability to set standards that go beyond the federal standard. Other states may not independently set standards, but do have the authority to adopt the California standards. The City of Boulder can use financial incentives, social marketing, business partnerships and infrastructure investments to try to shift the vehicle fleet, but the City may not directly regulate efficiency or emissions standards. This is quite different than other sectors, such as buildings, where the City has more direct regulatory authority.

As the accompanying emissions analysis demonstrates, vehicle electrification combined with cleaner generation will provide the greatest emissions reductions over the long term. In the short to medium term, very high efficiency hybrid vehicles provide the greatest emissions reductions, unless the EVs are powered by renewables rather than by the existing grid mix. Thus, in this section we will discuss both strategies that are focused on EVs and strategies that are focused on more efficient hybrid vehicles.

Consumer surveys show that the top two concerns of prospective EV buyers are the vehicle's price and its driving range.[37] Therefore, policies that directly address these two concerns are most likely to have an impact on purchasing decisions. Other concerns expressed by consumers such as maintenance costs, performance and reliability indicate that education can still play an important role in promoting EVs because these concerns are not well founded.

In this section, we discuss a number of potential strategies that the City can use to encourage more widespread adoption of lower emission vehicles. Some are relatively simple to implement; others could involve significant costs or political challenges, and one case may require state legislation to expand local authority.

We group these into financing incentives, public vehicle fleets, social mobilization and education, building codes and parking, support for vehicle charging, and potential utility roles.

Table 12 | Summary of Policy Options

Policy	Time Frame*	Difficulty**	Potential GHG Impact
Financial Incentives			
Feebate	Short - Medium	High (may require state approval, administratively challenging)	High
Rebate for EVs	Short	Medium (needs funding)	Medium
Financing to convert tax credit to rebates	Short	Medium	Medium
Incentives for Public Charging	Short	Medium (needs funding)	Medium
Public Fleets			
Performance Contracting	Short	Low	Low (due to small size of fleets, but shows public sector leadership)
Transit Electrification Pilot	Short	Medium	Low (but paves way for future larger scale)
Maximize use of CMAQ rebates for transit electrification	Short	Medium	Medium

[37] Harris. 2013. Speed Bumps Remain for Electric Cars; Incentives Could Recharge Interest. http://www.harrisinteractive.com/NewsRoom/HarrisPolls/tabid/447/ctl/ReadCustom%20Default/mid/1508/ArticleId/1216/Default.aspx.

Table 12 (continued)

Policy	Time Frame*	Difficulty**	Potential GHG Impact
Building Codes/Parking			
Building Codes	Long (may not take a long time to adopt, but results are not quick)	Low – Medium (depending on how aggressive with existing stock)	Low
Charging Requirement for Existing Buildings	Short – Medium	Medium (could be significant resistance from building owners)	Medium
Workplace Charging	Short	Low	Low – Medium
Social Mobilization			
Targeted Efforts with Employers	Short	Low	Low
Broadening Energy Smart	Short	Low	Low
Support for Bulk Purchases	Short	Medium	Medium
Targeting Larger Vehicles	Short	Low	Medium
EV/PV promotion Pilot	Short	Low	Low (but could pave way for larger scale EV/PV programs that would have larger impact)
Utility Strategies			
Utility rebates for EVs, charging	Medium	Medium	Medium
EV rates or appropriate time of use rates for EV charging	Medium	Medium	Low (but could be important to managing load at high EV penetration)
Battery buyback by utility, or battery ownership by utility, leased to customers	Medium – Long	Medium – High	Medium – High

*Time Frame: Length of time it would take for policy to be implemented and begin providing results. Short term: 1-3 years; Medium 3-10 years; Long term: 10+ years.

**Difficulty: This is based on both the difficulty of getting the policy adopted and the administrative challenges.

Strategies Involving Financial Incentives

The first three strategies listed in Table 12 involve different variations on offering rebates for highly efficient vehicles. The programs range from simple time-of-purchase rebates (which are relatively easy to implement, but require a funding source) to more complicated feebates and vehicle trade-in programs (which can be set up to be self-funding and are expected to have greater climate benefits, but are more complicated to administer).

