Colorado PUC Electric Vehicle Working Group Report

Colorado Public Utilities Commission

January 15, 2019

Contents

I) Introduction

Over the past several months, the Colorado Public Utilities Commission (Commission) has expressed an interest in understanding both the near-term and long-term challenges and opportunities associated with electric vehicles (EVs). This research document answers Commissioner questions and informs the Commission and other interested stakeholders on the regulatory issues facing the development of EVs and the associated charging infrastructure in Colorado.

On November 16, 2017, by Decision No. C17-0931, the Commission opened a proceeding (17I-0692E) as a repository for presentations, comments, and other materials relating to EVs and the numerous issues associated with the electrification of the transportation, heating, and building sectors in Colorado. The Commission recognized that it might have an active role to play in the development of EVs and EV infrastructure (sometimes referred to as EV Supply Equipment or EVSE, which refers specifically to chargers). The Commission noted that a growing EV market coinciding with managing EV charging loads to off-peak times has the potential to flatten load curves and improve system utilization, leading to potential benefits. By contrast, it noted that unmanaged load from EV charging has the potential to increase peak demand, alter peak load shapes, increase demands, and ultimately increase costs on the electric system. Additionally, the charging patterns for EVs, including geographic clustering and timing of the charging load, are potential distribution system issues, which merit additional evaluation and consideration by the Commission.

On December 8, 2017, the Commission held a Commissioner's Information Meeting (CIM), to help the Commission understand the hurdles that have inhibited the growth of the EV market and the ways market growth could be further managed or encouraged. The Commission heard a presentation on preparing for an "EV Revolution," by the Rocky Mountain Institute (RMI)[1] and discussed with presenters the role of EVs envisioned in Governor Hickenlooper's Executive Order 2017-015 "Supporting Colorado's Clean Energy Transition." Presentations also provided experience from other states in developing EV infrastructure and deployment programs. The Commission heard from representatives of the EV infrastructure and transportation vehicle industries, as well as from the Colorado electric utilities.

At its May 9, 2018 Weekly Meeting, the Commission adopted Decision No. C18-0479-I directing assigned members of Commission Staff (Staff) [2] to form the CoPUC EV Working

[1] CIM, December 8, 2017 Presentation "Preparing for the EV Revolution", by Chris Nelder, Rocky Mountain Institute.

[2] The member of Staff assigned to the EV Working Group includes James Lester of the Advisory Section and was supported by Drew Bolin and Rebecca Lim of the Research and Emerging Issues Section.

Group (or Working Group) to gather information and, through a written report, to accomplish the following:[3]

1. Provide recommendations discussing the possible design of a new rate (or rates) that:
   a. assists in the growth of the EV charging marketplace (*e.g.,* promotes EV charging infrastructure investments by third parties); and/or
   b. balances rate design principles with economic development principles associated with new load growth, consistent with recently passed legislation.
2. Provide recommendations of electric rate design for end users, specifically residential customers, to achieve the objectives of:
   a. encouraging load growth beneficial to all by improving system utilization efficiency;
   b. leveraging market development efforts underway, including state and local government; and
   c. avoiding adverse impacts on the principles that underlie reasonable rates.
3. Provide recommendations to electric rate design for end users, specifically commercial and industrial (C&I) customers, to achieve the objectives discussed above through encouraging "at-work" charging (*i.e.,* EV charging stations at business locations for use by employees or other patrons).
4. Provide recommendations as to whether the Commission should consider unique tariffs for corporate fleets and workplace and commercial EV charging infrastructure.
5. Provide recommendations to the Commission regarding "Make-Ready Infrastructure" investments by electric utilities that will encourage desirable load growth for EV charging.
6. Provide recommendations regarding other utility strategies to promote new load growth, particularly applicable to EVs.
7. Present information about best practices relating to how the Commission would address proposals by utilities seeking to make rate-recoverable investments in the pursuit of beneficial electric load growth. For example: What information or data would be necessary? What questions would guide the pursuit of determining whether the investments are in the public interest? What types of analyses should be conducted in order to determine cost-effectiveness and prudency?

[3] The recommendations attributed to the assigned member of Staff do not reflect any official position or findings of the Commission or of the Advisory staff and Trial staff as defined in 4 *Code of Colorado Regulations* 723-1-1004 of the Commission's Rules of Practice and Procedure.

8. Present information about how to develop a strategy and partner with other state agencies, and how best to consult with utilities, to address grid-related costs associated with vehicle fleet electrification.[4]

This report is the result of discussions with and written comments from over 70 participants from more than 40 organizations. In addressing the questions set forth by the Commission, the Working Group broke into six topic Work Groups: Beneficial Electrification; Make-Ready Infrastructure; Residential Sector; Commercial, Industry, and Fleets; Education and Outreach; and Next Steps. Each Work Group held bi-weekly calls where issues were discussed and experts from within the Work Group and as well as outside experts presented on relevant topics. The participants were invited to submit written comments to help the formulation of this report.

Figure #1: CoPUC EV Working Group Participant List

Government	Non-Profit	Industry	Utilities
Boulder County*&	Colorado Energy Consumers (CEC)	Alliance for Transportation Electrification&	Black Hills
Boulder&	Dietz and Davis	Auto Alliance*&	GCEA
BW Energy Law	Earthjustice	BYD North America*	Public Service
Colorado Department of Transportation (CDOT)	Grid Alternatives	Chargepoint*	Tri-State
Colorado Department of Public Health and Environment (CDPHE)	NRDC*&	Electrify America	
Colorado Energy Office (CEO)	Rocky Mountain Institute (RMI)*	eMotorWerks*	
University of Colorado, Boulder&	Sierra Club*&	EV Box*	
Denver*&	SWEEP*&	EVGo*&	
Lakewood	Vote Solar*&	FHueng Engineering	
Regional Air Quality Control (RAQC)	Western Resource Advocates*&	Ford	
RTD*&		GM*	
Summit County&		Green Lots*&	
		National Car Charging*&	
		Proterra*&	
		Siemens*&	
		Tesla&	

(*) indicates that the organization was part of the October 31 filing of joint responses to Commission questions in 17I-0692E (The Joint Participants). (&) indicates that the organization supported the Statement from PUC EV Work Group Members on Make-Ready Infrastructure filed on October 11.

Key stakeholder groups were well represented during this process. Utilities, local governments, transit agencies, universities, and State agencies provided a wide-range of expertise and

[4] Decision No C18-0749-I

knowledge. Environmental organizations and consumer groups such as the Colorado Energy Consumers (CEC) provided their unique perspectives to this process. A wide variety of the industry was represented, including auto manufacturers (OEMs), Heavy Duty vehicle manufacturers, and EV charging infrastructure companies with a range of business models (see text box below).

> Every EV charging provider has a unique business model, ranging from manufacturing, owning, and operating EVSE, to manufacturing and selling EVSE and associated network services, to providing subscriptions to public charging stations, and to developing and providing associated software and network services. They are all, however, in universal agreement that an active partnership with the electric industry is necessary to expand the EV market. They have different opinions about what form that collaboration should take (some oppose utility ownership of EVSE in most segments, others are strong advocates for utility ownership in nearly every segment, and yet others are largely agnostic as to who owns what and focus on other elements of program design), but they all view electric utilities as essential partners.

Another issue is customer choice. Some in the industry advocate that end customers should be allowed to choose the utility as their provider of EVSE and service. Others advocate that end customers should not be allowed to choose the utility and that EVSE and service should be available from only non-utility companies.

In order to set the stage for this understanding, this introduction will first provide an understanding of the current EV market and growth potential, current Colorado EV initiatives, the role of regulators in the EV market, the potential role of utilities, and finally, the risks of not taking a proactive approach to EV market growth.

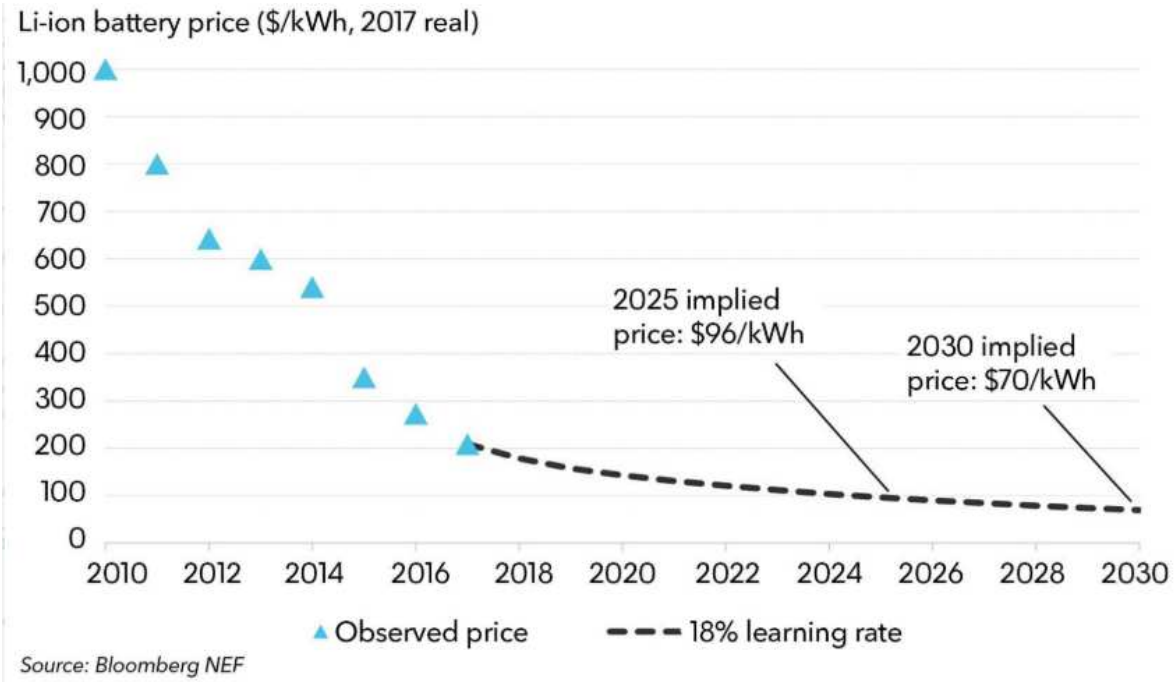
Electric Vehicle Market Trends

> *"The auto industry will change more in the next 5 years than it has in the last 50," General Motors Chair and CEO Mary Barra wrote in a recent GM annual report.*

There are several factors adding to the potential growth of EVs. First, ongoing battery-cost reductions, the most expensive part of an EV, are finally making a shorter range (100-mile range), EVs competitive with Internal Combustion Engine (ICE) vehicles. A recent UBS analysis

stated that EVs are approaching cost parity with equivalent ICE vehicles far more quickly than previously expected, as battery costs fall, and lower vehicle maintenance costs become more evident.[5] However, as the demand for longer-range EVs (which are not yet cost-competitive with their equivalent ICE vehicles) grows, there is likely a continued need for incentives such as Colorado's EV tax credit.

Figure #2: EV Battery cost forecasts



https://about.bnef.com/new-energy-outlook/#toc-download

A recent McKinsey analysis showed the price of batteries fell from $1,000/kWh in 2010 to $227/kWh in 2017 and is forecasted to fall to near $100/kWh by 2020. RMI research points to numerous gigawatt-scale lithium-ion battery factories under planning and construction around the world, and an expected sharp increase in vehicle sales by 2020.[6] In response to this increase in battery supply and reduction in costs, automakers are expected to meet a growing customer demand by introducing an estimated 340 new EV models around the world in the next three years.[7] Volkswagen plans to spend $40 billion by 2030 to build electrified versions of its 300-plus models. Volvo announced that all new models will be electrified. General Motors (GM) has outlined plans to introduce 20 new battery and fuel cell EVs by 2023. Daimler has said it will spend at least $11.7 billion to introduce ten electric models, including electric alternatives for all Mercedes-Benz model series by 2022. Ford Motor Company (Ford) has announced its plans to

[5] (Fitzgerald & Nelder, 2017)
[6] Utility Dive: Why utilities need to respond now to the EV boom (10/19/18): https://www.utilitydive.com/news/why-utilities-need-to-respond-now-to-the-ev-boom/506761/
[7] *Ibid.*

invest $11 billion in new electrified vehicles globally by 2022. Many other global OEMs along with innovative new automakers are also planning to increase the number of models available.
In addition to the market pull of lower prices and increasing model choices, EVs will benefit from a variety of policy initiatives across the world. Great Britain and France have pledged to ban all new gas and diesel cars and vans after 2040.[8] The Netherlands, Norway, and Germany have contemplated implementing similar bans as soon as 2025.[9] In China and India whose markets are considered by automakers as the key new growth markets for vehicles globally, EVs are expected to take a significant market share. China's "road map," released in April 2017, calls for 20 percent of new vehicle sales to be alternative fuel vehicles by 2025. In India, the government is aiming for full electrification of all vehicles by 2032.

States across the country are also pushing for increased EV adoption and spending on infrastructure. Such coordination in EV infrastructure planning amongst states, communities, and the utility industry will likely be a significant factor in increasing EV adoption rates. Forty-three states and Washington DC are looking at policies to develop the EV market as well as encourage the expansion of both private and public infrastructure for EV charging.

California is leading the way in providing support, as well as planning for massive EV deployment. For example, California's Zero Emission Vehicle (ZEV) Program has been adopted by nine other leading states. Under a ZEV program, automakers are required to obtain "ZEV credits," which they can receive for the EVs they produce and deliver for sale. They must maintain the requirement, which becomes more stringent and will rise from 4.5 percent in 2018 to 22 percent in 2025.[10] GM has called for a nationwide ZEV program that could result in seven million EVs in the U.S. by 2030.[11]

Bipartisan efforts between states including Regional Electric Vehicle (REV) West, Drive Change Drive Electric, Southeastern EV Readiness, Charge Up Midwest, and the West Coast Electric Highway are coordinating investments in EV programs and charging infrastructure investments to maximize their benefits and enable EV travel across state borders.[12]

In October 2017, the governors of Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming signed an MOU to provide a framework for creating a regional electric vehicle plan for the West (the REV West Plan). The plan spans more than 5,000 miles of highway and calls for a coordination group to:

- Create best practices and procedures;

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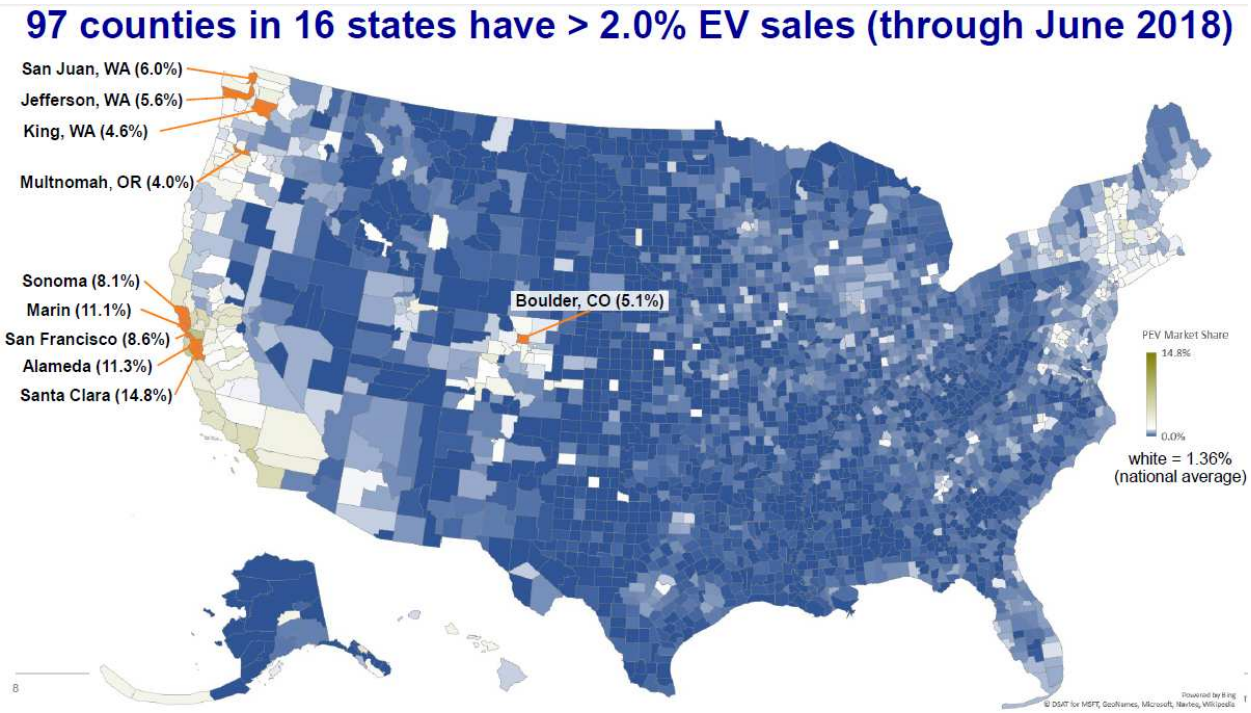
[8] *Ibid.*
[9] (Fitzgerald & Nelder, 2017)
[10] California Air Resources Board, https://www.arb.ca.gov/msprog/zevprog/zevprog.htm
[11] GM https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2018/oct/1026-emissions.html
[12] (The Gridwise Alliance, Jul 2018)

- Create voluntary minimum standards for EV charging stations;
- Identify and develop opportunities to incorporate EV charging station infrastructure into planning and development processes;
- Encourage auto manufacturers to stock and market a wide variety of EVs within the Signatory States; and
- Identify, respond to and, where possible, collaboratively fund opportunities to support the development of the Regional Electric Vehicle West EV Corridor.[13]

The REV West MOU created a framework for collaboration in developing an Intermountain West Electric Corridor. Interstates 70, 76, and 25 are part of Colorado's commitment to the REV West Plan.

