Executive Summary

The City and County of Denver has set aggressive goals for reducing greenhouse gas emissions and energy consumption while improving air quality in both its 2015 Climate Action Plan and Sustainability 2020 Goals. The adoption of plug-in electric vehicles (PEVs) is expected to play an important part in meeting those goals, as transportation emissions are the second largest contributor in Denver’s greenhouse gas portfolio. In addition, the entire metropolitan region faces significant challenges in meeting federal ozone standards and increased adoption of PEVs plays an important role in reducing ozone precursors. To maximize the health and environmental benefits of PEVs, Denver plans to double the PEV growth rate between now and 2020 by leveraging the findings in this analysis.

PEV adoption rates in Colorado have been growing rapidly, with 43 percent growth in 2016 PEV sales compared to 2015, and a 48 percent increase in sales in the first quarter of 2017 compared to the same period in 2016. In order to achieve the medium growth scenario (where five percent of vehicles on the road in 2030 are PEVs) identified by the Colorado Energy Office’s Electric Vehicle Market Implementation Study, Colorado will need to maintain an annual growth rate of over 40 percent.

The following report examines some of the major barriers to higher PEV adoption rates in Denver such as a lack of DC fast charging (DCFC) stations statewide and the difficulty of providing access to charging for residents of multi-family housing. Steps to address these barriers are also identified. The report also analyzes the emissions benefits of PEVs charging on Colorado’s Xcel Energy’s grid compared to gasoline vehicles.

DC Fast Charging

Current DCFC stations allow PEV owners to recharge their vehicles relatively quickly, adding about 50 miles of range in about 20 minutes. Higher power DCFC stations, which are beginning to enter the market, will provide even faster recharging.

A well-planned network of DCFC stations will provide PEV owners the ability to make longer trips and reduce range anxiety. A survey conducted for this report indicates that over 80 percent of PEV owners in Colorado feel limited in their PEV use due to lack of public charging. Making longer PEV trips more convenient should also increase sales of PEVs in Colorado as higher levels of DCFC correlates with higher levels of PEV adoption.

Colorado PEV drivers feel limited due to lack of public charging
The top locations identified by PEV owners for fast charging stations were along the interstate corridors and at recreational destinations in the mountains.

In concert with this report, the National Renewable Energy Laboratory (NREL) has done research using their Battery Lifetime Analysis and Simulation Tool for Vehicles (BLAST-V) model to identify locations for DCFC stations, across the state and the potential utilization of these stations.

Due to the high costs to install and operate these stations and their utilization rates at current levels of PEV adoption (which lead to insufficient revenue generation), it is difficult for a DCFC station host to cover the costs of acquiring, installing and operating a station. Figure ES-1 shows that at current utilization rates, DCFC stations in urban areas and along highways struggle to recover their operating costs without even including the capital and installation expenses. Significant expansion of the DCFC network in Colorado likely requires that, at a minimum, much of the capital cost of stations be covered by public sources. This report finds that the full costs for future-proofed stations with two fast chargers and

**Figure ES-1.** Total Revenue Minus Total Operating Costs After Ten Years of Operation from a DCFC Station
a co-located Level 2 station range from approximately $170,000 in urban areas to $200,000 along highway corridors.

A significant cost associated with operating a DCFC station are demand charges which may make up approximately 80 percent of the electrical bill incurred by these stations. Variances in demand charges at utilities across the state can lead to identical DCFC stations having differences of tens of thousands of dollars in their annual electrical bills. Working with utilities to find creative ways to reduce or eliminate demand charges while still allowing them to recover costs will be critical to improving the business model for DCFC stations. A number of utilities in other states have adopted new tariffs that charge higher time of use energy charges and reduce or eliminate demand charges for DCFC stations.

Reducing or eliminating demand charges will be critical to improving the business model for DCFC stations.

Multi-Family

Most PEV charging takes place at home, so the availability of home charging is critical to PEV adoption. Forty-four percent of Denver residents live in multi-family housing and without access to charging at their homes these residents will be unlikely to purchase a PEV. Charging simulations done by NREL show the provision of charging at multi-family residences increases electric vehicle travel more than a robust set of urban DCFC stations which shows the critical importance of home-based charging. Providing people who live in multi-family buildings access to charging stations at their residences has proven to be a significant challenge. Owners of condominiums may struggle to convince Home Owner Association (HOA) boards and members to pay for electrical infrastructure upgrades to support charging stations in common parking areas. Due to the temporary nature of residency, apartment dwellers and building owners may be reluctant to invest in charging stations that may not be used in the future. The barriers faced by residents of lower income apartments are even greater as these buildings tend to lack extra amenities. Compared to a single-family home, the cost of retrofitting a multi-family property may be much more challenging and expensive due to panel upgrades, trenching and new wiring on top of the cost to purchase and install the charging station itself.

To address the inclusion of charging stations in new multi-family buildings (and other commercial properties), municipalities can adopt PEV Ready building codes that, at a minimum, require the provision of conduit or wiring between the electrical panel and the parking area and sufficient additional panel capacity for future charging stations. This significantly reduces the cost of installing stations in the future. It is recommended Denver adopt a policy to help move this part of the market in the right direction.

PEV Ready building codes will help get charging into new multi-family buildings.