Feebate for Electric and Highly Efficient Vehicles

The use of "feebates" to incentivize the purchase of high efficiency vehicles has been implemented in Denmark, France, the Netherlands and Norway. 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 implement such a program at the local level. This might require legislation allowing a febate program to be implemented at the city or county level.

Under this approach, the City or the County would assess a fee on new vehicles that achieve less than average fuel efficiency, and use that revenue stream 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, less 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 as they increase the overall demand for motor fuels and the resulting emissions, drive the price of fuels higher, and reduce our energy security.

Under this approach, fees would be assessed to approximately half of the vehicles sold – those with below average fuel economy. For Boulder, this would be approximately 1,750 vehicles per year, and the revenue would go to support the purchase of approximately 1,750 more efficient vehicles. The fees would be assessed on a sliding scale, with the size of the fee increasing as the vehicle efficiency gets worse. Likewise, rebates would be awarded on a sliding scale, with the largest rebates available for the purchase of EVs.

In its simplest version the feebate would be set as:

> *Fee (rebate) = Rate x (emission rate-benchmark), where the benchmark is set at the average carbon emissions per mile of new vehicles.*[38]

[38] Bunch, D. and Green, D. 2012. Potential Design, Implementation, and Benefits of a Feebate Program for New Passenger Vehicles in California, University of California, Davis, Institute of Transportation Studies. http://www.tsrc.berkeley.edu/node/488.

Following is an example of how this could work:

> *For 2015, the average combined fuel efficiency under the CAFE standards will be 32.7 mpg. This corresponds to tailpipe emissions of 271 gms CO_2/mile.*
>
> *Based on the European examples, a typical rate might be $20/(gm/mile).*
>
> *A zero emission vehicle would be eligible for a rebate of $20*271 = $5400.*
>
> *A Toyota Prius getting 50 mpg, with emissions of 178 g/mile, would be eligible for a rebate of $20 x(271-178)= $1881*
>
> *By contrast, a Subaru Outback M6 getting 24 mpg and emitting 370 gms/mile would pay a fee of $20* (370-271)= $1970*

There are many ways such a program could be structured. There could be separate programs for different categories or footprints of vehicles; for example, small cars would be compared to small cars, and light trucks to light trucks.

The level of emissions reduction depends on program design. Studies of potential programs in California and Connecticut have estimated potential reduction in the emissions from an average new car ranging from a low of 18 grams/mile up to a high of 90 grams/mile (about one third of new car emissions standards).[39, 40]

Cost: the only cost would be the administrative costs, as the ongoing rebates would be funded by the fees.

Impact: Consider, for example, a VMT level of 2.4 million daily VMT. Each year the feebate program will reduce the carbon intensity of the new vehicles added to the fleet. By 2025, after 10 years, 35,000 vehicles, or approximately half the fleet, would be impacted. Since the program is targeted at vehicles registered in Boulder, only resident and student GHG would be impacted.

However, it is also important to realize that the impact of vehicle strategies on total GHG emissions will be greater than shown here, since these numbers do not capture reduced emissions on longer trips outside of the Boulder area.

By 2050, the impact would grow, as the entire resident fleet would be impacted.

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[39] Ibid.
[40] State of Connecticut, Department of Environmentla Proection. 2006. Connecticut Clean Car Inncetive Program. http://www.ct.gov/deep/lib/deep/air/climatechange/ctcleancarincentive.pdf.

Table 13| Greenhouse Gas Emissions Impact of Different Feebate Programs

Year	Reduction at -18 grams/mile		Reduction at -90 grams/mile	
	Metric tons	Percentage	Metric tons	Percentage
2025	5,000	1.4%	25,000	7%
2050	10,000	2.8%	50,000	14%

Challenges: While there is no federal pre-emption, legal analysis would be required of the ability of a home rule municipality to implement such a program under Colorado law. Unlike many of the other strategies, which would likely have support from the auto industry, this strategy would likely be opposed by this industry. Administratively, it would be very difficult for the City to administer, since motor vehicle registration is managed at the county level, so in practice such a program would likely need to be implemented at a county level. This would require legislative authorization.