In addition to state government action, electric utilities (investor owned, municipals, and Co-ops) are finding that EVs may provide an opportunity for load growth in a market of shrinking overall electricity usage. The EV is also an opportunity for utilities to engage better with their customers. Utilities are proactively planning for the deployment of EV load on their systems, as well as applying for program approvals in front of Commissions and utility boards.

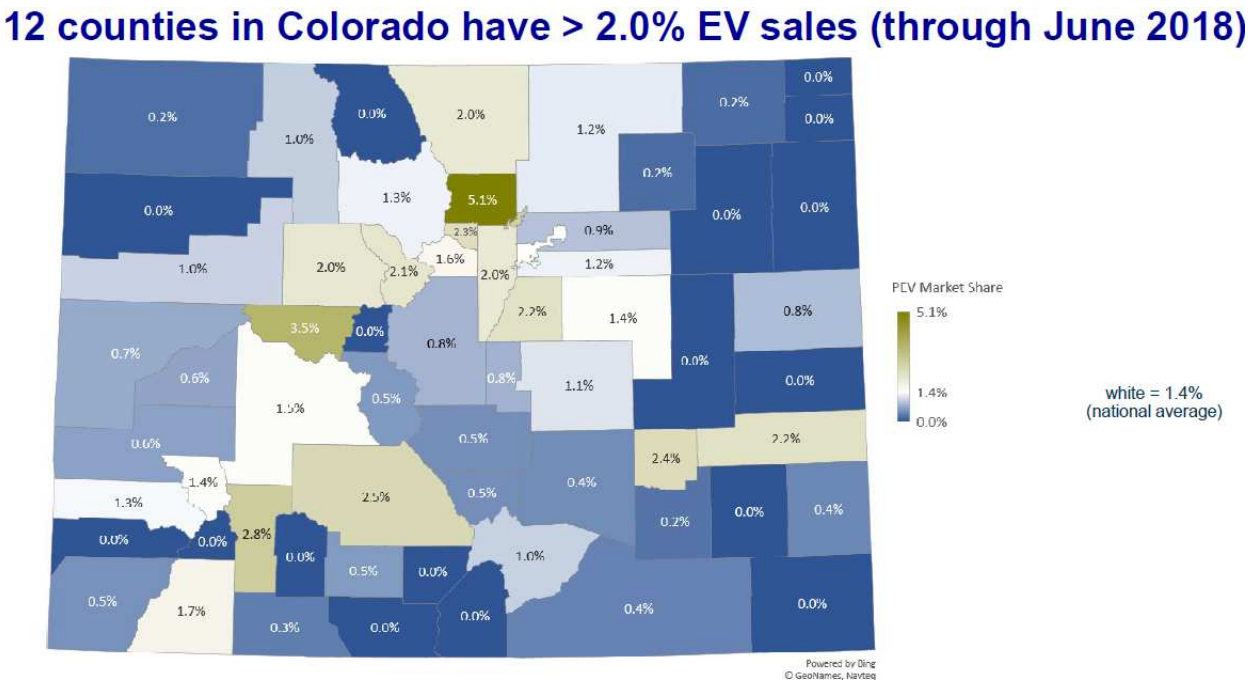
Figure #3: Nationwide EV Sales Data



[13] Ibid.

Source: EPRI presentation to CoPUC Working Group (Oct 10, 2018)

Figure #4: Colorado EV Sales



Source: EPRI presentation to CoPUC Working Group (Oct 10, 2018)

Colorado EV Activities

Context

In addition to regional efforts such as the REV West Plan described above, Colorado has been pursuing state-specific actions to promote EV purchases and ensure adequate charging infrastructure along highway corridors and at publicly available sites within communities.

In January 2018, Governor John Hickenlooper announced the *Colorado Electric Vehicle (EV) Plan,* based on a July 2017 Executive Order, "Supporting Colorado's Clean Energy Transition." The plan was developed in partnership with the Colorado Energy Office (CEO), Regional Air Quality Council (RAQC), Colorado Department of Public Health and Environment (CDPHE), and Colorado Department of Transportation (CDOT). The agencies undertook an extensive stakeholder engagement process with utilities, government entities, non-governmental organizations, and industry representatives.

Colorado's Electric Vehicle Plan explains in detail the funding sources and programs that coordinating agencies will use to support the EV market in Colorado. The plan proposes five key action areas:

1. Create strategies and partnerships to build out publicly accessible DC fast charging stations both for intercity corridors and for denser urban community areas.
2. Coordinate with the Regional Electric Vehicle West (REV West) states on the memorandum of understanding on an intermountain electric corridor.
3. Develop statewide plans to accelerate the deployment of EV infrastructure, including strategic partnerships with utilities, local governments, and other stakeholders.
4. Update signage and wayfinding requirements to include EV fast-charging.
5. Ensure that economic development and tourism benefits accrue equitably for all Coloradans.

Fast-Charging Corridors

There are two parallel efforts to establish fast-charging corridors in Colorado:

1. **ALT Fuels Colorado.** Through this existing program, CEO is awarding grants to fund DC Fast Charging (DCFC) along designated "Tier 1 and Tier II" corridors. Starting in 2018, existing Congestion Mitigation and Air Quality funds were directed to this effort. In addition, of the estimated $68.7 million it received as part of Volkswagen's settlement (the environmental mitigation trust); CEO has allocated $6.8 million to the ALT Fuels program for DC fast-charging stations along Colorado's major transportation corridors.

CEO also coordinated with Electrify America (see #2 below) and others to ensure optimal siting for infrastructure in Colorado.

Station Charging Requirements

- Stations on Tier 1 corridors shall include four DC Fast Chargers capable of providing at least 150 kW simultaneous charging for two vehicles and at least 50 kW simultaneous charging for four vehicles (16 sites).
- Stations on Tier 2 corridors shall include two DC Fast Chargers capable of providing at least 150 kW charging for a single vehicle and at least 50 kW simultaneous charging for two vehicles (17 sites)
- CHAdeMO/SAE CCS on each dispenser

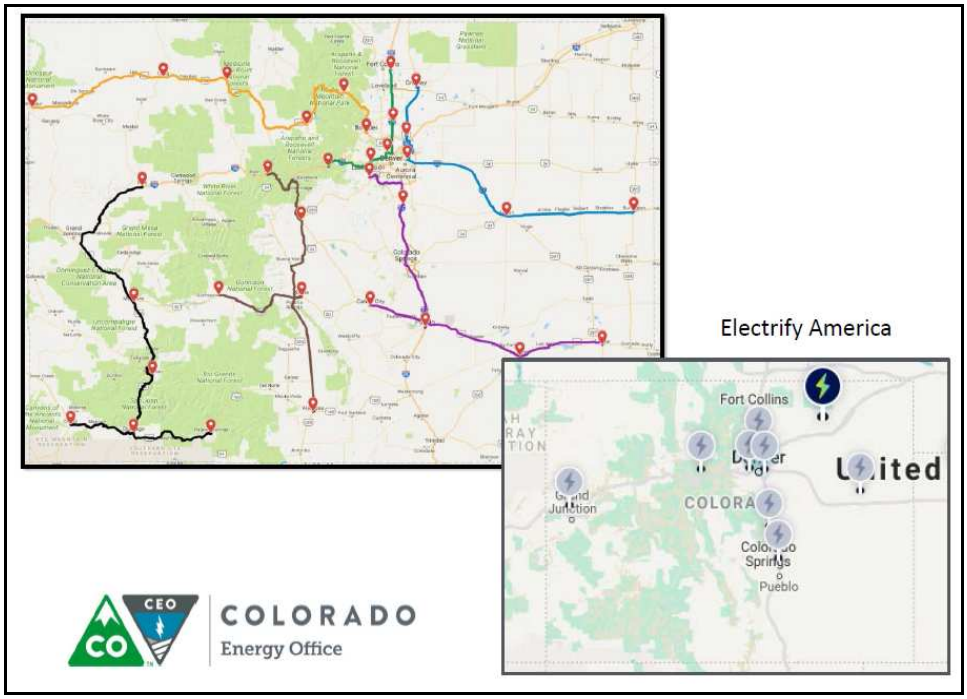
Funding Levels

- Tier 1 sites are eligible for up to 80 percent of equipment and non-labor project costs up to $380,000.
- Tier 2 sites are eligible for up to 90 percent of equipment and non-labor project costs up to $250,000.

On November 29, 2018, Governor Hickenlooper announced a $10.33 million ALT Fuels Colorado grant to ChargePoint to build EV fast-charging stations. The fast-charging stations will be located at 33 sites across 6 Colorado corridors comprised of Interstate, State, and U.S. highways.

2. **Electrify America**. The national settlement also required that VW itself invest $2 billion over ten years in zero emission vehicle infrastructure and education programs. Electrify America, a newly created subsidiary of VW, is administering this investment. In Colorado, DCFC stations will be built along I-70, I-25, and I-76. According to the Electrify America website, highway sites will include between four and ten 150kW and 350kW individual DC fast chargers at each location before June 2019. These sites will be located no more than 120 miles apart and on average just 70 miles apart.

Figure # 5 Colorado EV DCFC Corridor Program



Source: CEO

Community-based Charging

There are also two different programs that are supporting installation of community-based charging stations. These include stations in locations such as workplaces, retail (shopping centers, restaurants, etc.), multifamily residential locations and municipal lots and garages, as well as high-speed community depots.

1. **Charge Ahead Colorado**. Through this program, CEO and the Regional Air Quality Council have already made awards for 685 community charging stations. Of the estimated $68.7 million it received as part of Volkswagen's settlement (the environmental mitigation trust), CEO has allocated $3.5 million to Charge Ahead Colorado to support additional community charging stations. In addition, this program is funded through CMAQ dollars as well as the EV Fund, which is made up from a portion of the $50 fee paid at the time of registration by EV owners.

Charge Ahead Colorado Grants

up to 80 percent of the total cost, capped as shown below

Type	Grant	# expected to fund
Level II Dual Port Station	$9,000	260 to 270[14]
DC Fast Dual Protocol Station	$30,000	15 to 20

2. **Electrify America.** In addition to the plan for DCFC highway stations described above, Electrify America has also selected Denver as one of the cities in which to locate community-based charging stations.

Accelerating EV Purchases

In addition to supporting and funding EV charging stations, Colorado provides grants and other incentives for EV purchases. The Colorado EV Plan cites a goal of achieving a light-duty sector high growth scenario of approximately 940,000 EVs in Colorado by 2030.

Charge Ahead Colorado. For fleets and entities located in the 7-county Denver Metro Area (Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas and Jefferson Counties), the Regional Air Quality Council will fund 80 percent of the incremental cost differential between an EV and the comparable gasoline vehicle up to $8,260.

[14] These numbers are specific to funds from the VW settlement. Charge Ahead expects the number of Level II stations will be higher as a result of other sources of funding.

Plug-In Electric Vehicle (PEV) Tax Credit. Colorado offers a tax credit for qualified all-EVs and plug-in hybrid electric vehicles (PHEVs), titled and registered in Colorado. A purchaser may assign the tax credit to the financing entity, allowing the purchaser to realize the value of the tax credit at the time of purchase, lease, or conversion.

Colorado Plug-In Electric Vehicle (PEV) Tax Credit

Category	2017-2019	2020	2021
Light-duty EV or PHEV	$5,000 for purchase or conversion; $2,500 for lease	$4,000 for purchase or conversion; $2,000 for lease	$2,500 for purchase or conversion; $1,500 for lease
Light-duty electric truck	$7,000 for purchase or conversion; $3,500 for lease	$5,500 for purchase or conversion; $2,750 for lease	$3,500 for purchase or conversion; $1,750 for lease
Medium-duty electric truck	$10,000 for purchase or conversion; $5,000 for lease	$8,000 for purchase or conversion; $4,000 for lease	$5,000 for purchase or conversion; $2,500 for lease
Heavy-duty electric truck	$20,000 for purchase or conversion; $10,000 for lease	$16,000 for purchase or conversion; $8,000 for lease	$10,000 for purchase or conversion; $5,000 for lease

Source: https://afdc.energy.gov/laws/11702

At the Commission's November 27, 2018 CIM, CEO also listed the following actions related to achieving the high growth scenario goal:

- Colorado Electric Vehicle Coalition subgroups are exploring strategies to increase model availability in Colorado and increase assignability of the CO tax credit;
- CEO and the Southwest Energy Efficiency Project (SWEEP) released updated EV Group Buy Handbook;
- The State is developing a workplace charging policy for State agencies;
- CEO has incorporated EV-ready guidelines in building code training for interested jurisdictions;
- CEO and RAQC are prioritizing workplace and multifamily housing facilities under the Charge Ahead Colorado grant program;
- State agencies are on track to double the number of EVs purchased in this year's procurement cycle versus last year's.

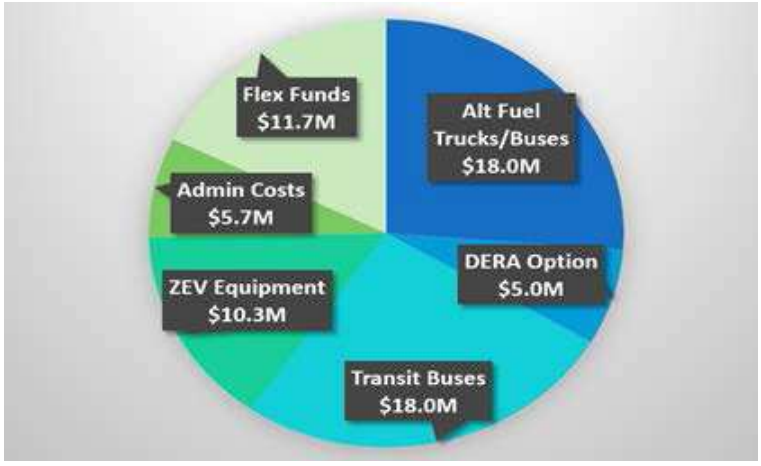
Specifics of the VW Settlement Fund: The Colorado Beneficiary Mitigation Plan

The CDPHE is the designated agency in charge of allocating the estimated $68.7 million it receives as part of Volkswagen's settlement of its emissions cheating scandal.

In order to determine how best to spend the money, state officials started taking recommendations from the public in 2016. Those recommendations resulted in the following proposed spending breakdown:

- $18 million: Replace medium- and heavy-duty diesel trucks, school buses and shuttle buses with vehicles that run on alternative fuels or electricity;
- $18 million: Replace diesel transit buses with CNG and electric buses;
- $10.3 million: Install charging stations for zero-emission cars and trucks;
- $5 million: Reduce emissions from other diesel engines/equipment;
- $12.2 million: Establish a fund that can be allocated to other projects on demand.

Figure #6: State of Colorado Spending Plan



Regulatory Preparation for EVs

Researchers at RMI note that although the EV market is growing, it is unlikely that EV adoption will become widespread until there is also widely available charging infrastructure sufficient to give consumers confidence that they can recharge their vehicles whenever they need to. The development of Level II charging has been slower than anticipated. Although individual Level II charging stations are not expensive, investments in them can be too slow to pay off to interest

speculative commercial locations, at least until the market matures and utilization rates improve.[15] It has also been shown to be difficult for EV charging companies to create a business case that would make it possible to finance and build additional public DCFC capacity (see Section V for more). This is in large part due to the high cost to build and operate, combined with low utilization rates of existing DCFC, which is in turn a reflection of the current small share of EVs in the personal vehicle market. Many experts argue that this is a sign that a proactive approach on charging infrastructure from policymakers, regulators, and utilities is needed.

Research has shown that in order for EVs to gain wide adoption, the charging stations will need to be not just more plentiful, but strategically deployed with the help of utility planning to match both customer and grid needs.[16] A larger charging network increases the value of adopting electric vehicles, and when there are more electric vehicles in circulation, the value of investments in charging infrastructure increases. Each side of this market may spur each other's growth in a virtuous cycle. However, as the market has developed thus far, individual automakers may be hesitant to invest in a more robust charging network because their competitors would also benefit from the chargers, so they may under invest. Additionally, automakers historically have not been in the business of vehicle refueling, and this is not a core competency of theirs or necessarily something that they should be taking on going forward. Without government intervention to support the market there is a risk that the market may not develop sufficiently as predicted. Recent research has looked at the effectiveness of public subsidies and concludes that public spending on charging infrastructure could be twice as effective at encouraging EV adoption as subsidies on the vehicles themselves.[17] However, several participants point out that point-of-sale subsidies are still critical to promoting EV adoption.