Currently, the Charge Ahead Colorado (CAC) program provides grant funding that covers up to 80 percent (up to $6,260) of the cost of a Level 2 multi-port charging station. Due to the additional barriers existing multi-family buildings may face compared to public or workplace charging installations and the importance of access to charging at one’s residence, it may make sense to increase the maximum funding for multi-family properties, especially apartment buildings.

44 percent of Denver residents live in multi-family housing.
Figure ES-2. Average Costs for Multi-Family Projects Funded by Charge Ahead Colorado

Utilities can play an important role in addressing the need for more charging stations

Figure ES-2 breaks down the average retrofit costs compared to station costs for multi-family buildings which have received funding from the Regional Air Quality Council (RAQC) for charging station installations. The figure shows that the cost of the station makes up about half the cost of the total installation.

There is currently a lack of research on the financial benefits to building owners of adding charging stations to a multi-family property. Without data showing that the costs of installing charging stations can be recovered through higher rents, improved tenant retention or higher sales prices for properties, many building owners may be reluctant to make this type of investment.

In both the multi-family and DCFC areas, the engagement of electric utilities can be important to addressing the infrastructure demands of additional charging.

Air Quality Benefits

Based on an analysis by the study authors, PEVs provide significant environmental benefits when driven in the Denver metropolitan area. In 2016, a battery electric vehicle (BEV) reduced emissions of Nitrogen Oxides (NOx) by 38 percent, Volatile Organic Compounds (VOCs)

PEVs provide significant environmental benefits when driven in the Denver metropolitan area
ExEcutivE Summary

Figure ES-3. Emissions Comparison of New Vehicles in 2016

by 99 percent and greenhouse gas (GHG) emissions by 30 percent compared to a new gasoline vehicle.

Comparing a BEV to the average gasoline vehicle on the road gives even greater emissions benefits. NOx is reduced by 63 percent, VOCs by 99 percent and GHG by 43 percent.

Due to the replacement of electricity from coal by natural gas, solar and wind energy, the fuel source for existing and new PEVs will become even cleaner over time. While new gasoline vehicles will also reduce their emissions, the emissions benefits of PEVs will continue to improve over the next eight years. By 2025, a BEV will reduce NOx emissions by 84 percent, VOC emissions by 99 percent and GHG emissions by 49 percent compared to a new gasoline vehicle.

The GHG emissions from a BEV are the equivalent of a 47 MPG gasoline vehicle in 2016, and a 75 mpg vehicle with the 2025 electricity mix.

The emissions of NOx and VOCs from Denver’s light-duty vehicles play a significant role in the high levels of ground level ozone the region experiences. More PEVs on the road can play an important part in improving air quality and the health of the region’s citizens.

The following table summarizes the potential action items identified as part of this research that could contribute to lowering barriers to PEV adoption. It also indicates which parties are most important to taking these actions.
<table>
<thead>
<tr>
<th>Potential Actions</th>
<th>Impact</th>
<th>Impact Timeline</th>
<th>Potential Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide increased capital cost funding for new DCFC stations</td>
<td>High</td>
<td>Short-Term</td>
<td>RAQC, Colorado Energy Office (CEO)</td>
</tr>
<tr>
<td>Develop new funding to support the operating costs of DCFC stations</td>
<td>High</td>
<td>Short-Term</td>
<td>RAQC, CEO</td>
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<tr>
<td>Work with utilities to develop tariffs that limit the impact of demand charges on DCFC stations</td>
<td>High</td>
<td>Medium-Term</td>
<td>Denver, CEO, RAQC, Investor-owned utilities (IOUs), Municipal utilities, Cooperative utilities, Public Utilities Commission (PUC)</td>
</tr>
<tr>
<td>Engage with utilities to encourage them to invest in DCFC stations</td>
<td>High</td>
<td>Medium-Term</td>
<td>Denver, RAQC, CEO, IOUs, Municipal utilities, Cooperative utilities, PUC</td>
</tr>
<tr>
<td>Prioritize future-proofed new DCFC sites to allow for higher capacity charging in the future</td>
<td>Medium</td>
<td>Long-Term</td>
<td>RAQC, CEO</td>
</tr>
<tr>
<td>Prioritize modular new DCFC stations to allow for adding more capacity without the need for replacing hardware</td>
<td>Medium</td>
<td>Long-Term</td>
<td>RAQC, CEO</td>
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### Table ES-2. Potential Actions to Promote Multi-Family Stations

<table>
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<th>Impact Timeline</th>
<th>Potential Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage with utilities to encourage them to invest in charging at multi-family buildings</td>
<td>High</td>
<td>Medium-Term</td>
<td>Denver, RAQC, CEO, IOUs, Municipal utilities, Cooperative utilities, PUC</td>
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<tr>
<td>Consider raising cap for grant funding for existing multi-family housing</td>
<td>High</td>
<td>Short-Term</td>
<td>RAQC, CEO</td>
</tr>
<tr>
<td>Adopt building codes to make new and remodeled multi-family housing (and other commercial buildings) PEV Ready</td>
<td>High</td>
<td>Long-Term</td>
<td>Denver</td>
</tr>
<tr>
<td>Focus new urban DCFC and Level 2 stations in areas with high percentages of multi-family buildings</td>
<td>Medium</td>
<td>Medium-Term</td>
<td>Denver, RAQC, CEO</td>
</tr>
<tr>
<td>Initiate research into the impacts of charging stations on multi-family property values and tenant retention</td>
<td>Low</td>
<td>Medium-Term</td>
<td>Denver, RAQC, CEO</td>
</tr>
</tbody>
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