Vehicle Trade-In Program Plus Feebate: "Cash for Clunkers"

Some type of vehicle trade-in or "Cash for Clunkers" program could be considered. This could work for both light and heavy duty vehicles and would bring more climate benefits than Prius owners switching to EVs, by focusing on replacing less fuel efficient vehicles in the fleet.

A Cash for Clunkers program would operate similarly to the feebate program except that to qualify for the rebate one would have to trade in a relatively inefficient vehicle, perhaps one in the bottom 10 percent of efficiency, to receive a rebate on a new highly efficient vehicle. Because it ensures that the vehicles receiving a rebate are replacing low efficiency vehicles, there is a clearer climate benefit. For example, with the rebate and feebate programs it is possible for a current Prius owner to use the rebate to purchase a new Prius, which would have no net climate benefit.

This would entail some additional administrative challenges as far as certifying the trade-ins and disposal of the clunkers, but the primary challenges would be the same as for the feebate option.

Rebates for Purchase of EVs

Currently, there is a significant upfront cost premium for purchasing an EV, driven primarily by the cost of the batteries. While the lifecycle cost may be lower than a conventional vehicle, due to reduced fueling and maintenance costs, the upfront cost is a significant barrier to EV adoption. Over the longer term, this price premium is expected to come down as the cost of batteries declines.

In order to help address this issue in the near term, both the state and federal governments offer significant tax credits for EVs. The federal credit is currently $7,500, and the state credit is up to $6,000. The City could also offer a local incentive in the form of a rebate at time of purchase. Time-of-purchase rebates have a greater impact than a tax credit for the same level of incentive, so a

rebate of $1,000 to $2,000 might be expected to have an impact on adoption rates, even though this is substantially smaller than the combined state and federal credits.

There are approximately 3,500 new vehicles purchased in Boulder each year. Boulder vehicles are fairly evenly split between passenger cars and light trucks. In the near future, EVs are likely a real option primarily for the passenger cars. In the decade since hybrid vehicles have been introduced, market share has grown to about five percent of the current vehicle fleet, with 1.3 percent of the fleet comprised of Toyota Priuses. Nationally, EV sales are growing faster now than hybrid vehicle sales grew soon after hybrids were introduced, so it may not be unreasonable to expect a baseline of five percent EVs in Boulder by 2025, or about 3,400 vehicles. This would require that about 340 EVs a year be purchased in the City, or just under 10 percent of new vehicle purchases over the next decade.

If Boulder offered a $2,000 rebate for EVs, it might be possible to push this to a higher share of new vehicle sales.

Table 14 | Impact of Different Levels of EV Adoption Due to Rebate

Passenger car adoption rate	Vehicles/year	Annual Cost	Total Number of EVs in 2025
5%	175	$350,000	1,750
15%	263	$525,000	2,630
25%	620	$1,200,000	6,200
50%	1,750	$3,500,000	17,500

Note that these are very aggressive scenarios. The Energy Information Administration's 2014 Annual Energy Outlook projects total sales of battery EVs and plug in hybrids combined at only one percent of new vehicles sold in 2025.[41] The most aggressive national forecast projects 2025 EV sales at approximately 10 percent of new light duty vehicle sales, the equivalent of approximately 20 percent of passenger cars.[42] Currently the highest adoption rate in the country is in the state of Washington, where 1.6 percent of new vehicles sold in 2013 were EVs. Colorado is among the top ten states, with EVs accounting for 0.4 percent of new vehicles sold in 2013. California is aiming to reach 15% of new vehicle sales by 2025.

[41] Energy Information Administration. 2014. Annual Energy Outlook 2014. Light Duty Vehicle Sales by Technology Type: Mountain Region. http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2014&subject=0-AEO2014&table=48-AEO2014&region=1-8&cases=ref2014-d102413a.