Utilities and regulators will have to face EV integration challenges as EV sales and charging deployment increase over time, such as accommodating EV charging without increasing the system load peak, or without overloading distribution system equipment where EVs are clustered. As will be discussed in Section II, there may be opportunities over time from a proactive approach, such as managing EV loads to optimize grid assets and maintain grid power operational limits at what is projected to be minimal cost. As with any new load, utilities will invest in the electric system to provide reliable service. However, growth of EV charging offers potential benefits to the grid as a flexible and manageable load, along with regional air emissions benefits. Some of these benefits can be captured through charging infrastructure and related grid investments that encourage and align with future EV growth. Regulators, utilities, and

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[15] (Fitzgerald & Nelder, 2017)

[16] Utility Dive: Location Matters: Utilities focus on charger placement to drive EV adoption (8/31/16) https://www.utilitydive.com/news/location-matters-utilities-focus-on-charger-placement-to-drive-electric-ve/425276/

[17] https://energyathaas.wordpress.com/2018/08/20/counteracting-the-epas-tilt-away-from-electric-vehicles/

stakeholders can work together in order to consider how to tap the potential synergies between managed EV charging and the operational needs of the grid in ways that are designed to maximize the benefits for all customers and for society at large, while minimizing and managing potential risks.[18]

The Role of Regulators

With many issues identified surrounding EV policy at the state level, RMI has presented key questions that regulators in each state should begin to answer, including:

- Who will guide and plan charging infrastructure deployment in a state or region: competitive market forces (non-utility); utility and transportation planners as regulated services; per Legislative fiat or statutory direction to the Commission and state agencies; or per the direction or encouragement of Governors in a region.
- Who should install, own, and operate charging infrastructure, and what choices should end customers have in this, how should pricing be set for these charging services, and how transparent should they be.
- What the role of utility and other state regulators and agencies should be in guiding or monitoring the EV infrastructure build-out in a state, how much of the total cost of publicly accessible EV infrastructure should be paid by drivers and third party providers, and for regulated utilities, how such costs should be allocated to EV owners and other classes of ratepayers and how much should be socialized.
- How to design tariffs to reward charging behavior that moves the EV load from potentially peak to off-peak periods, thereby facilitating greater utilization of the distribution grid, and also how to develop tariffs and programs that link zero to low-carbon generation to these EVSE services, and where to place site charging stations so that they will be well used and produce sufficient revenue.[19]

According to RMI, regulators must balance competing sets of public interests when shaping policies on EV-charging rate design, charger siting and planning, and the utility's role in EV infrastructure ownership. As with other utility investment decisions, regulators will face the need to balance the interests of ratepayers with public policy goals. For EVs, this can mean deciding between supporting utility infrastructure investment that benefits the local utility customers or supporting infrastructure that may benefit non-ratepayers, such as highway fast charging between cities and towns.

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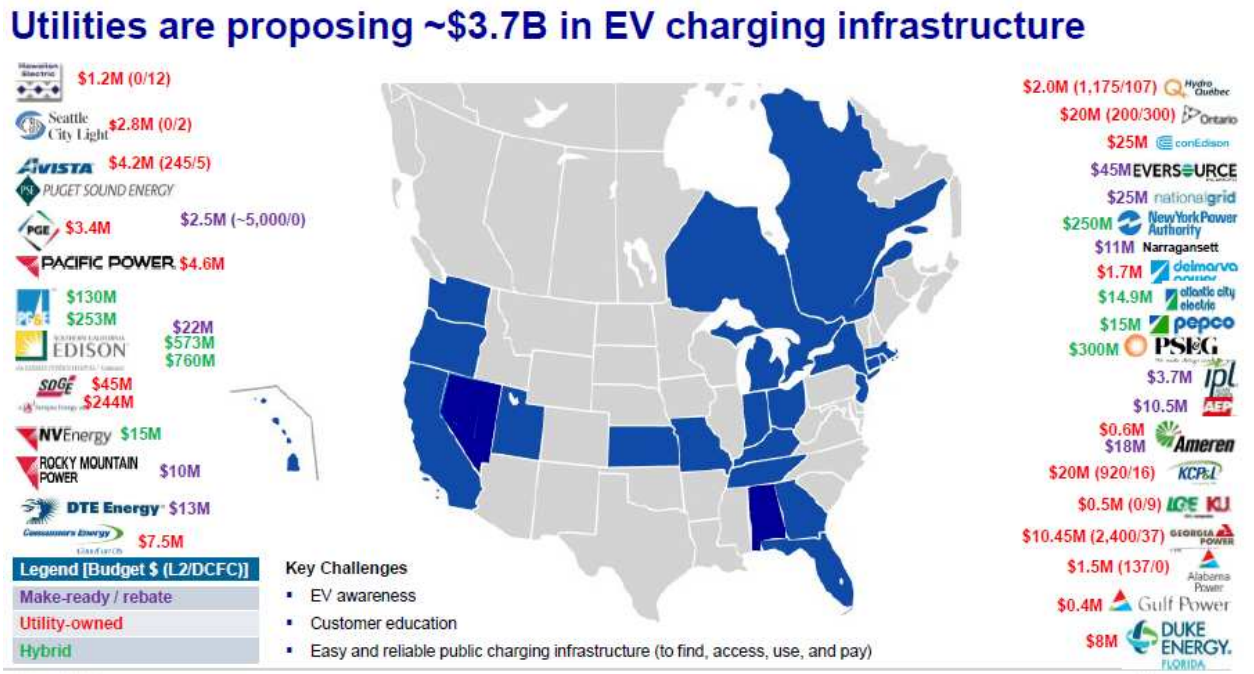
[18] (Nelder, Newcomb, & Fitzgerald, 2016)
[19] (Fitzgerald & Nelder, 2017)

Finally, to capture the potential value from EV integration, RMI believes utility regulators should work with utilities to provide customers access to rates and price signals that incentivize charging during the times of the day when energy demand is low and significant supply is available. In doing so, regulators should evaluate both system-focused rates that encourage charging during certain times and at certain locations based on their jurisdiction's grid needs, and customer-oriented rates, which incentivize charging in convenient locations that influence customer adoption.[20]

> EV Working Group participant, Phil Jones, co-author of a recent report published by Lawrence Berkley National Lab, points to the need for a collaborative process at the State level, stating that if a utility files a proposal to build out EV charging, it can quickly turn into a drawn out and difficult litigation. By starting with a workshop or a stakeholder meeting, as opposed to an official filing — including regulators, utilities, private companies, consumer groups, environmental groups and others — it can avoid conflict and ensure that the utility is designing the right kind of program from the get-go. Jones also encourages regulators to issue some kind of policy guidance through a pre-rulemaking process, Order, or other means to provide utilities some direction. He also encourages Commissions to establish an ongoing policy Docket across all utilities in which one can examine ongoing issues involving technology, rate design, and cost benefit methodologies.[1]

[20] (Gold & Goldenberg, 2016).

Figure #7: North American Utility Investment (as of June 2018)



Source: EPRI presentation to CoPUC Working Group (Oct 10, 2018)

State Examples

There are, however, many opportunities for regulators and utilities in different states to learn from one another. Some state commissions and legislative bodies have taken action to establish standard guidelines for review of cost recovery for utility ratepayer portions of EV infrastructure program proposals.

- **Minnesota:** The public utilities commission (PUC) established a generic docket for EV adoption and EV infrastructure issues. Minnesota utilities and stakeholders in-state and around the country, including auto manufacturers, non-profit organizations, and charging infrastructure companies were invited to present at a workshop in March 2018. The workshop attracted diverse and broad attendance, including a number of state agencies and local governments and transit agencies. The commission has subsequently asked for public comments in E999/CI17-879, the policy docket. Meanwhile, on October 16, Xcel Energy (Xcel) filed a proposal for six pilot programs before the Minnesota PUC (Docket 18-643) ranging from commercial fleet services to metro transit programs; these are presently pending with comments requested from interested parties.

- **Washington**: The State passed a law in June, 2015 (House Bill (HB) 1853) that recognizes that regulated utilities play a central role in the acceleration of transportation electrification and allows the UTC (Utilities and Transportation Commission) to approve an "incentive rate of return" for utility provision or subsidization of EV charging

infrastructure up to a maximum overall rate impact of 0.25 percent. The UTC developed a final policy statement in June 2017, intended to provide guidance to Washington utilities investing in EV charging services. The UTC bases its proposal on the regional "market transformation" approach that has been employed successfully to usher a number of innovative energy conservation technologies into mainstream markets. (Policy Docket: UE-160799). Meanwhile, Avista is proceeding with a series of pilot programs based on an ownership and operation model; Pacific Power has received approval for a modest pilot program; and Puget Sound Energy (PSE) has proposed a comprehensive range of pilot programs, ranging from residential to workplace and DC fast charging, which are presently before the Commission.

California: This year, the PUC approved wide-ranging proposals from the state's three investor-owned utilities to expand EV infrastructure and rebate programs with a total budget of more than $750 million.

- Southern California Edison can spend up to $343 million for up to 8,500 medium- and heavy-duty vehicle infrastructure investments at 870 sites. The utility will also experiment with time-of-use rates for charging all types of vehicles. (Proceeding # A1701021)
- Pacific Gas & Electric will invest up to $236 million in infrastructure and rebates for up to 6,500 medium- and heavy-duty vehicles such as trucks, cranes and forklifts across 700 commercial and industrial sites. It will also receive $22 million to add 234 DC fast-charging stations for passenger vehicles at 52 sites. (Proceeding # A1701022)
- San Diego Gas & Electric will get $137 million to offer rebates and installation services for a cap of 60,000 customers for charging at home and at small multi-unit dwellings. (Proceeding # A1701020)

- **Maryland**: The commission, through commissioner engagement and staff facilitation, brought together a large number of utilities, charging infrastructure companies, environmental organizations, and other stakeholders. The EV working group is part of a larger grid modernization effort. After several months of deliberation, workshops and opportunities for comments, the working group submitted its comprehensive proposal to the commission in January 2018. The utility proposals in this proceeding amount to about $105 million in investments for Maryland EV infrastructure. (Case No. 9478)

- **Massachusetts**: The Department of Public Utilities (DPU) issued an order that requires any utility submission for cost recovery of PEV infrastructure investments to meet the following terms: a) be in the public interest; b) demonstrate that the program will advance PEV deployment in the state that otherwise would not be met by the competitive PEV charging market; and c) not interfere with the growth of the competitive PEV charging

market. Under this standard, the DPU has approved $60M in combined investment for its regulated utilities National Grid and Eversource. In response to a request by National Grid for a series of pilot programs, the Department issued an Order in September largely approving such pilot programs, with modifications, considered to be Phase One. On November 15th, National Grid filed a much larger series of programs for EV infrastructure in Massachusetts spanning all types of charging infrastructure and including both make-ready and ownership and operation models, in order to comply with the 80 x 50 (80 percent reductions in greenhouse gas (GHG) by 2050) goals in the Commonwealth (Department of Public Utilities: DPU Order 17-13, issued September, 10, 2018).

- **Oregon:** The State passed a law in 2016 (Senate Bill 1547) allowing rate-base treatment of a utility's "transportation electrification program" and laying out six criteria for approval. The Public Utility Commission must consider whether the proposed investment and/or expenditures meet the criteria. Both Portland General Electric (PGE) and Pacific Power (PAC) subsequently developed a series of pilot projects in filings to the commission in 2017, after which multiple stakeholders engaged in settlement talks that resulted for PGE and PAC in a series of investments for pilot programs for all-electric buses, education and outreach, and an expansion of DCFC in charging stations in Portland. This was a litigated case, and only one party objected to the multi-party settlement agreement. In addition, the Commission initiated a related proceeding regarding increasing EVSE loads, and how regulated utilities should plan for this load in the context of IRP planning and other administrative processes. The commission staff issued a proposed rule in November (Docket AR 609) (Final PGE rate case order decided in February, 2018: UM 1811).

- **Missouri:** Several utilities have proposed EV programs, however, the commission initially denied each proposal to rate base EV infrastructure ownership. The PSC has since decided to take a deeper look at EV policies in a new proceeding. Kansas City Power and Light has pursued its own charge station pilot without regulatory preapproval from either state in which it operates. When neither Kansas nor Missouri regulators would allow any portion of its costs for 1,000 installed charge stations (with 2,000 ports) to be recovered through general rates, the cost and risk were absorbed by the utility, which has initiated the service at no cost to users. However, recently, the Missouri Commission approved most of the recovery of these costs in a multi-party settlement proceeding that include other provisions as well regarding rate design and EV infrastructure. Moreover, Ameren Missouri currently has an EVSE proposal pending before the Commission.

- **Michigan:** The commission has initiated several technical workshops, and notice and comment periods, to engage with the broad stakeholder community in Michigan, and

specifically the auto manufacturers, to develop policy guidance and direction for the utilities and stakeholders. The commission deferred action on a proposal by CMS Energy to build and deploy several inter-city DC fast charges in its service territory; instead, the commission established a series of technical workshops in which it explored a comprehensive range of issues related to EV adoption and EV infrastructure spanning several months. In response, the two regulated utilities in Michigan – CMS Energy and DTE Energy – have filed EVSE proposals separately in the context of larger general rate cases, which are presently pending before the Commission. (Case No. U-18368, with Commission Order issued on 12-20-2017).

The Risks of No Preparation

In a previous Decision, the Commission stated that, at some future point, a 'critical mass' penetration of EVs will have a significant and potentially adverse impact upon the electric grid, particularly regarding peak demand.[21] As is standard practice with any new customer load, including EVs, the utility will invest in and maintain its electricity system to serve that load. This report acknowledges that a potential mix of policies and programs, reflecting the market structure, supply mix, load dynamics, and societal goals may lead to EVs becoming a substantial benefit to the system, but without a proactive exploration, unmanaged EV growth could lead to:

- Higher costs for all customers,
- Less reliable, less resilient system.
- Shorter life for grid infrastructure components
- Risk of stranded assets owing to proprietary EVSE networks
- Requiring greater investment in gas-fired peak and flexible capacity
- Making the grid less efficient
- Inhibiting integration of renewable sources
- Increased emissions from the electricity grid if charging is unmanaged

However, the biggest risk may be that EV adoption could lag and Colorado will not be prepared to enjoy the benefits of widespread transportation electrification (discussed in Section II) without investment by utilities in EV infrastructure and related programs,

Distribution Impacts

Even at lower vehicle penetration levels, an electric utility's distribution system could see impacts from charging "clusters" in early adoption neighborhoods or from public DC fast charging, which can draw as much electricity at a given time as an entire commercial complex. For a number of socio-economic reasons, EV adoption includes a "clustering effect" — if one

[21] Decision No. C11-0406 issued April 19, 2011 in Proceeding No. 10I-099EG.

person buys a vehicle, the chance their neighbor does as well rises significantly.[22] Research from the National Renewable Energy Laboratory (NREL) finds distribution transformers may need to be replaced more frequently, and peak load could push system limits, with just one or two EVs on a neighborhood circuit. As a second-wave of EV purchasers comes online, research has suggested they will not be as engaged with energy management, or respond to incentives as their early-adopter predecessors.[23]

Peak Load

As more DC fast charging stations are installed, particularly when concentrated in charging hubs in downtown areas or along travel corridors, local distribution lines could experience significant local spikes in demand. These impacts will be highly dependent on the level of vehicle penetration, when charging occurs, and where public infrastructure for charging is developed.

Planning

In a recent paper published by Advanced Energy Economy, *EVs 101: A Regulatory Plan for America's Electric Transportation Future,*[24] the authors found that a key implication of these infrastructure impacts of EVs is that electric utilities will be responsible for some level of infrastructure investment to support charging, regardless of whether the utility is directly investing in the charging infrastructure. At a minimum, when conducting distribution and transmission system planning, utilities should be considering contingencies that include significant penetration of EV charging. The authors state that proactively addressing the regulatory aspects of EVs will help accelerate adoption, enhance the benefits they provide, ensure utilities pursue system investments that seek to maximize benefits and limit costs, and mitigate any challenges that could arise as the number of EVs on the road grows.

If utilities and regulators hope to shape how and where EV users charge their vehicles, they will need to act early to engage other stakeholders to influence the evolution of technology, infrastructure, policy, and customer expectations.

Beyond siting and planning issues, another risk pertains to stranded assets, a cost burden that utilities and ratepayers would likely share. Beginning a public charging infrastructure program without understanding broader market conditions and trends may result in siting and construction of infrastructure that is not optimally located for current or future customer usage. Utilities, Regulators, the Colorado Legislature, and stakeholders should be working in concert with the EV

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[22] Utility Dive: Uncoordinated trouble? Electric vehicles can be a grid asset, but only with planning and investment (1/31/18). https://www.utilitydive.com/news/uncoordinated-trouble-electric-vehicles-can-be-a-grid-asset-but-only-with/515787/

[23] (National Renewable Energy Laboratory (NREL), 2018)

[24] (Advanced Energy Economy (AEE), Sept 2018)

charging industry to establish incentives that are aligned toward increased utilization of both charging stations and existing utility assets.

A collaborative stakeholder effort can ensure that the potential benefits of EV adoption in Colorado (discussed in the next section) be maximized while ensuring just and equitable treatment for all ratepayers.

II) Beneficial Electrification

The Commission tasked the Working Group with several questions regarding utilities' pursuit of beneficial electrification of the transportation sector. One key question included how the Commission would address proposals by utilities seeking to make rate-recoverable investments in the pursuit of beneficial electric load growth such as EVs. The Commission is interested in determining what information or data would be necessary to evaluate a proposal, as well as what types of analyses should be conducted in order to determine both cost-effectiveness and prudency. In response to these questions, the CoPUC Working Group formed a sub-topic Work Group focused on Beneficial Electrification from EVs.

The Beneficial Electrification Work Group attempted to identify the benefits and costs that could be included as part of a Commission review of EV investments or programs proposed by utilities. The discussion included an effort to identify the timing of short-term and long-term benefits, as well as the up-front costs to both the utilities and ratepayers. The Work Group was asked to identify any steps the Commission could take to ensure that potential investments in charging infrastructure would be properly sited to maximize benefits to the system and minimize potential risks such as underutilized investments. Finally, as instructed by the Commission, the Work Group identified states and utilities that are leading the way with innovative filings and pilot projects that attempt to maximize the benefits of Beneficial Electrification.

Identifying Beneficial Electrification

Beneficial electrification is a term for replacing direct fossil fuel use (*e.g.,* gasoline, propane, and heating oil,) with electricity to produce benefit(s). Electrifying transportation, water heating, and space heating can produce multiple benefits, including improving the management of the electricity grid, cost savings for utilities, air and GHG pollution reductions, and fuel cost savings to customers, as well as creating new business opportunities and new load growth for utilities. While there is growing interest in all of these technologies, most of the current focus is on the development of the EV market to displace gasoline and diesel use.

Consultants, national laboratories, and research organizations including RMI have conducted an extensive review of literature on EV cost-benefit analysis.[25] RMI has found that the benefits of electrifying transportation are felt by EV drivers, utilities, ratepayers, and communities. In addition, an MJ Bradley and Associates Report estimated that a mass market for EVs could

[25] (Fitzgerald & Nelder, 2017)

provide cumulative benefits of $43 billion to the State of Colorado. The benefits to Colorado may include:

1) reduced electric bills resulting from improved utilization of the grid and associated incremental revenue (which MJ Bradley estimates to be $4.1B);
2) reduced expenditures on transportation fuel and vehicle maintenance (which MJ Bradley estimates to be $29.1B); and
3) the societal value of emissions reductions of both GHG and criteria pollutants (which MJ Bradley estimates to be $9.7B)[26]

Despite the multitude of analyses showing cost-effectiveness of vehicle electrification over the long-term, some Work Group participants argue that the Commission should evaluate any program or investment by utilities on its own merits. One possible evaluation could involve recommending utilities present a framework for an EV focused cost-benefit analysis in order to justify investments in pilot projects, charging infrastructure, or other expenses related to promoting load growth and system efficiency from EVs. The Work Group identified the fact that many benefits can be difficult to quantify, such as load-shifting, demand response potential, economic development, and emissions reductions.

The response by the Joint Participants, representing 21 Work Group stakeholders[27] stated a somewhat different perspective, that "*The Commission should not impose cost-benefit tests developed for energy efficiency programs upon transportation electrification programs and should avoid impossible counterfactuals related to attribution." Instead, the Commission should require the utilities to maximize benefits and minimize costs and should require the utilities to track and report on metrics*." This perspective is based on already available evidence of system, public, and customer benefits of expansion of the EV market in Colorado. Furthermore, EV growth should not be disadvantaged by utility line-extension and investment policies compared to other types of load growth for which the utility invests to serve. As an example, the Commission should note that utilities are not required to examine whether a new house would have been built but-for utility line extension policy.

Examples from other states have shown it to be challenging to estimate how quickly the market for EVs will grow, and when and how the benefits of EV loads can be realized. However, Coloradans appear to be adopting EVs rapidly when compared to other states. This is a unique situation for the Commission in that while there are certainly market indicators, including industry announcements on EV model availability, to drive adoption, customers must be assured

[26] (Lowell, Jones, & Seamonds, April 2017).

[27] Joint Participants include The Alliance of Automobile Manufacturers, Boulder County, BYD North America, ChargePoint, City and County of Denver, Conservation Colorado, eMotorWerks, EVBox, EVgo, GM, Greenlots, National Car Charging, Natural Resources Defense Council, Proterra, Regional Transportation District, Rocky Mountain Institute, Sierra Club, Siemens, Southwest Energy Efficiency Project, Vote Solar, and Western Resource Advocates.

that charging is available when and where needed. It will be a calculated leap of faith to compel market development to accelerate the benefits.[28]

MJ Bradley recently conducted studies for several Midwest states including Illinois, which considered the impacts of a "moderate" and "high" adoption scenario for EVs in the state, with EVs reaching either 18 percent or 56 percent of light duty vehicles in 2050. In both scenarios, the net present value benefits to utility customers, Illinois drivers, and society would total $12.2 billion (moderate) or $43 billion (high).[29] A similar study conducted in Michigan had similar results: $8.6 billion in cumulative net benefits in 2050 under a "moderate" adoption scenario, and $31 billion in a "high" adoption scenario.[30]

Energy + Environmental Economics (E3) conducted a study specific to American Electric Power's (AEP) Ohio service territory, which found that increased EV adoption under two scenarios resulted in $380 million in regional net benefits in a "high" adoption case and $256 million in a "low" adoption case, with a regional net benefit of $1,595 per vehicle sold in the high adoption case.[31]

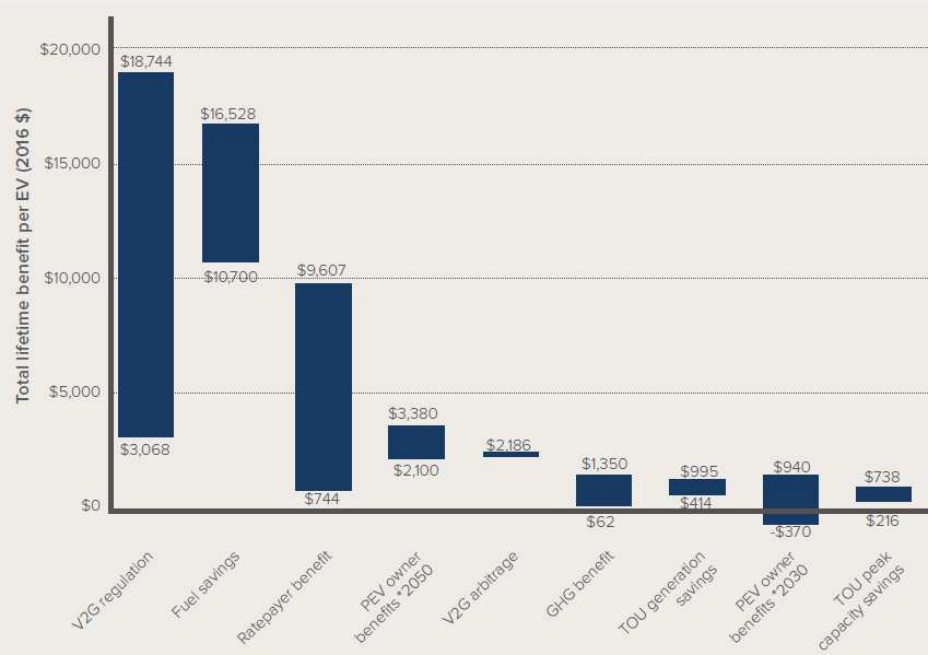
[28] https://www.colorado.gov/governor/sites/default/files/colorado_electric_vehicle_plan_-_january_2018.pdf, CO ranks 8th per capita.

[29] (M.J. Bradley & Associates, September 2017)

[30] (M.J. Bradley & Associates, August 2017)

[31] (Energy and Environmental Economics (E3), April 2017)

Figure #8: Range of Stakeholder Benefits for EVs



Source: RMI Gas to Grid, 2017[32]

While there is not complete agreement among the Work Group participants on every benefit that needs to be quantified in an application, this report presents the three major types of benefits and briefly describes how electrifying the transportation sector can potentially maximize these benefits.

Economic Benefits

As EV adoption grows, studies have demonstrated that there may likely be downward pressure on electricity rates over time as charging facilitates better utilize the grid; time-of-use (TOU) rates and smart charging technology are implemented and the new EV loads result in increased marginal revenues to the utility. These could result in economic benefits not only to EV drivers, but potentially all ratepayers and utility shareholders.

> **Driver Savings.** A large set of EV benefits to customers comes from the value that they can gain in the form of reduced operational costs. Per mile driven, electricity ($/kWh) is less expensive than gasoline ($/gallon), creating immediate cost savings for EV drivers. With TOU rates or managed charging programs, EV owners may be able to lower their bills further by charging at beneficial times for the grid. Substantial savings are also available to EV drivers in the form of lower maintenance costs throughout the life of the

[32] RMI reviewed over 150 pieces of recent literature on EVs, and summarized the quantifiable benefits, including GHG reduction, gasoline savings, savings for all utility customers, savings in system investment, fuel and maintenance savings, and the potential for managed charging of EVs to deliver various grid benefits.

vehicle. Lower operational cost along with low maintenance costs can yield a significantly lower total cost of ownership (or TCO).

Capacity Investment Savings. Electrical systems operate below maximum capacity for most of the year, so with optimal EV charging management, potentially millions of vehicles could be electrified without adding significant investment in new generation assets. If underutilized capacity is used more frequently, the fixed capital costs will be spread out over more sales, which would reduce pressure on rates for all customers. This is referred to as the benefit of incremental load or revenue.

Equitable Benefits. Although there are some hurdles to overcome to encourage EV adoption among low-income populations, as further discussed in the Education and Outreach chapter, more transportation electrification could especially benefit such populations, who spend a disproportionate portion of their incomes on transportation and energy costs and who often endure most of the air pollution caused from vehicles. Low-income ratepayers may especially benefit from the electrification of transit fleets, and from the downward pressure on electricity rates caused by increased EV adoption. Full integration of equitable access considerations in planning, such as the location of infrastructure investments and targeted rebates will have beneficial public policy impacts.

Grid Benefits

Importantly, rate design can lead customers to behave in ways that lead to beneficial electrification. The topic of rate design is covered in detail later in the document. Additionally, EV charging can potentially provide numerous distinct services to the grid as well as benefits for ratepayers:

Grid stability. EVs represent an opportunity to expand utility business and promote new beneficial incremental load growth. However, the greatest benefit to the grid may lie in increased flexibility on the system. Light-duty EVs generally are only used a few hours of the day and are frequently charged at home overnight. A full charge with a Level II charger requires around five to ten hours, depending on the range of the vehicle and whether any load management technology is used. This flexibility may allow utilities, third parties, or customers to manage EV charging within a narrow window to benefit the electricity grid through a variety of programs. Medium and Heavy-Duty EVs such as fleets can provide additional grid benefits (discussed further in Section IV).

Peak shifting. Because electricity demand is highest in the late afternoon and early evening when EV customers might normally plug in their vehicles after work, uncontrolled charging can result in additional peak demand. This could result in

expensive distribution network upgrades and additional generation capacity. However, EV charging could be shifted to either late at night, when electricity demand and rates are the lowest, or during the day when solar power is most plentiful. This can be done using well-designed opt-in incentives (such as TOUs rates) or smart charging technology.

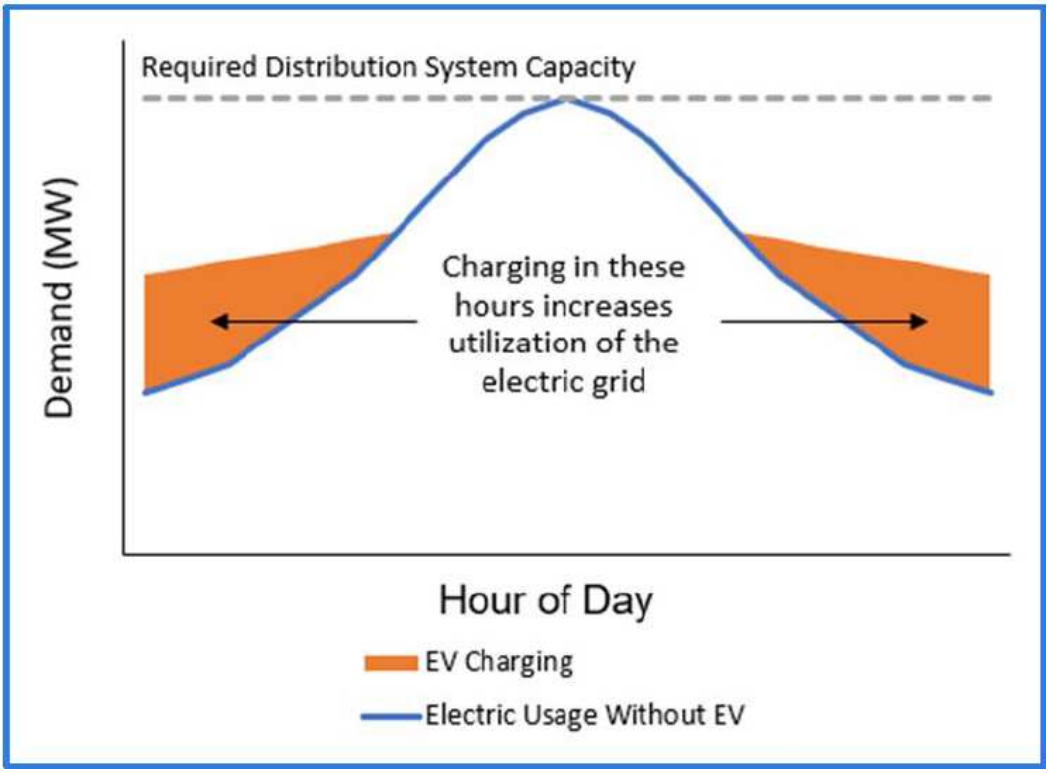
Demand response/managed charging. With technology that enhances communication between the EV or EVSE and the grid (often called V1G), charging can be paused or slowed when demand spikes or there are disruptions in supply, which can prevent a drop in frequency. When demand drops or additional renewable resources come onto the grid, EV charging can be turned on or sped up and utilized for different benefits. This capability, representing an evolution to traditional demand response (DR), has been demonstrated in many trials, for public Level II, DCFC, and household charging.[33] This is no different from what is done in existing DR programs with other technologies. DR programs could thus become technology agnostic where the customer has the choice of whether to turn down his or her thermostat or stop charging in order to respond to a DR event.

Integration of Renewable Energy. Manageable EV loads can also enable new kinds of grid services and help integrate variable renewable generation resources, particularly overnight when wind generation may exceed current demand. Pilot projects are also being developed to deal with oversupply of solar, particularly in California. Some use cases can be particularly useful for renewable integration such as workplace charging.

Frequency regulation. As EV adoption reaches much higher levels, future benefits to the grid could include providing active power support and frequency regulation services via Vehicle-to-grid (V2G) technology. Through V2G technologies, EVs can provide power to the grid, which may significantly improve the performance of the stability, efficiency, and reliability of power grid operation. This may also enable spinning, non-spinning, and supplemental reserve capacity (available to be dispatched in lieu of normal supply resources). V2G technology is still in its early development stage, but could provide many benefits beyond frequency regulation in the future. There are concerns about the impact of V2G on battery life, as well as being able to capture the value power support and frequency regulation. Other technologies such as Vehicle-to-Home (V2H) and Vehicle-to-Building (V2B) could provide more immediate benefits in certain situations.

[33] (Myers, 2017)

Figure #9: Increasing Utilization of the Electric System



Source: Gridwise Alliance

A recent analysis conducted by E3 shows that California utility customers are likely to benefit from the additional revenue provided by EV smart charging.[34] The E3 study for the California Electric Transportation Coalition that assessed the costs and benefits of California's Zero Emission Vehicle Program found California's utility customers are better off because of growing EV use, because incremental revenues to the utility can pay down fixed electric system costs and be shared with customers as reduced electricity prices. A concern is if EV charging takes place in the late afternoon when people arrive home from work it could actually exacerbate peak demand issues.[35] However, the M J Bradley study for Colorado found net ratepayer benefits even when consumers start charging immediately after coming home from work, but the benefits are much greater if TOU rates are used to switch most residential charging to begin after the afternoon peak.

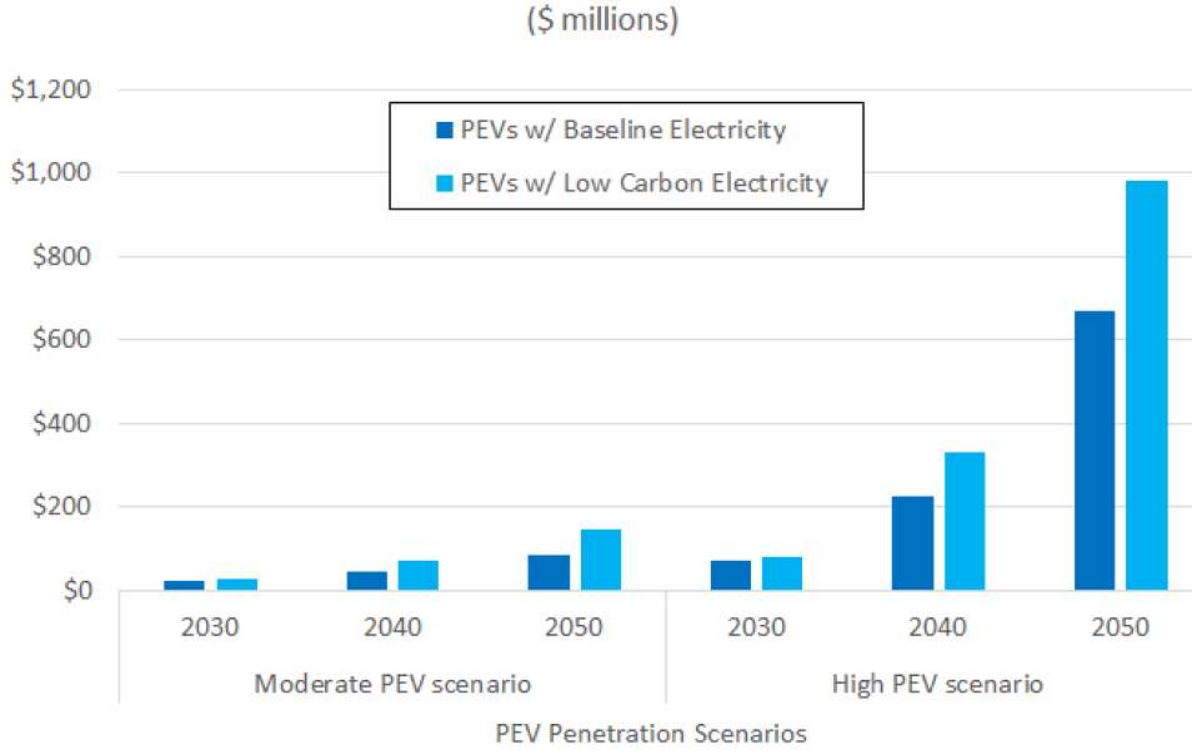
Environmental Benefits

In addition to electricity grid and economic benefits, a growing EV load could have significant environmental benefits. Research by the City of Denver and SWEEP showed that compared to a