[42] Edison Electric Institute. 2013. Forecast of On-Road Electric Transportation In The United States, 2010-2035. http://www.edisonfoundation.net/iei/Documents/IEE_OnRoadElectricTransportationForecast_0413_FINAL.pdf.

Such rebates could also be used to incentivize the purchase of extremely fuel efficient conventional vehicles.

This would be a relatively straightforward program; there are no legal challenges, and the number of transactions is small enough that the administrative burden should be manageable. However, it would require a significant ongoing funding mechanism, and could raise equity concerns that these rebates might be going largely to wealthier households that are more likely to buy new cars.

Financing Program to Convert Tax Credits to Time-of-Purchase Incentive

The current tax credits for EVs are significant – up to $13,500. However, the impact of tax credits is much less than the impact of point-of-sale incentives. One approach is to create an upfront rebate, but tie it to recapture of the same amount from the tax credits – essentially to finance the tax credits.

For customers who are leasing, the dealer is generally able to take the $7,500 federal credit, and apply this upfront to lower the cost of the lease. This is not possible given the current structure of the state tax credit.

It is theoretically possible to create a rebate program with the cost, or a portion of the cost, paid for by capturing a portion of the tax credits received by the customers. There are clearly significant administrative challenges, and some level of financial exposure, but this potentially a less expensive way to create an upfront rebate incentive.

A variant to this would be to amend the state statute to allow dealers to take the credit in the case of leasing, and pass the savings on to the lessees. This would allow the private sector to use the tax credits to lower the upfront cost, at least for those consumers who choose to lease.

Public Vehicle Fleets

While most of the vehicles in Boulder are privately owned, public sector leadership can be very important in developing broader public awareness and support. In addition, because some of the public sector vehicles are larger vehicles that are driven many miles (transit vehicles, for example) the emissions impact can be significant.

Use of Performance Contracting

Last year, legislation passed in Colorado to expand the allowable uses of performance contracting by government agencies to include financing efficient vehicles, with the upfront costs paid back through fuel savings, in much the same way that upfront costs of building energy improvements are

financed through performance contracting. The City of Boulder is working with McKinstry to acquire 30-35 EVs in what we believe will be the first such contract in the state. This could provide a model for large-scale fleet replacement by other large public agencies (Boulder County, BVSD, the University and the national labs) as well as other private institutions that are large enough for performance contracting to work. Historically, the Colorado Energy Office (CEO) has actively supported performance contracting; there could be an opportunity for the city to partner with CEO to actively promote its use for vehicles.

In addition to passenger vehicles, performance contracting could be used for medium and heavy duty vehicles as more options become available in these sectors. To give a sense of the scale, the BVSD has approximately 250 buses and 150 light duty vehicles; Boulder County has approximately 60 heavy duty and 440 light duty vehicles. Among all of the fleets, the total might be on the order of 1,000 light duty vehicles, and several hundred buses and trucks.

Transit Electrification

This strategy would require working with the major providers of transit service: the BVSD, RTD, and Via. Currently, the vast majority of these buses are diesel vehicles. A number of manufacturers, including ProTerra and BYD, are now making electric buses for transit agencies, and one company (9transTeach) is manufacturing electric school buses. In the United States, the use of electric buses is largely in a pilot phase, with only a handful of transit agencies (in locations including Los Angeles, New York and Nashville) trying out small numbers. However, in China the market has expanded to thousands of electric buses.

A program in Boulder would likely need to begin as a pilot effort, in collaboration with one of the transit agencies, to try a small number of electric buses and address operational issues, including how recharging would take place. This would also allow cost data to be collected. (Electric bus manufacturers have argued that the higher upfront costs of the vehicles will be outweighed by much lower fuel and maintenance costs, but local experience will likely be required for transit operators to take this seriously.) Given the smaller scale, and its pre-existing relationship with the City, Via might be the most likely candidate for a pilot project.