[34] (Ryan & Lavin, 2015)
[35] (Salisbury & Toor, Feb 2016)

gasoline vehicle, an EV reduced NOx emissions by 38 percent, VOCs by 99 percent, and GHG emissions by 30 percent compared to a new gasoline vehicle. The same study compared an EV to an average gasoline vehicle on the road in 2016, where NOx is reduced by 63 percent, VOCs by 99 percent, and GHG by 43 percent. Forecasting a cleaner electricity mix by 2025, an EV will reduce NOx emissions by 84 percent, VOC emissions by 99 percent, and GHG emissions by 49 percent compared to a new gasoline vehicle in that year.[36]

Figure #10: Colorado NPV of Annual Social Value of EV CO_2 Reductions



Source: MJ Bradley & Associates, April 2017

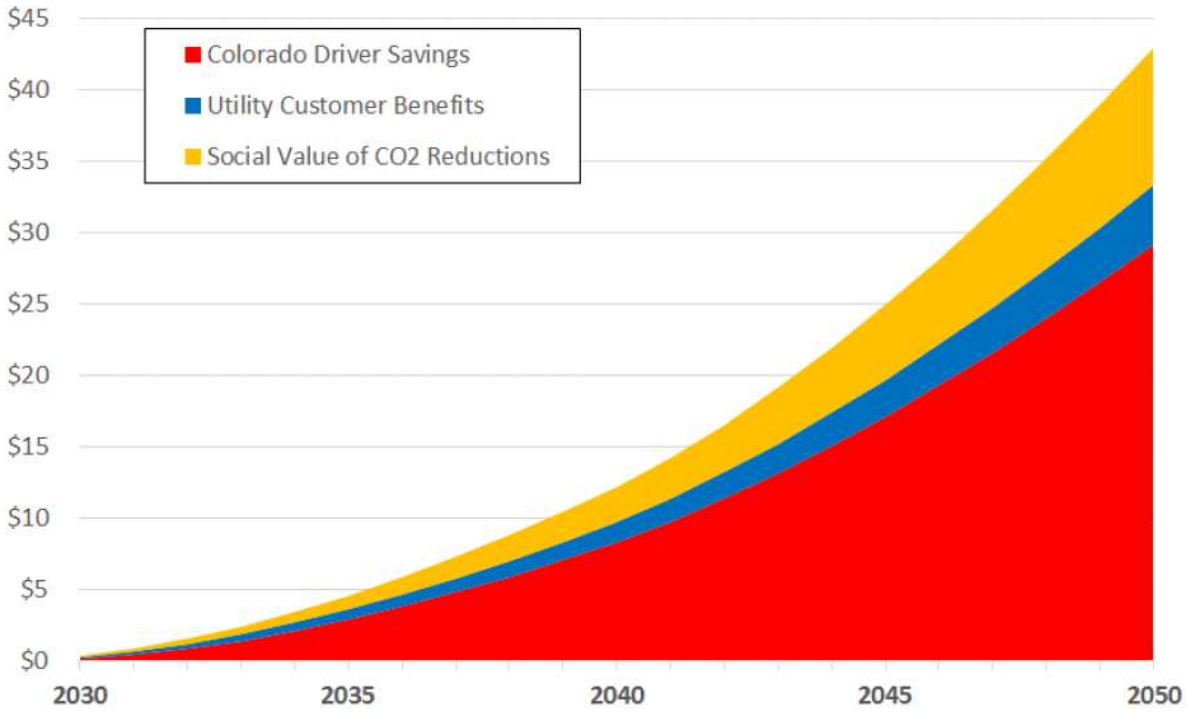
Medium-and heavy-duty ICE vehicles are a large source of smog-forming emissions and fine particulates, particularly in urban areas, so electric buses, local delivery vehicles, and freight trucks have significant potential to improve air quality.[37] These emissions also disproportionately affect disadvantaged communities. Additionally, school buses in particular affect a vulnerable population, as an estimated 27 million children in the country board buses powered by diesel fuel.

[36] *Ibid.*
[37] (Advanced Energy Economy (AEE), Sept 2018)

Figure #11: NPV Cumulative Net Benefits from EVs in Colorado

(High PEV Scenario- Off-peak Charging - Low Carbon Electricity)

$ billions



Source: MJ Bradley & Associates, April 2017

In response to questions on evaluating benefits and costs of transportation electrification, the Joint Participants state that the Denver metro area and North Front Range are currently out of compliance with the federal ozone standard, and are classified as a moderate nonattainment area. These regions are likely to be bumped up to serious nonattainment status due to the significant violations that took place in 2018. Source apportionment conducted by RAQC has found that the two major sources of ozone precursors are oil and gas extraction and on-road vehicles. They point to an analysis conducted for the RAQC and the City of Denver in 2017 that found that by 2025, the emissions from an EV operating under the current grid mix would emit 84 percent lower NOx emissions and 99 percent lower VOC emissions than a new gasoline vehicle meeting Tier 3 emissions standards. [38]

Public Service Company of Colorado (Public Service or Company), in its response comments, states that the Company views many of the same benefits to the system as has been identified through this Work Group process, but notes that one potential area of non-alignment among parties is the treatment of environmental costs and benefits. Public Service states that it would encourage cost-benefit analysis primarily on "hard" costs as measured through customer bills

[38] Regional Air Quality Council, Moderate Area Ozone SIP, 2016, Table ES-2, https://raqc.egnyte.com/dl/q5zyuX9QC1/FinalModerateOzoneSIP_2016-11-29.pdf_/

rather than externality-type costs such as the above-mentioned environmental benefits. The Company notes that they are not debating here the existence or levels of reduced emissions, but believes the best case for EVs can be made by relying on the set of costs and benefits that are measurable with accuracy.

Public Service adds that an analysis of an EV proposal or program might measure direct or "hard" costs in a base case, and then consider emission benefits (*i.e.,* a cost of carbon) as sensitivities to inform Commission decisions. This is a similar process to how Electric Resource Planning analysis is now performed, and the Company feels that this type of analysis has helped to inform recent Commission decisions.

The CEC states that minimizing costs and maximizing benefits is philosophically appropriate but CEC cautions that to ascertain the cost-effectiveness of an investment, all stakeholders will need transparency into the all-in measurable costs, and similarly the quantifiable benefits. CEC notes that the temporal relationship is also important, and stresses that ratepayers should not be expected to pay a premium today on future benefits that may not materialize.

Ford points to its 2017 through 2018 Sustainability Report that states much of Ford's work to improve the life cycle performance of its products has focused on tailpipe – or tank-to-wheels) emissions. However, Ford continues to study the well-to-wheels (WTW) impacts, which account for the effects of both the production and consumption of the fuels. Estimates of WTW emissions vary with the specifics of the vehicle, engine, and fuel type. In vehicles with alternative powertrains (*i.e.,* electrified), overall CO2 emissions are dependent on the carbon intensity of the fuel production process. The emission benefits of lower-carbon options such as EVs are maximized when the electricity used is generated from renewable sources.[39]

Greenlots responded by noting that just because a particular benefit can be difficult to measure, that does not mean it does not exist or should not be valued. It added that in the context of cost-benefit analysis, the least accurate course of action is to not include a broad and recognized real benefit because the numbers or accounting are difficult or beyond traditional cost tests. Greenlots points to Societal Costs Tests (SCT) being explored and used in other jurisdictions as an example of a more holistic form of cost/benefit accounting.

Examining Up-Front Costs and Short Versus Long-run Benefits

The Beneficial Electrification Work Group was tasked with identifying potential up-front costs, as well as looking for analysis on estimating when the above mentioned benefits might occur and

[39] "Greenhouse Gas Emissions in the Vehicle Lifecycle," Ford 2017-18 Sustainability Report, https://corporate.ford.com/microsites/sustainability-report-2017-18/customers-products/reducing-emissions/life-cycle-approach.html.

be reliably measured. The EV market currently represents a minor impact on the electric grid and there are not easy ways to accurately measure short-term benefits and costs.

As CEO/RAQC points out in its response comments in the case of Make-Ready Infrastructure investments (see Section III), as an example, the upfront costs would be the initial capital investment (though as with other utility investments this would be depreciated over some period of time). There may also be some ongoing operating and maintenance costs generally similar to those of line extensions that the utility has invested in for decades.

Other up-front costs also may include upgrades to neighborhood distribution transformers and secondary side service as the local load could exceed current transformer capacity. This may particularly occur if EVs "cluster" in certain neighborhoods. Research from California suggests that these costs will be relatively small, however, totaling less than 1 percent of the utilities' annual capital budgets. It should be noted that the California Public Utilities Commission (CPUC) ordered the utilities to track EV-related upgrade expenses in order to provide an empirical basis for setting policy on upgrade costs.[40] These types of grid investments are similar to any other type of grid investment required to address load growth and serve customers reliably. Requirements that utilities forecast and plan for such growth would be useful to ensure smart investments and to best utilize available flexible charging and other capabilities of EVs.

The Joint Participants point out that *when charging is properly managed or incentivized, EVs do not pose a stress to the electric grid and that costs associated with integrating EV load will likely be insignificant in the short term.* Pointing to the analysis from California with a large number of EVs on the road, often clustered on specific distribution circuits, adverse grid impacts have been very small. Approximately 0.17 percent of EVs have triggered the need for a distribution system upgrade.[41] They point out that costs associated with accommodating EV charging account for less than one hundredth of 1 percent *i.e.* (1/100 of 1 percent) or (0.001 percent) of total distribution capital expenditures.[42]

While up-front costs and early potential benefits can be identified in a formal utility application, research by RMI, MJ Bradley, and several others report that net benefits become more significant in the long-term (*i.e.,* the 2030 to 2050 timeframe). With this in mind, the Joint Participants suggest that the Commission should encourage utility investments and programs that accelerate widespread transportation electrification so that utility customers realize those benefits sooner rather than later.

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[40] (McCoy, Jan 2016).
[41] (Synapse Economics, March 2018)
[42] *Ibid.*

Public Service states that some degree of further analysis of EV programs, their costs, and their eventual benefits, is likely needed to understand whether a specific program or investment that a utility might make can "pay off" over the long-term in terms of benefits to other customers. They recommend that this could be done on a specific Colorado utility basis with data potentially collected through a limited offering program. Alternately, the Company suggests the Commission might review the set of cost-benefit literature and studies that now exist, even though these are not specific to any Colorado utility. Public Service agrees with many of the other Work Group participants that long-term benefits could likely equal or exceed shorter-term costs and these conclusions might support approval of filings for initial or pilot-scale investments or EV programs.

CEC recognizes in its comments that there are potentially untapped benefits of electrifying the transportation sector but notes there are still indeterminate costs and potential risks of over-investing. Thus, CEC recommends approaching this new stream of costs and potential benefits with a blend of optimism tempered by circumspection, within the existing framework of governing statute and time-tested public utility regulatory principles.

Tesla states that short-term benefits can be considered within the next five to ten years consistent with the duration of early EV charging infrastructure utility programs deployed in other parts of the country. Greenlots stresses that costs can be minimized and benefits can be maximized as early as possible with the use of smart charging technology and programs as an essential component of EV load management. Siemens adds that costs can be additionally minimized by having diverse business models being applied to EV infrastructure deployment including procurement of technology at scale to drive cost efficiencies.

Siting of Infrastructure

The issues of optimally siting public EV infrastructure led to a diverse set of opinions among participants, as states across the country are also taking a variety of approaches. A key question remains how much of a role the Commission should have in the siting of EV infrastructure such as a public DCFC station. The utilities and market participants have the business expertise to determine the ideal locations; however, as will be noted later in the report, the current economics of DCFC under current rate designs are extremely challenging as private investment may not be enough to sustain this infrastructure in certain locations under current conditions. As we mentioned in the introduction, without enough publically available DCFC, the EV market will be significantly hindered. Without a growing number of EVs on the road, the utilization of many DCFCs will remain low and unprofitable.

Many experts suggest that the siting of charging stations should be evaluated based on not only maximizing benefits to the system, but also supporting the EV market as a whole. There are certain sites that are likely to bring greater benefits to the electric grid, particularly if benefits are defined by a charging station's ability to maximize adoption of EVs and the resulting increase of manageable load. A comprehensive planning analysis conducted by the utility and stakeholders can ensure that charging stations are effectively sited, providing the best returns on investment while also meeting critical service requirements. Tools are being developed across the country as states grapple with this important issue, including NREL's EVI-Pro, and at the University of California at Davis in partnership with Pacific Gas & Electric.[43]

The Joint Participants recommend the Commission consider the fact that utilities will likely only install Make-Ready infrastructure at sites where there is a willing site-host such as a fleet operator, who will generally be making a much more significant investment in a vehicle or multiple vehicles (Make-Ready Infrastructure is examined in Section III). This will naturally minimize the potential risk of underutilized investments. This, however, does not provide incentive for investments in multi-unit housing or workplace charging. In addition, the Joint Participants recommend the utilities identify how they will consider and prioritize potential applications from would-be site-hosts for Make-Ready support. Additionally, utilities should provide more visibility into available capacity on their electric distribution system for the purpose of siting charging infrastructure. This can be done with a detailed hosting capacity analysis provided by the utility for all interested stakeholders.[44]

Public Service states in its response that it shares the Commission's goal of maximizing benefits, minimizing risks and avoiding underutilized investments. To the extent Public Service proposes to own supporting infrastructure for EV charging, they believe the Commission will have a role in minimizing risks and avoiding underutilized investments. Potentially, Public Service or Black Hills Colorado could propose to the Commission to invest in supporting infrastructure, and in that application or similar filing, the utility would have to make the case that the infrastructure is a good investment from a risk and usage perspective. The case would likely include some degree of location or siting information (*e.g.,* a Make-Ready Infrastructure program aimed at transit fleets). The Commission would then have the role of judging whether the risk and usage aspects support an investment presumed to be prudent.

CEO/RAQC states in its response that a charging network must provide drivers a variety of charging options. They assert that public charging stations that include DCFC are likely to result in inconsistent, and therefore, unmanageable load. However, they note that charging stations

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[43] PG&E, https://www.pge.com/en/about/newsroom/newsdetails/index.page?title=20161129_pge_launches_new_tools_to_support_electric_vehicle_adoption_in_northern_and_central_california

[44] In response, Tesla notes that the Commission should ensure that charging locations should be determined based off customer-need, and that the utility should not be incentivized to disapprove projects that do not align perfectly with grid capacity.

with inconsistent demand are just as important as stations that experience reliable, permanent load (such as workplace or fleet charging) because they provide long-distance charging needs and the perception of widespread charging availability and therefore stimulate the market and generate broader benefits to the entire system. They suggest that the Commission could help ensure that utility investments in EV charging and related policies are effective by supporting those that stimulate the market by providing drivers with a variety of charging options, while also providing system and societal benefits.

In its response, Tesla[45] states that when evaluating charging infrastructure investments, the Commission should incorporate lessons learned from other states and focus on Level II investment where demand is growing similar to what initial programs in California and Nevada have done. Greenlots adds in its response that while location is certainly important, many factors go into where stations can ultimately be installed and that modeling and needs assessments can be useful guides, but are not dispositive tools.

Recommendations

The Working Group was tasked by the Commission to include information relating to how the Commission would address proposals by utilities seeking to make rate-recoverable investments in the pursuit of beneficial electric load growth. In particular, the Commission was seeking input on what types of analyses should be conducted in order to determine cost-effectiveness and prudency and what information or data would be necessary.

- While there was discussion regarding building a consensus of benefits and costs, the assigned Staff agrees with Public Service who stated the report could only reflect consensus as it exists among parties. At this point in time, there has not been sufficient dialogue to have a detailed consensus among parties on Commission consideration of costs and benefits.

- The assigned Staff concludes that using the benefits described in the MJ Bradley Report as a basis for such consideration is appropriate at a high level. However, the burden of proof will fall to the utilities to estimate those costs and benefits, specific to each utility, and present them transparently in applications to the Commission based on the best available data. The Commission should continue to review the growing set of cost-benefit literature and studies that now exist, even though these are not specific to any Colorado utility. It will be important for all stakeholders to follow the development of new cost-benefit analysis, such as the Holistic Value Test being developed by The Brattle

[45] Tesla notes that despite the current statute, the Commission should only determine whether utility-owned stations are properly sited. For private investments, there should be no concern about where stations are sited or whether they are underutilized.

Group in cooperation with EPRI. In this early stage, however, it is sensible for the Commission to allow utilities to develop the evidence and data and file cases using various CBA's – including the RIM (ratepayer impact), the total resource cost test, or the SCT – since they bear the burden of proving why such investments are prudent and cost-effective.

- In addition, the Work Group found that efforts to forecast the timing of benefits over the long term are difficult at this stage. The assigned Staff agrees with Public Service that some degree of limited-scope offerings in the form of pilot projects may be appropriately made based on current information perhaps augmented by appropriate supplementary analysis within an application for such programs. Specific pilot projects will be discussed in following sections. Pilot projects could improve the information used for more detailed and comprehensive cost-benefit analyses that may inform broader EV-related programs.

- Finally, the assigned Staff suggests that perhaps a two-track approach would be appropriate: namely, continuing this generic policy docket in which we can examine dynamic and emerging issues generally, while allowing and encouraging regulated utilities to file applications, specific pilot programs, and tariffs related to EVs.

III) Make-Ready Infrastructure Investments

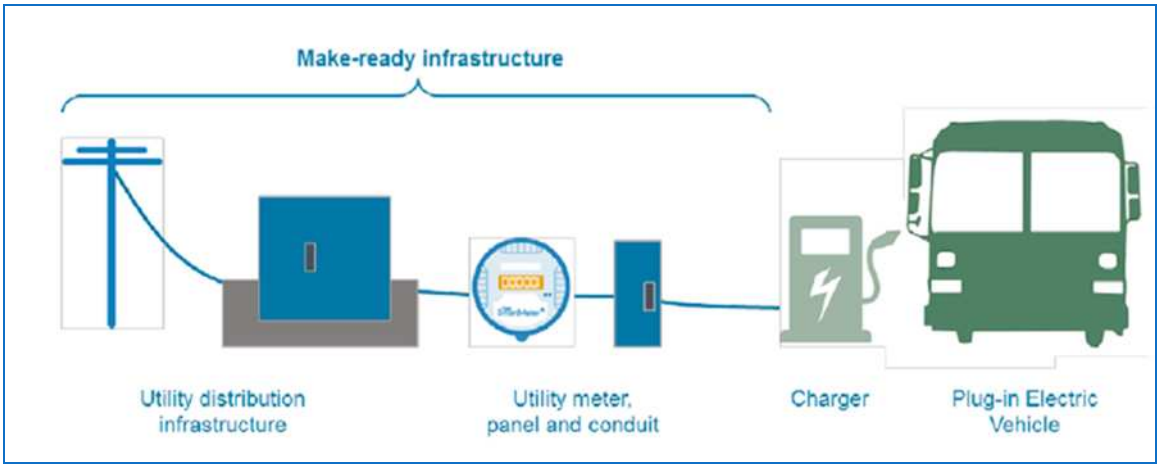
The Commission as well as the CoPUC EV Working Group felt that the issue of "Make-Ready Infrastructure" investments to encourage desirable load growth for EV charging was a very important question to address in this report. With that in mind, a Work Group was formed specifically on the topic. In particular, the Make-Ready Infrastructure Work Group attempted to identify the biggest barriers for utilities to pursue proposals to invest in EV charging Make-Ready Infrastructure and how the Commission might address those impediments.

The Make-Ready Infrastructure Work Group also addressed costs and other policy related barriers to make ready investments for different customers (*i.e.,* residential, multi-family housing, workplace, commercial, and medium- and heavy-duty fleets,). The Make-Ready Infrastructure Work Group further explored the issue of adopting or recommending "Interoperability and Communication" standards for EV infrastructure.

What is Make-Ready Infrastructure?

The Make-Ready Infrastructure model typically involves utility participation beyond traditional demarcation of service at the meter but importantly, does not include utility ownership of the charger itself. As is already common practice for grid investments to support customer load, the utility will locate, design, build, maintain, own, and operate the infrastructure to serve EV charging loads up to the customer's meter. Depending on each state's regulations, a utility may be able to go beyond the customer meter and own and operate infrastructure connecting the customer meter to the charger with or without owning the charger itself. Some states permit utility ownership of the charger, which is beyond the scope of Make-Ready Infrastructure equipment. In an ideal situation to stimulate EV deployment, Make-Ready Infrastructure investment produces a nearly complete "stub" site that can be quickly interconnected with a customer or third-party charging station, streamlining the EV infrastructure interconnection process.

Figure #12: EV Charging Distribution Infrastructure



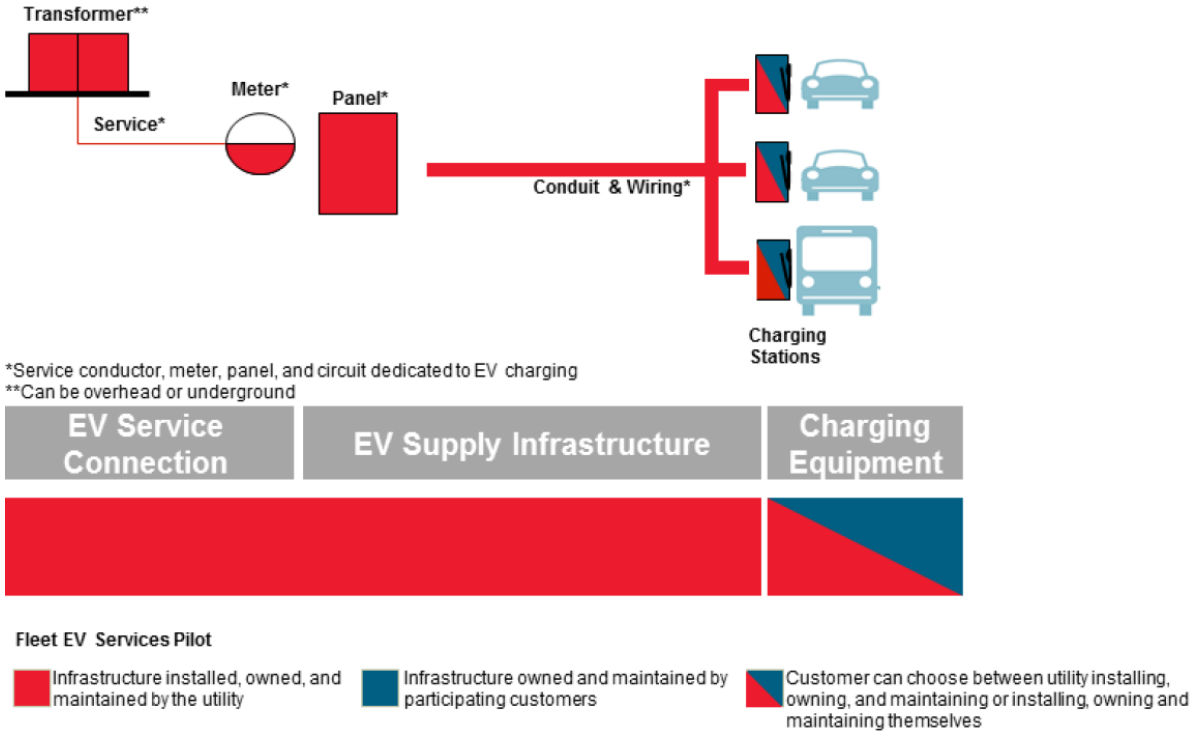
Source: Pacific Gas and Electric

We note, "Make-Ready" refers to the infrastructure depicted in the above diagram, regardless of who owns it. This distinction is important because a make-ready program can involve both utility ownership of make ready infrastructure, as well as utility incentives that offset the cost of the make ready infrastructure in which the site host retains ownership.

The Make-Ready Infrastructure approach limits a utility's investment to the equipment necessary to connect the EV charging infrastructure to the grid. Since this can often be a large part of project costs, some form of utility investment here can likely increase the pace and lower the costs of infrastructure investment that leads to fewer barriers for third-party charging station development.

Public Service describes its interpretation of Make-Ready Infrastructure in two parts: First, the EV service connection includes any needed transformer upgrades, service conductors, and new meter. The utility currently invests in these assets per existing line extension policies. The Company notes there may be a customer contribution to these costs as part of the extension policy. Second, the EV supply infrastructure consists of new service panels, conduit, and wiring up to the charger stub. Public Service states that it has not yet invested in these latter types of assets for EV infrastructure.

Figure #13: Public Service's Make-Ready Infrastructure Model



Source: Public Service

The Joint Participants argue that the single-biggest impediment to utility investment in Make-Ready Infrastructure in Colorado is the lack of regulatory certainty on allowable investment.

Current Law

Section 40-1-103.3 (2018), C.R.S., may place some limits on the utility ownership of EV charging infrastructure. The statute identifies three activities that are presumed to be unregulated: (1) utilizing distributed generation to generate electricity for use in alternative fuel charging; (2) "resell[ing]" electricity provided by a public utility for use in EVs; and (3) buying electricity stored in such vehicles for resale. That section goes on to state a public utility may do any of these three things as unregulated services that are not subsidized by the utility's regulated services.

There is little dispute that the Commission possesses the jurisdiction and discretion to evaluate any proposals regarding EV charging infrastructure owned by regulated public utilities, so long as they do not fall into one of the three categories specifically prohibited by statute. Such proposals may include, for example, authority to conduct pilots or programs for EV charging, or requests to invest in EV Make-Ready Infrastructure. If such a proposal is approved by the Commission, then § 40-1-103.3(6), C.R.S., requires that "[t]he regulated expenditures and

investments made by a public utility to accommodate alternative fuel vehicle charging and fueling facilities are equal in priority to all other infrastructure necessary to serve any customer of the public utility in its service territory, but are subordinate to the safety and reliability obligations of the utility."[46]

On October 11, 2018, Working Group participants including, the Natural Resources Defense Council, SWEEP, Sierra Club, and Western Resources Advocates (WRA) (supported by 20 additional entities),[47] submitted a Statement in Proceeding No. 17I-0692E. The full statement can be found in Attachment A. In the statement, the participants believe that § 40-1-103.3, C.R.S., indicates any other EV charging-related investments or activities not enumerated in the statutory text may be treated as part of the regulated side of the utility's business, provided they are consistent with other statutory provisions and regulatory standards.

The Statement further argues that § 40-1-103.3(6), C.R.S., implies that: (1) the investment in physical infrastructure should be treated similarly to all other investments in the distribution grid; and (2) investments in EV charging infrastructure should not come at the expense of other distribution grid investments the utility would otherwise be making. The statement argues the language applies only to "infrastructure" and should not be seen as limiting the utility's ability to undertake non-infrastructure EV charging programs such as rebates or incentives. The statement also urges the Commission to act quickly to leverage funds that are available pursuant to the VW Environmental Mitigation Trust, and recommends the Commission "invite utilities to submit Applications for EV Make-Ready Infrastructure, including cost-recovery from ratepayers where appropriate."

In its response, CEO/RAQC states that they agree with the Joint Respondents' conclusion that utility investment in, and cost-recovery of, Make-Ready Infrastructure is legally permissible. However, they interpret § 40-1-103.3(2), C.R.S., slightly differently than the Joint Participants, stating it affirmatively exempts certain services related to EV charging stations from being regulated as a public utility by the Commission. Such activities include generating electricity for use in alternative fuel vehicle charging facilities, reselling electricity supplied by a public utility, and buying electricity stored in electric EVs for resale. The primary purpose of § 40-1-103.3, C.R.S., was to allow non-public utilities to sell and buy electricity from charging stations.

CEO/RAQC clarifies that the statute also permits public utilities to participate in these listed activities; however, public utilities cannot charge for the associated costs of these activities in their regulated service rates. CEO/RAQC concludes that, although public utilities do not pay for the entire cost of infrastructure upgrades on the utility's side of the meter as a dedicated

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[46] CEC notes that while the statutory language itself is clear, there is not consensus on its applicability.
[47] WRA Memorandum (Attachment A) filed July 29, 2018

connection for a new EV charging station, or for any of the necessary infrastructure changes on the customer's side of the meter, there is no legal impediment to utilities doing so. According to CEO/RAQC, the Commission has authority to approve such utility expenditures through its general authority over public utility investments.

CEC points out that under § 40-1-103.3(6), C.R.S., investments to accommodate EV charging or fueling cannot take priority or be given preference over other infrastructure investments needed to serve customers, nor can EV related investments compromise a utility's reliability and safety obligations. As a result, CEC recommends adherence to prevailing bedrock regulatory principles, such as prudence, used and usefulness, and cost causation in any future applications or filings. In this respect, CEC takes issue with respect to Joint Participants seeking the Commission's "invitation" to utilities to file applications for approval to invest in make ready infrastructure and providing guidance in terms of what information is required for consideration. Noting the lasting impacts on ratepayers, CEC cautions against the Commission's engagement in *de facto* rulemaking, which may occur from defining or implementing any criteria as a generally-applicable standard for utilities to follow. CEC agrees with Public Service that, at their discretion, utilities are free to make investments in make ready infrastructure in a manner consistent with current statutory requirements, regulatory principles, and approved tariff provisions.

Role of the Utilities

In addition to allowing Make-Ready Infrastructure investments, there are various models of utility EV investment developing throughout the country. As mentioned previously, Utilities have the potential to play a wide range of important roles in EV infrastructure deployment, operations, and maintenance, depending upon state law, or existing regulations. Currently, regulators and utilities are experimenting with several of these roles, perceiving a range of opportunities to support EV customers and explore new load growth from EV deployment. RMI has developed a helpful description of these various utility roles:

1. Utility as Facilitator: The utility treats EV charging like other potential load, providing nondiscriminatory electric service when and where requested, but not engaging in the business of vehicle charging.
2. Utility as Manager: In addition to delivering electric service to the location of the vehicle charger, the utility manages the charging operation to better integrate charging with grid capabilities and grid needs.
3. Utility as Provider: The utility provides both the electric service to the charger and the charging equipment and charging service. It receives a cost-based payment for charging.

4. Utility as Exclusive Provider: Vendors other than the utility are prohibited from providing charging service to the public, under laws precluding the resale of electric service.[48]

Utilities in Colorado can also invest in Make Ready equipment beyond the typical categories of distribution system equipment, but not including the charger, according to the analysis of CEO/RAQC and the Joint Participants. This variant is not specifically identified in the RMI model, but make ready investments are a common element of utility programs in many states. These various statutory constraints on the utility's role are a unique fixture to Colorado.

Make-Ready Infrastructure for Different Customer Types

The Work Group gathered information on various costs and barriers associated with different customers (*i.e.,* residential, multi-family housing, workplace, commercial hosts, fleet charging, medium, and heavy duty). Research and experience among the participants showed that these costs and barriers vary significantly and that the Make-Ready Infrastructure model may not be sufficient to overcome barriers in some segments.

Based on other states' leadership, one way that has been shown to minimize charging infrastructure costs is through building codes that require buildings to be "EV ready" with panel capacity and conduit in place at the time of construction.[49] This minimizes significant retrofit costs, which can involve disturbing and repairing pavement or sidewalks to setup the stations as well as running hundreds of feet of conduit, if electrical supply is located in places far from parking areas. This approach promotes customer choice of charging equipment and services and could encourage a competitive marketplace by allowing charging providers to compete based on product and network quality. This could be helpful to giving site hosts such as commercial and office buildings, multi-unit housing, and government buildings, the tools to manage their own property and features to meet their specific needs.[50]

One particularly important issue facing the EV industry is accessing the multi-family housing market. Analysis shows that most charging currently takes place at home, so the availability of home charging is thought to be critical to EV adoption for many households. Particularly in

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[48] (Fitzgerald & Nelder, 2017)

[49] Colorado is a 'Home Rule' State and each jurisdiction has the responsibility to include EV readiness into its building code. For an example, see the City of Lakewood's Municipal Code (14.02.040 Amendments to certain provisions of the International Building Code):

https://www.lakewood.org/City_Clerk/Codes_and_Laws/Municipal_Code/Title_14_-_Buildings_and_Construction/Title_14_-Buildings_and_Construction.aspx

[50] Greenlots notes the language does not pertain to EV ready building codes specifically or in particular. This language could be used to describe any variety of approaches or charging infrastructure programs, including rebates, make ready, or even a variety of utility ownership approaches.

metro areas, many residents live in multi-family housing without access to charging at home, making the ability to own an EV very limited in this market. There are a variety of barriers and challenges for multi-family housing, including:

- The temporary nature of many apartment dwellers makes it challenging to convince either the tenants or building owner to invest in charging stations;
- shared parking areas;
- the cost of retrofitting a multi-family property may be much more challenging and expensive due to panel upgrades, trenching and new wiring;
- HOA limitations;
- split incentives between an owner or building manager and the renter or tenant; and
- higher percentage of low-income customers

Because of these various barriers and challenges, lighter touch approaches may not be adequate in addressing this market segment. This is shown in evidence coming out of a variety of jurisdictions including California, where utilities that have piloted make-ready programs for this market segment -that even included a rebate for the charger- have experienced significantly less successful results than those providing a turn-key solution, and in program revisions are now proposing a turn-key component to their program.[51] In these pilot programs, utilities found that rebates alone were ineffective in producing the necessary results to achieve the goals of the pilot programs, for a variety of reasons outlined in their filings to the Commission.

California has estimated that its EV readiness codes avoid $3,750 to $6,975 in retrofit costs per parking space. California codes currently require 3 percent or 6 percent of parking spaces be EV ready in apartment, condominium, and other commercial buildings. An update to California's 2019 triennial code will require 10 percent of spaces to be EV ready.[52] A similar proposal was recently approved in Washington, requiring EV readiness in 5 percent of parking spaces for new construction.[53] These types of building codes can be a significant policy to help address some of the barriers to EV infrastructure. Cities across the country, including Atlanta, San Francisco, and Santa Monica have set targets beyond statewide code requirements with 20 percent of all available parking EV ready.

In addressing the request to identify costs and barriers, Public Service points out that Make-Ready Infrastructure service can present very different technical, operational, legal, and

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[51] SCE's "Phase 2" of its Charge Ready program, filed on June 26, 2018 includes turn-key utility ownership for its MUD offering, mirroring SDG&E's "Power Your Drive" pilot, which originated with this approach.

[52] http://www.bsc.ca.gov/Rulemaking/adoptcycle/2018TriennialCodeAdoptionCycle/45-Dayand15-DayPublicCommentPeriods/PublicCommentPeriodSeptember7-October22,2018/PublicCommentPeriodSeptember14-October29,2018-.aspx

[53] California Energy Commission, https://www.energy.ca.gov/title24/2019standards/

economic issues depending on the location and use case. For example, across the country most Make-Ready Infrastructure programs have been targeted at multifamily units, workplaces, light and heavy-duty fleet operators, and public charging locations. According to the Company, most utilities have not sought approval from regulators to install, own, and operate the wiring inside of residential customers' homes for their EV charging needs. Earlier this year, the CPUC denied San Diego Gas & Electric's (SDG&E) initial proposal to install make ready and charging stations in 90,000 customers' homes, although revised attempts are being made to couple some type of performance based ratemaking metrics with the program. In Washington, however, Avista has sought and received approval from the Washington UTC to deploy infrastructure in an ownership and operation model that extends beyond the meter, and has achieved significant results to date. This demonstrates that a variety of market development models is possible and achievable.[54]

Various factors determine the costs of each of the components of deploying charging infrastructure. This includes site specific factors such as where the charging station is located, how close it is to the electrical service, whether a new service connection is needed, and how many ports will be installed and how the charging station will be used, among other items. For existing buildings for residential, multi-family housing and workplaces, Make-Ready Infrastructure is often the most expensive component when installing charging infrastructure. As an example, a recent report from Southern California Edison's (SCE) Charge Ready program states that the average cost of the Make-Ready Infrastructure per port for Level II charging installation is $13,374.[55] Siemens points out that in a utility-led model, costs would be lower given scale in procurement.