There is a window of opportunity over the next four years. The CEO and the RAQC will be administering a $15 million fund for replacing trucks and buses in the metro area with alternative fuel vehicles, including both electric and compressed natural gas (CNG) vehicles. With many other rebate programs (such as the Xcel DSM and Solar Rewards programs), Boulder has had a much higher uptake rate than the statewide average. The City could have a focused campaign to maximize the use of these truck and bus funds, in order to kick start a pilot project or larger scale electrification.

Support for EV Charging

Lack of access to charging infrastructure is another significant barrier to more widespread adoption of EVs. Most daily travel is well within the range of a typical EV, but it is important for vehicle purchasers to be comfortable that they can make longer trips. Evidence to date suggests that most charging will take place at home, with workplace charging the next largest slice of the pie. In addition, it may be important to have fast charging stations available at destinations outside of Boulder that are important to Boulder residents.

In addition, if the city is successful at achieving high levels of market penetration, the nature of workplace and public charging needs will change. For example, there may be many employees who commute and park all day in a single private parking lot or municipal parking structure. Meeting this demand may require large banks of charging outlets. In order for this to be practical, future charging needs may require larger numbers of Level 1 chargers, which are significantly less expensive to install than the faster-charging Level 2 units.

There are a number of potential actions Boulder could take to enhance the charging network.

Building Codes

A number of jurisdictions have begun to adopt building codes that mandate either pre-wiring for EV charging or that a certain number of spaces in new parking facilities are wired for charging. Adopting building codes that include language supporting the provision of charging in new commercial and residential structures is important to enabling a charging network. Establishing capacity for charging during construction (or during planned renovation) costs significantly less than retrofitting, as retrofitting often requires retrenching, rewiring or upgrades to electric panels. For commercial installations, retrofitting can cost an additional $1,100 per station for surface lots and $800 for parking garages.[43] For residential single-family homes, the Vancouver Electric Vehicle Association estimates that, on average, the cost of retrofitting for Level 2 charging is at least $900 more than preparing that home during new construction.[44]

Building codes can utilize three primary mechanisms to promote EV charging installation:

1. require that all buildings install the electrical capacity for a certain level of charging;
2. require a minimum number of EVSEs per parking space; and
3. require that all businesses of a certain size provide EVSE.

[43] MITRE. 2011. Electric Vehicle Charging Infrastructure Recommendations to Fairfax County. http://www.edisonfoundation.net/iei/Documents/IEE_OnRoadElectricTransportationForecast_0413_FINAL.pdf.

[44] Vancouver Electric Vehicle Association. 2013. EV Infrastructure Costing Worksheet. http://www.veva.bc.ca/home/index.php.

Several local governments throughout the US and Canada have already enacted these regulations, as shown below.

Table 15 | Building Code Regulations Currently Enacted by Local Governments

Local Jurisdiction	Single Family Residential	Multi-Family Residential	Commercial
Boulder County, Colorado[45]	240 volt outlet or upgraded wiring or conduit for future installation		
City of Vancouver, British Columbia[46]	Conduit for future dedicated outlet for EV charging in the parking area	Conduit for EV charging in the parking area; 20% of parking spaces accommodate EVSE	
City of Los Angeles, California[47]	240 volt outlet or sufficient panel capacity and conduit for future installation	240 volt outlet or sufficient panel capacity and conduit for 5% of parking spaces	Enough 240 volt outlets for 5% of total parking spaces
State of California[48]	Conduit from service panel to the parking area.	3% of all parking spaces would have the capacity to support future charging	Capacity and conduit for 1-4 future chargers, depending on the number of spaces
State of Hawaii[49]			Places with at least 100 parking spaces will have one charging location near the building entrance

Requirements for existing buildings

Boulder has adopted requirements for energy upgrades for existing residential rental property (SmartRegs). The City could consider adding an EV charging requirement for existing multifamily residential, and could consider EV charging requirements in a future commercial energy