Applications to the Commission

The Commission has yet to rule on what it considers Make-Ready Infrastructure allowable investment for a regulated utility. Participants noted that the phrase and definition of Make-Ready Infrastructure is not currently in Colorado statutes. However, this omission in the statutes likely does not restrict the Commission's ability to review and decide on a utility application for Make-Ready Infrastructure. Many participants strongly felt that a key result for this Working Group process would be to help the Commission rule on an application for such investment.

[54] Washington Utilities and Transportation Commission, Docket UE-160082
[55] Southern California Edison, https://evrebates.sce.com/homeinstallation

The Joint Participants state that in addition to traditional components like program specifics and costs, a utility application for Make-Ready Infrastructure investments should include an explanation of how the program will:

- accelerate transportation electrification in the target segment or segments;
- improve the utilization of the grid, support the integration of variable resources;
- increase access to the use of electricity as a transportation fuel;
- deliver the cost-savings that motivate EV purchases;
- interact and partner with competitive market and utility customer participants;
- leverage other funding sources; and
- collect data to inform Commission policy and program evaluation.

Public Service states in its comments that the Company would base its plans for Make-Ready Infrastructure investments on the needs of its customers as provided through contact with its customers. Make-Ready Infrastructure investment for EVs would be a new service for an emerging market, with limited cost and benefit information available to support broad rollout of a new program or policy. As such, Public Service would restrict the size and scope of the plan and would present in its plan proposed:

- objectives;
- program rules, budgets, operations;
- accounting treatment;
- request for waiver of service policy/other provisions as needed; and
- evaluation plan.

Public Service further clarifies that an expanded plan may require a form of cost-benefit test to ensure the societal benefits are achieved at a reasonable cost (See Section II), beyond what has been shown in the MJ Bradley analysis of Colorado. In addition, the Company believes a utility filing to invest in Make-Ready Infrastructure would have to comport with § 40-1-103.3, C.R.S. Section 6 of this statute provides that investments made by a utility to accommodate charging of EVs "are equal in priority to all other infrastructure necessary to serve any customer of the public utility in its service territory." Public Service states that the "equal in priority" language is unique in the Colorado Public Utilities Law. The Company believes that the statute does not prohibit utility investments in Make-Ready Infrastructure, but wishes to draw the Commission's attention to the need to account for this language in filings for EV-related infrastructure investment.

Public Service also argues that utilities have service policies and tariffs designed over decades to provide safe, reliable, and affordable electrical service to homes and buildings. Any adjustment to these policies and tariffs are rightfully considered carefully to ensure the desired outcomes are

achieved. To the extent a new policy or program potentially shifts costs from one customer or set of customers to another, it is critical that stakeholders are involved and that regulators both understand and approve of the new policy or program. Most states in which utilities have taken on an investment role in Make-Ready Infrastructure have been states with clear policy supporting electrification and a prominent role for the electric utilities.

CEO/RAQC recommends that the Commission allow utilities to own and rate-base the cost of Make-Ready Infrastructure because of the broad set of system benefits accrued through increased adoption of EVs. They state that public utilities do not currently pay for the entire cost of infrastructure upgrades on the utility's side of the meter as a dedicated connection for a new EV charging station, or for any of the necessary infrastructure changes on the customer's side of the meter. However, they agree with the Joint Participants that there is no legal impediment to utilities doing so.

Tesla states that it was one of the organizations that supported recommendations on Make-Ready Infrastructure contained in the Statement to the Commission. That Statement explains why utility investments in Make-Ready Infrastructure may be approved under existing law and Tesla urges the Commission to act quickly to leverage funds that are available today.

Greenlots signed on to the Statement as well and further argued that Make-Ready investment programs, while representing an important first step in accelerating EV deployment in Colorado, will not sufficiently support equitable and widespread transportation electrification. Greenlots notes that only authorizing Make-Ready investment does not resolve deeper statutory limitations on broader, flexible utility participation which will be necessary to adequately support and accelerate widespread transportation electrification. Resolution to this barrier is needed to provide a structure to meet long-term transportation electrification and emissions reductions goals, and to do so in an equitable manner.

Recommendations

The Make-Ready Infrastructure Work Group attempted to identify the biggest barriers for utilities to pursue proposals to invest in EV charging Make-Ready Infrastructure and how the Commission might address those impediments.

- From the beginning of the Working Group process, participants felt that a key result for this Working Group process would be to resolve the Commission's jurisdiction to offer guidance, accept, review, and evaluate utility applications for these types of investments. Notwithstanding their interest and efforts, the assigned Staff concludes that the Commission will establish its jurisdiction as necessary through appropriate means and then may consider and evaluate utility proposals to own and rate-base the cost of

Make-Ready and/or potentially other infrastructure, which may further enable the broad set of system benefits that can be accrued through increased adoption of EVs.

- Given the support by stakeholders expressed for utility investment in make-ready infrastructure, the assigned Staff recommends that the Commission indicate that utilities can file applications for make-ready infrastructure investments, but cautions against defining or implementing criteria or other generally applicable requirements. In evaluating any make-ready proposals submitted by the utilities per the Commission's guidance, Make-Ready Infrastructure proposals by other state utilities should be studied to determine applicable funding levels and program specifics.[56]

- Many participants pointed to the example of developing a Commission "Policy Statement" like the Washington UTC's "Policy and Interpretive Statement Concerning Commission Regulation of Electric Vehicle Charging Services" released in June 2017. Greenlots stated in its response that this policy statement likely represents the best representative approach and set of guiding principles issued by a state regulator with respect to utility involvement in transportation electrification.[57] The document laid out a broad framework under which utilities may propose programs:

  "…it is appropriate to allow utilities to offer a range of EV charging services on a regulated basis, eligible for a standard authorized rate of return, provided that the infrastructure investments meet our traditional rate-making requirements … we adopt a policy supporting a "portfolio approach" to electric vehicle charging services, similar to the approach used in utility conservation programs. Rather than a single "measure" or program offering, utilities should provide customers with multiple options for EV charging services, designed to serve a range of customer types, target multiple market segments, and evolve as technology changes. A program portfolio of EV charging service offerings will promote customer choice by allowing customers to choose among a portfolio of services meeting the criteria as outlined in this policy statement." [58]

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[56] CEC states a concern that this approach runs afoul of the *Home Builders'* prohibition against *de facto* rulemaking. *See Home Builders Ass'n v. Public Utilities Comm'n,* 720 P.2d 552 (Colo.1986).

[57] Staff notes that Washington Law explicitly allows utilities to own charging stations themselves, not just make-ready infrastructure.

[58] UTC Policy and Interpretive Statement Concerning Commission Regulation of Electric Vehicle Charging Services ¶¶ 73 and 74 (Emphasis Added).

IV) Residential Sector

The Working Group was tasked with providing recommendations on the design of a new rate (or rates) that assists in the growth of the EV charging marketplace while balancing rate design principles with the economic development principles associated with new load growth.

With these key issues in mind, two Work Groups were formed, one focusing on Residential sector issues, and the other dealing with Commercial, Industrial, and Fleets. For the Work Group on Residential, the Commission instructed participants to consider electric rate design for end users, specifically residential customers, to achieve the objectives of:

- Encouraging load growth beneficial to all by improving system utilization efficiency;
- Leveraging market development efforts underway, including state and local government; and,
- Avoiding adverse impacts on the principles that underlie reasonable rates.

The Work Group also addressed additional questions, including the key components of EV TOU rates for residential customers and the issue of EV specific versus whole-house metering. In addition, the Work Group discussed whether the Commission should encourage the adoption of Smart Charging technologies and how the Commission should evaluate potential impacts on non-EV users.

Foundational Role of Time-of-Use Rates

A common conclusion among researchers and the Work Group participants is that TOU rates (sometimes called time-differentiated rates) are a foundational tool for managing EV adoption. These rates encourage EV drivers to charge in off-peak times, when energy production costs are lower, to minimize system impacts and maximize the immediate fuel cost savings. Therefore, both the electric system and customers with EVs can benefit from TOU rates. In contrast, existing standard residential rates of Public Service and Black Hills Energy penalize EV owners with tiered rates that increase for monthly usage above a threshold. Notably, both of these utilities have embarked on TOU rate trials. The Commission will be evaluating in 2020 the potential benefits of extending TOU rates to all small customers based on these trials.

With TOU rates, customers are incented to use less energy at times when prices are highest. Simple TOU rates are the foundation for load management in the residential sector, upon which more dynamic forms of load control can be layered. As mentioned in Section II, without time differentiation of rates, or other measures encouraging off-peak charging, EV owners might charge their vehicles during peak demand periods causing strain on the grid, the potential need for distribution upgrades, as well as a potential increase in generating capacity. The MJ. Bradley

study of the Colorado EV market supports the idea that managing the charging dynamics of the EV market should be an important focus for policymakers and will offer the potential for significant benefits over time.[59]

Researchers are also paying close attention to an extension of TOU rates, known as dynamic, or real-time, electricity pricing. These tools could allow utilities to adjust rates even more frequently to reflect wholesale market prices, grid capacity, or renewable energy availability. Dynamic prices could help to reduce secondary peaks from TOU rates and match EV charging to solar or wind resources that otherwise might have to be curtailed. However, some types of dynamic rates involve more complexity for utility and customer implementation and might need to be proposed in a pilot format.

> San Diego Gas & Electric's (SDG&E) Power Your Drive program provides customers in apartments, condominiums and workplaces with access to charging stations with an EV rate structure that reflects the hourly cost of electricity. Dynamic hourly pricing is set the day before, and customers use a phone app to enter their preferences for a maximum energy price or number of hours to charge. SDG&E's dynamic rate for EVs will vary to reflect the market price of producing electricity, making it cheapest to charge when renewable resources like wind and solar are plentiful. SDG&E has proposed program revisions that would implement a turnkey utility ownership approach.[1] This example requires an additional meter because it is an EV-specific rather than a whole-house rate design. It will be important to monitor the results both from customer impact and utility perspectives when sufficient data has been gathered from the SDG&E program.

The Joint Participants point to the success of EVs on TOU rates in California, where EVs consume less than 5 percent of their total kWh during system peak hours. They state that to both ensure EV customers are adequately motivated to charge during off-peak hours and to maximize fuel cost savings relative to gasoline, rates should have at least a 2:1 on-peak to off-peak price ratio, and no more than three TOU periods that remain constant throughout the year, even if the prices during those TOU periods vary to reflect differences in seasonal costs.

The Joint Participants stress the importance of introducing rates that are simple for customers, noting that shifting time-periods or introducing new time-periods seasonally will confuse customers and undermine the associated response, while also emphasizing the need to introduce more advanced forms of dynamic pricing and load management that leverages technology to

[59] (Lowell, Jones, & Seamonds, April 2017)

automatically optimize charging in response to grid demands. For TOU rates, off-peak periods should be of sufficient length to accommodate the regular charging needs of EV drivers, even at lower power levels, while on-peak periods should be concentrated into as few hours as possible, in order to ease the burden on customers, produce a better response, and accurately track underlying increased costs.

The Joint Participants state that customers should be able to internalize the price signal (*e.g.,* avoid charging during a fixed time period that corresponds to evening peak demand) and should be able to program their EVs or their charging stations once to respond. It is also unrealistic to expect customers to re-program their EVs or their charging stations every spring and every fall to accommodate a shift in the structure of the rate. They need to be able to "set and forget" to provide durable load shifting that benefits all customers and maximizes fuel cost savings. These considerations point to the value of smart charging technology to maximize customer and grid value without the need for manual programing and re-programming.

Public Service also stressed that time-differentiated rates are a key consideration for new rate design for EV customers and all residential customers. The Company agrees that the differential between on-peak and off-peak prices is a key component of rate design. Public Service states it has designed its pilot TOU rate option (which includes EV owners) to capture real costs, both variable and fixed. Public Service cautions against straying far from cost-based rate design that may have unintended cost shifts across customer types. Further, Public Service argues that preliminary results show both TOU and RD-TDR (Residential Demand-Time Differentiated Rates) trial rate designs that show potentially significant savings opportunities to EV drivers, due to lower off-peak rates or by only applying the generation and transmission demand charge to the period of 2 p.m. to 6 p.m. during weekdays.

Tesla notes that TOU rates should include no more than three periods —such as peak, off-peak, and super off-peak — and provide a reasonable opportunity to switch the customer's consumption to off-peak periods. This means that peak periods should generally be less than six to eight hours. Tesla points to Georgia Power as a well-designed TOU rate, which includes a super off-peak period from 11 p.m. – 7 a.m. every day, and a peak period that is limited to 5 percent of hours in a year. Georgia Power has combined several of its EV programs into a "Get Current. Drive Electric" media awareness campaign to help customers make the best informed decisions.[60]

Tesla also notes that an additional best practice is to provide customers with some certainty about billing. Given that many customers have little experience with TOU rates and may be wary of enrolling, some utilities have a provision that allows EV customers to receive a credit

[60] Georgia Power, https://www.georgiapower.com/residential/billing-and-rate-plans/pricing-and-rate-plans/plug-in-ev.html

following the first year of enrollment in a TOU rate for the difference, if any, between what the customer paid on the TOU rate and what the customer would have paid on the non-TOU residential rate. This provision essentially provides customers with a risk-free trial for switching to a TOU rate as a good way to encourage additional customers to enroll in the rate, as well as educating them on the potential benefits of such rates.

Siemens notes that another alternative is shadow billing where utility customers receive parallel bills in addition to their actual bills that show how much their bills would have been that month if they were on a prevailing TOU rate.

The City of Boulder (Boulder or City) notes that TOU rates can be effective in encouraging customers to shift usage away from peak periods if the price differential offers an opportunity to save money with limited impact on comfort. However, Boulder states that it is not yet clear that TOU rates currently available in Colorado achieve this objective or that they could be structured in such a way as to see widespread customer participation. The City's calculations on the existing TOU pilot rates provided in its response comments show the financial savings available from shifting charge time is negligible and unlikely to result in material changes in behavior and will not be a determining factor in customer decisions to buy an EV.

Boulder further notes that TOU rates do not solve the problem of locational, distribution system peak demand concerns (unless TOU rates are designed with different price points for customers depending on their location on the distribution system).[61] TOU rates may also result in the undesirable consequence of motivating multiple chargers to be put into use at the exact same time (often referred to timer peaking), resulting in distribution level stresses. These timer peaks do not exist with the more staggered behaviors that would be expected in the absence of a time-variant rate design. Boulder states that system stability concerns are much better addressed through encouraging smart charging and behavioral demand response program participation such that the utility can shift loads on an as-needed basis.

Greenlots stressed the need for rates and programs that send accurate price signals to drivers reflecting local or grid constraints and realities, in order to align the increased electrification of the transportation system with the interests of the utility system and the broader public. They emphasize the importance of moving towards technology-facilitated smart or managed charging, as discussed later, and real-time or dynamic pricing to maximize system-wide benefits, and the importance of a central and flexible utility role for effective management in doing this.

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[61] Boulder points to California, with more than 475,000 EVs on the road (1.5 times more than the mid-case scenario in the CEO's 2015 EV Market Implementation Study), less than 0.2 percent of total EV required distribution system upgrades solely as a result of the new EV load. Further, only 15 percent of those upgrades (15 percent of 0.2 percent) exceeded the standard construction allowance, requiring a customer financial contribution. California Public Utilities Commission. "Joint IOU Electric Vehicle Load Research Report." December 29, 2017. http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442455828

Metering Requirements

States across the country are beginning to evaluate the several options that are available when it comes to metering for residential EV owners.

(1) Single metering entails billing EV load as part of the customer's entire load, as measured by one pre-existing meter;
(2) Separate metering requires an additional meter dedicated to measuring EV load, thus allowing EV load to be billed separately from a customer's non-EV load; and
(3) Submetering requires a separate meter dedicated to tracking EV load but located on the customer's side and connected to the primary meter, rather than requiring a second primary meter.[62]

Thus far, most states have found that while an EV-specific meter may be helpful so that a household's entire electricity consumption is not subject to TOU rates, the cost of the second meter and its installation may outweigh the benefits. Additionally, many EV charging stations now contain embedded meters, which can enable utilities to do subtractive billing manually.

California PUC staff has recommended that the CPUC encourage single metering in the short term until submetering becomes more functional. They also required regulated utilities to collaborate to create a submetering protocol to "enable manufacturers and customers to be sure that the meters, whether purchased separately or included in the vehicle or as electric vehicle service equipment, are compatible with the utility billing and communication system."[63]

The Joint Participants responded to this issue, stating that whole house TOU rates are a reasonable first step in Colorado, particularly as both Public Service and Black Hills are just now exploring TOU rates. The Joint Participants note that in the future, dedicated metering may be needed to reap additional benefits associated with more advanced load management strategies, including the use of more dynamic price signals to which EVs can respond. Dedicated EV metering can also be used for programs with limited and targeted participation, such as Smart Charging programs described below.