[45] Boulder County. 2012. Boulder County Building Code Amendments. htttp://www.bouldercounty.org/property/build/pages/buildingamends.aspx.
[46] City of Vancouver. 2015. Greenest City 2020: A Bright Green Future. http://vancouver.ca/sustainability/EVcharging.htm.
[47] The City of Los Angeles. 2011. Sections 99.04.106.6 and 99.05.106.5.3.1 http://ladbs.org/LADBSWeb/LADBS_Forms/PlanCheck/2011LAAmendmentforGreenBuildingCode.pdf.
[48] California Building Standards Commission. 2013. California Green Building Standards Code. Sections: A4.106.8, A4106.8.1, A4.106.8.2, A5.106.5.3 and A5.106.5.3.1. http://www.ecodes.biz/ecodes_support/Free_Resources/2013California/13Green/13Green_main.html.
[49] State of Hawaii. 2012. S.B. 2747. http://www.capitol.hawaii.gov/session2012/Bills/SB2747_.htm.

conservation ordinance. Because most of the projected 2050 building stock in Boulder has already been built, regulatory requirements for existing parking areas may be an important strategy.

Financial Incentives for Installing Charging

The City could also provide financial incentives for installation of EV charging infrastructure. For example, NV Energy, for example, provides incentives to businesses equivalent to 50 percent of the cost of installing charging stations. An order of magnitude estimate might be $10,000 per site for purchase and installation of a Level 2 charging station, so a 50 percent incentive would be approximately $5,000 per station.

Workplace Charging

The greatest need beyond residential charging is likely for workplace charging. Workplace charging not only makes it easier for commuters to use EVs, but also serves as an important marketing tool, making EVs visible to other employees. This can lead to additional demand and the need for a bank of EV charging locations. Because many employees will park for many hours at a time, multiple inexpensive Level 1 chargers could be appropriate at worksites and in publically owned parking lots or parking structures used by regular commuters. The City could provide matching funds to encourage installation of workplace charging, and could tie this to a phased-in regulatory requirement, perhaps requiring that chargers be installed when parking areas are resurfaced.

The City could also consider a workplace charging challenge, in which businesses receive recognition for efforts to expand charging for their employees. This could be a standalone program or incorporated into existing programs such as the Partners for a Clean Environment (PACE) program administered by Boulder County Public Health.

Partnership Effort to Install Chargers at Key Destinations Outside the City

While many EVs are likely to replace second cars in two-car households, thus allowing the other vehicle to be used for longer trips, high levels of EV penetration will require people to be confident that they can use the EV for longer distance trips outside the city. The use of PHEVs can certainly help to address this concern, allowing most urban trips to be driven on electricity while using gasoline for longer trips. In addition, decreasing costs and increasing energy density in batteries may also help address this concern. But another important strategy may be to place chargers at destinations that are important to Boulder residents. We would need to do additional analysis to understand more about out-of-city destinations for Boulder drivers. However, given the strong outdoor recreation culture in Boulder, we would anticipate that recreational destinations such as the Eldora Ski Area and major trailheads in the Indian Peaks and Rocky Mountain National Park might be appropriate locations. The City could either directly invest funds, or could serve in a role

that helped to organize projects and seek funding from sources such as the EV Infrastructure Fund administered by the CEO.

Social Mobilization Approaches

The city could create a focused effort to promote the adoption of both EVs and more efficient gasoline or diesel vehicles. There are a number of programs that the City, the County and other local partners have developed to impact public behavior in related areas, including GO Boulder's programs to promote alternative modes of transportation, the EnergySmart program's effort to get residences and businesses to make home energy upgrades, PACE program that works to promote environmentally responsible practices in local businesses. These programs have combined financial incentives, infrastructure improvements and thoughtful community based social marketing efforts. In another example, the Electrification Coalition has taken a social mobilization approach in the communities that they have identified, such as Fort Collins and Loveland. Creating a social mobilization effort around EVs in Boulder would require funding for dedicated staff or a community partner, and could require integrating elements around efficient vehicles into existing workplans.

We strongly recommend that vehicle efficiency and EVs be incorporated into the mission, programs, and messaging of these existing programs.

Potential program elements include:

- **Targeted efforts with large employers, including events with EV drive-along opportunities**
  Evidence suggests that anyone who actually rides in an electric car is far more likely to buy one than someone who has not been in an EV. The City could work with employers to organize opportunities for their employees to try out EVs; this could be linked to efforts to promote workplace charging. The existing network of Employee Transportation Coordinators could be used to work with businesses to promote efficient and electric vehicles in addition to the current work focused on commute mode choice.

- **Broadening EnergySmart**
  Energy advisors who are working with residents on home energy improvements could also provide advice on efficient vehicles. This could be particularly effective if there are even small rebates or financing available that the advisors can connect customers to.

- **Support for bulk purchase of EVs, EV charging, or EV and PV together**
  As the Solarize program in Portland has demonstrated, there can be significant uptake if there is a focused effort among a particular group (it could be a neighborhood or an

employer) to promote a clean technology, along with a time limited opportunity to buy at a preferential rate.

This approach could be used to promote the purchase of EVs, combined with installation of home chargers. It could also be combined with bulk purchase of solar PV in order to incentivize people to move towards transportation with close to zero net emissions.

This could be piloted among City employees, as a relatively manageable size for an initial effort. This could be an opportunity to develop partnerships with private sector entities that the City has not previously had a close relationship with, such as auto dealers or car manufacturers. This could be an opportunity to pilot the use of rebates paid back by tax credits on a small scale. If successful, such a program could potentially be expanded to other large employers in the city.

Targeting Users of Larger Vehicles

The analysis of the Boulder fleet showed that Boulder has a higher percentage of light trucks than the national average. This may reflect the wealthier population or the strong emphasis on outdoor recreation. At this point, the EVs that are available are really replacements for smaller passenger vehicles. One effort could focus on encouraging Boulder residents to consider the most fuel efficient larger vehicles that are available.

For example, the Prius V actually has as much cargo capacity as a small SUV, although it is not clear that this is widely known. For many applications that are currently served by minivans and small SUVs, a Prius V could provide the same service at 40 mpg, as compared to the current average new light truck at 22 mpg.

Utility Role

There could be a major role for the electric utility to play in the expansion of use of EVs, whether the service is provided by Xcel Energy or a new municipal utility. A municipal utility may be more flexible to experiment and develop innovative programs such as the battery storage ideas listed below.

From a financial perspective, there is an economic benefit to utilities associated with EVs. Because EVs increase consumption of electricity, and most of the new demand comes during off-peak hours when power is cheap, greater sales are available to cover the fixed costs of the system. It should be possible to capture at least some of this value for investment into expanding the number of EVs. This is the logic, for example, that led NV Energy to offer rebates covering half the costs of installing commercial charging infrastructure.

Potential utility roles in the short term could include offering rebates for purchase of EVs or installation of chargers, and structuring time-of-use rates to incentivize EV charging at off peak hours.

Over the longer term there are very interesting possibilities involving the use of EV batteries for storage. One that has drawn significant attention is the potential for use of EVs as highly distributed storage through "Vehicle to Grid" energy transfer.

However, another great opportunity is the use of EV batteries for stationary storage after the end of their useful life in the vehicle. Estimates are that the current generation of EV batteries will typically last on the order of 10 years or 100,000 miles before their capacity to hold a charge drops to about 80 percent of the original capacity. That reduces the range to the point that the batteries are no longer useful for vehicle applications, although they still could have many years of use for stationary storage.

There could be an interesting opportunity to both develop storage and increase the uptake of EVs by committing to the purchase of the batteries at the end of their useful life; or acquiring the batteries up front, and essentially renting them to customers for use in their vehicles until they are ready to be used for stationary storage. Current estimates suggest that the residual value of the EV batteries could be $6,000, although this may come down if battery improvements make lower cost batteries available by the time current batteries are useful for resale.

To give a sense of scale here, a Nissan Leaf has a 24 kwh battery pack. After the capacity has declined to 80 percent, there will be about 19 kwh storage capacity in the remaining batteries. So the batteries from 50 Leafs would allow about 1 MWH of storage. At high EV penetration rates, there could be significant storage capacity available from used EV batteries.