Public Service believes that a well-designed residential rate should be applicable to all residential loads, including EVs. They state that this avoids the cost of redundant metering and generally sends more accurate price signal to all loads in the household, and not just to the EV charger.
The Company notes that even under standard rates, EV drivers save considerable fuel costs versus gasoline. Compared to the significant initial fuel cost savings from switching from a

[62] NYSERDA Electricity Pricing Strategies to Reduce Grid Impacts from Plug-in Electric Vehicle Charging in New York State https://www.mjbradley.com/sites/default/files/NYSERDA-EV-Pricing.pdf
[63] CPUC Resolution E-4651, http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M097/K049/97049639.PDF

gasoline vehicle to an EV on the standard residential rate, the benefits of TOU or other rate designs offer smaller incremental fueling savings.

Public Service provided Figure #14 below, which compares the cost of gasoline to the cost of charging an EV under three different rate structures. It shows that even under our standard rate there will be a fuel cost savings of about $900 per year. Moving from the standard rate to the current TOU pilot will save an incremental $123, and a hypothetical third option with off-peak prices that are 40 percent lower would save an additional $152 per year. With such small incremental cost savings to be had from rate design changes, the Company believes it may be difficult to justify the incremental metering and wiring cost for separate metering of residential EVs. ChargePoint notes that requiring an additional meter is likely not cost effective, but an embedded meter might deliver greater cost benefit such as a potential ~30 percent increase in savings.

Figure #14: Fueling Cost Comparison

	Cost of Gasoline		Average Residential Rate	TOU Off Peak	Hypothetical Super Off-Peak Rate
Miles Traveled Annually	15,000	**Miles Traveled Annually**	15,000	15,000	15,000
Mile Per Galon	30	**EV Miles per KWh**	3.4	3.4	3.4
Price of Gasoline	$2.80	**Electric Base Rate**	$0.06237	$0.04440	$0.02000
		Electic Rate Riders	$0.05000	$0.04000	$0.03000
Annual Gasoline Cost	$1,400	**Annual Electricty Costs**	$496	$372	$221

Source: Public Service Response Comments 17I-0692E

However, Public Service notes that circumstances may point toward a residential EV-specific rate in some cases. For example, until all households in Colorado are under a TOU rate, it may make sense to encourage most or all EVs to be on a TOU rate through separate metering. In addition, some consumers may prefer a flat rate on their house, but be willing to accept a TOU rate on their EV. Any further discussion will benefit from the information and analysis available once the residential rate pilots are complete at the end of 2019.

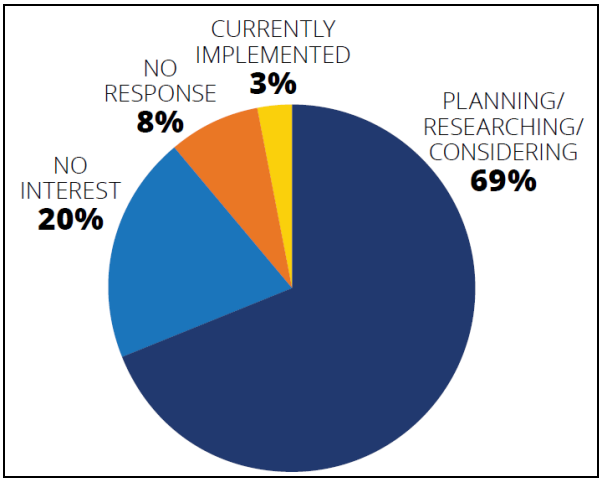
Smart Charging

Smart charging (often referred to as managed charging or V1G) refers to any program that manages electric vehicle charging to promote grid stability or more efficient resource usage. Smart charging entails deferring charging start times or throttling charging rates up or down and can provide a variety of grid services, including peak generation capacity, distribution capacity, frequency regulation, and renewable energy integration. Utilities and research organizations around the world are actively exploring smart charging technologies and their capabilities in order to maximize the benefits to electricity providers and EV owners. Many of the trials thus far have been conducted in fleet settings (discussed further in Section IV), as fleets with set cycles

may be able to benefit from smart charging programs without sacrificing flexibility during their normal operational times. Some of the simplest smart-charging programs involve demand response, which is the pausing of charging at times of peak demand or when supply is disrupted, which can enhance the grid benefits discussed in Section II.

In addition to offering TOU rates, Con Edison in New York developed the SmartCharge New York program, designed to help all EV owners who charge in the Con Edison service territory reduce their cost of charging and enhance electric grid efficiency and resiliency. The three-year program tracks participating EV driver charging behavior through Fleetcarma's C2 device, which collects driving and charging data and communicates this information using the cellular network. The C2 plugs into the vehicle's on-board diagnostic port or diagnostic connector. Participants in the SmartCharge New York program earn SmartCharge Rewards, with bonuses applied for avoiding charging during peak hours in the summer months. In addition, off-peak charging is incentivized year around with per kWh rewards.

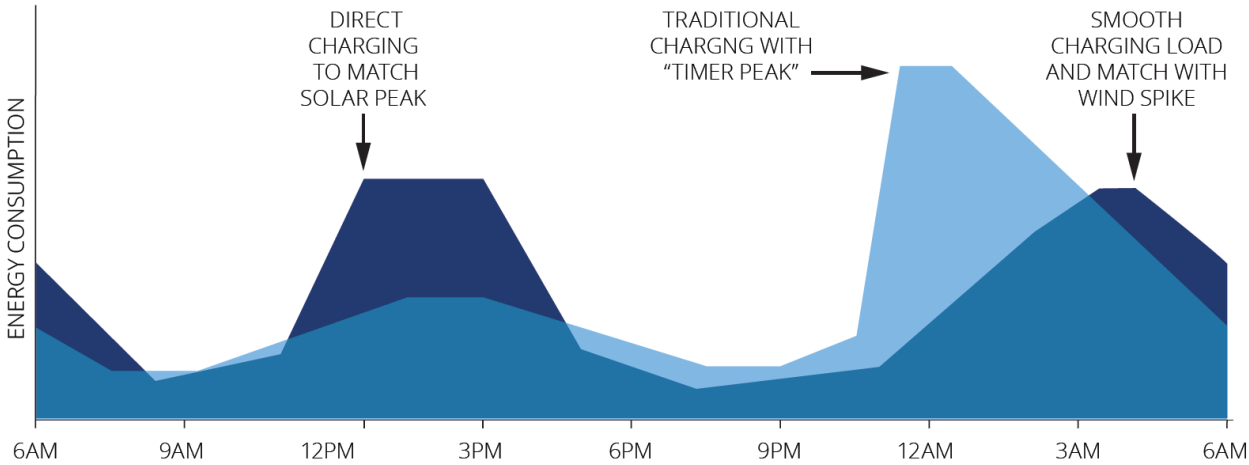
Figure #15: Utility Interest in EV Managed Charging Demand Response Programs



Source: SEPA 2017

Improvements in charging technology such as embedded smart charging capabilities are enabling more price-responsive charging among EV owners. For instance, most EVs now have on-board chargers that allow charging times to be programmed either within the vehicle or remotely via an internet-connected device. Using this technology, EV drivers will be able to take advantage of off-peak TOU rates simply by keeping their vehicle plugged in and programing it to only charge during the off-peak period, thus "set and forget."

Figure #16: Opportunities for EV Managed Charging to Meet Grid Needs



Source: SEPA 2017

The Joint Participants state that the Commission should encourage smart charging that takes advantage of the storage and flexibility inherent in EV batteries and enables EV owners to benefit further from low off-peak rates, but should be agnostic as to the technological pathway to achieve the result. Accordingly, the Commission and the utilities under its jurisdiction should look to leverage the "smarts" embedded in EV infrastructure and/or EVs, allowing for the most cost-effective solutions to emerge that maximize the rewards returned to customers.

Public Service states that pilot projects could be useful in exploring the current level of technical maturity, customer behavior, customer interest, and costs and benefits. The capabilities that smart charging can offer continue to expand as EV charging equipment includes more advanced software with each new model generation. In fact, many new EV charging stations can be used to collect and manage data, similarly to what a second meter would have been expected to do. The Commission should be open to proposals and pilots on smart charging, and evaluate their merits based on the details of a specific application. Importantly, pilots requiring collecting and managing data should be an opt-in option for customers.

Tesla describes five principles the Commission should consider when evaluating the need to adopt or encourage smart charging technologies that include:

- start from a place of universal understanding, including defining "smart charging" prior to considering if, how, and when it may be utilized;
- recognize that there are various technologies available and potentially under development;
- consider driver charging use cases;
- establish that customer experience is a key element of any program or pilot design; and
- evaluate the costs, benefits, and value proposition for impacted stakeholders (customers, companies, utilities, and grid).

The company eMotorWerks recommends that the Commission, in considering pilots and programs for smart charging and EVSE submetering, build upon the variety of program design models from other jurisdictions. For instance, a standard smart charging program design like Sonoma Clean Power's GridSavvy provides customers a monthly bill credit in exchange for controlling EV charging for demand response events. Customers are able to set departure time requirements and override DR events to meet mobility needs. Similarly, existing or expected pilots and programs are examining how EVSE submetering can enable different types of EV-only pricing.

Many utility submetering offerings center around the provision of TOU rates, such as Xcel Energy Minnesota's EV Service Pilot, while others, like SDG&E's anticipated Residential Charging Program, would provide a dynamic, submetering-enabled "grid integrated rate" based on day-ahead energy prices and other locational adders. Austin Energy's EV360 TOU rate program, while relying on a separate meter, provides unlimited off-peak charging for a flat monthly fee. Such fixed-rate TOU offerings could allow drivers to override on-peak charging restrictions for a penalty fee.

Greenlots both highlights the value of smart charging and illustrates how it is not limited to complementing rate design, but can instead go further and be a more effective alternative strategic solution for maximizing beneficial outcomes and charging behavior.

Cost Impacts

The Work Group participants were also tasked with avoiding adverse impacts on the principles that underlie just and reasonable rates, such as subsidizing EV owners with regard to non-EV owning residential customers. The Joint Participants clarify that rates optimized for EVs or other forms of beneficial electrification should generally not be subsidized, but should take into account the fact beneficial electrification represents incremental revenue, should reflect underlying marginal costs, and should encourage EV drivers to charge in a manner consistent with grid conditions, which maximizes potential benefits for all ratepayers, while also maximizing the fuel cost savings that motivate EV purchases.

They further state that the Commission should encourage investments that accelerate transportation electrification so that Colorado utility customers realize the potential benefits quantified in the MJ Bradley Report sooner rather than later, and to maximize those benefits (*e.g.,* by pushing load off-peak and lowering the costs of integrating variable renewables). The Commission should generally avoid subsidization via rate design, but should reform rates to account for different transportation electrification use cases and should do so mindful of the fact that load represents incremental revenue.

Public Service states that it is not advocating for an EV specific rate for residential customers, but as previously discussed, a well-designed rate structure should generally be applicable to all residential end uses. The Company states that if the Commission decides to adopt an EV-specific rate, any cost shift to other customers can be evaluated though a class cost of service analysis. In this type of analysis, the contribution of a load class to system coincident peaks, non-coincident peak, and total annual energy are evaluated and total system costs are allocated to each customer class based on those metrics. Then the revenue collected from the EV rate class could be compared to the costs that were allocated to that class. If revenues are less than allocated costs, it can be concluded that a potential cross-subsidization is occurring.

Tesla again points to the MJ Bradley report that found that "*majority of projected utility net revenue from increased electricity sales for EV charging would in fact be passed on to utility customers in Colorado, not retained by the utility companies, would put downward pressure or future rates, delaying or reducing future rate increases, thereby reducing customer bills"*.

Recommendations

The Working Group was directed to providing recommendations on the design of a new rate (or rates) that assists in the growth of the EV charging marketplace while balancing rate design principles with the economic development principles associated with new load growth. In particular, the Residential Work Group was tasked with the objectives of encouraging in the residential sector load growth beneficial to all by improving system utilization efficiency; leveraging market development efforts underway, including state and local government; and avoiding adverse impacts on the principles that underlie reasonable rates.

- The assigned Staff agrees with most of the participants that TOU rates can be a vital first step in developing an EV strategy. Managing charging patterns, first through a basic time differentiated rate design, is the most valuable objective with greater potential grid and economic benefits over time. As Public Service and Boulder point out, the financial savings for EV drivers on a TOU rate is unlikely be a determining factor in customer decisions to buy an EV and if not designed correctly, the TOU rate may be insufficient to alter charging behavior.

- Participants had varying opinions on whether the Commission should explore whole house TOU rates or EV specific rates. The assigned Staff suggests that a simple rate such

as a whole house TOU should be an option for EV drivers.[64] However, utilities should eventually provide options for customers who choose to use a separate meter, or can take advantage of new submeters within EV charging equipment to take advantage of EV-only tariffs. This may be a benefit to consumers who prefer time-varying rates for their EVs but do not want to expose their entire homes or businesses to such rates. With the goal of having simple and easy to understand options available to EV customers, dynamic pricing and demand rate pilots can be considered as well.

- Most participants agreed that smart charging technology is a very powerful tool in helping to manage and maximize the efficiency of utilization of grid assets and deliver value to all utility customers. The assigned Staff suggests that encouraging utilities to pursue pilot projects could be useful in exploring the current level of technical maturity, impact on customer behavior, and the resulting costs and benefits. It is particularly important for the smart charging technology and pilot project to result in "set and forget" customer behavior. As more OEMs are integrating smart charging capabilities into their vehicles, projects similar to BMW's ChargeForward pilot with PG&E could result in a very beneficial experience.

- As Colorado continues to increase its renewable generation, the assigned Staff offers that it will be important for utilities to develop pilot projects that explore more flexible ramping resources that would smooth power production fluctuations, such as when there is an overabundance of renewable energy on the system and low demand. For example, Arizona Public Service has proposed a "reverse" demand response pilot project for customers with loads of 30 kW or more. The pilot aims to mitigate negative pricing events caused by solar generation and the steep ramping that occurs as solar power declines. As mentioned previously, SCE in California is testing and proposing a suite of pilot projects aimed at easing solar and wind integration.

[64] Siemens cautions that a first time TOU user may find it difficult to adjust behavior to a whole house rate. Whereas if there is an option for an EV-only rate, then they could experience a limited exposure to dynamic pricing and if positive (most likely), would move to a whole-house rate.

V) Commercial, Industrial, and Fleets

In addition to the Residential sector, the Commission expressed interest in developing policies, including modifying electric rate design, for C&I customers, which can comprise fleet operators of small, medium, and heavy-duty vehicles, as well as public charging. In addition, the Working Group was tasked to determine whether the Commission should consider unique tariffs for fleets and workplace and commercial EV supply equipment. Finally, the Commission was interested in learning how to encourage "at-work" charging (*i.e.,* EV charging stations at business locations for use by employees or other patrons).

A Work Group was formed to try to address the many issues surrounding the Commercial, Industrial and Vehicle Fleet sectors. The Work Group was also tasked with several questions or issues, which included:

- Should fleet/heavy duty rate design be prioritized to maximize the early potential benefits to the electricity system?
- Should the Work Group explore means of subsidizing public fleet charging versus private fleets?
- Evaluate some of the 'creative' rate design tools being developed across the country, such as Demand Charge holidays or Economic Development tariffs.
- What are the key metrics the Commission needs to have when evaluating the installation of DCFC versus Level II public charging?

The Work Group found examples from across the country where regulators and utilities are grappling with these important and difficult issues. As described below, there were varying opinions among the participants on the best approaches for these key issues.

Fleets and Medium to Heavy Duty Vehicles

The Work Group identified several factors driving EV adoption in Section I, but it is also important to note that the market for electrifying medium- and heavy-duty vehicles is growing much more rapidly than early forecasts as technology and supportive policies continue to advance. In addition to the growth of light duty EVs that can be used for car sharing transportation network companies (TNCs), municipalities, utility fleets, and private fleets, the market for medium and heavy-duty EVs is expanding as more options are hitting the market. One key reason for this growth is the recognition by operators of high-utilization vehicles (car sharing, commercial fleets, public transit, and heavy-duty uses) that the total cost of ownership

savings for EVs are becoming very compelling. Owners of high-utilization vehicles drive more miles per year than average drivers, which lead to increased fuel and maintenance costs.[65] EV fleets are expected to drive significant savings in the form of low fuel costs and reduced maintenance over the life of the vehicles.

> FedEx Corp announced recently that it plans to add 1,000 electric delivery vans to its fleet of vehicles in a bid to save on fuel and cut down on pollution. The company will buy 100 Chanje V8100 vans and lease the remaining from truck rental company Ryder System. These electric vans will have a range of more than 150 miles when fully charged, with maximum cargo capacity of about 6,000 pounds. FedEx and its competition, UPS and DHL have also placed orders for Tesla's electric Semi-Truck, a substantively different use case than the medium duty vans previously mentioned. Utility programs should be considered based upon the unique customer use cases.

Research from examples across the country show that despite the TCO savings, significant barriers remain, in the form of high upfront investment costs and utility rate structures, which are not equipped to deal with the unique issues surrounding electrified fleets. The Work Group participants note, however, that EV fleets (light-, medium-, and heavy-duty) potentially offer an opportunity to add larger and flexible off-peak load to the system. As mentioned previously, this in turn has the potential to lower overall average costs of the entire system. CEO/RACQ point out that in addition to better utilizing capacity, the grid benefits of fleet and heavy-duty vehicles are very similar to those that will result from the widespread adoption of light-duty EVs in the residential sector. However, these benefits from the C&I and Fleet sectors may accrue more rapidly if charging is managed intelligently.

An EV fleet results in a smaller group of customers with a larger load, so it may be easier for utilities to work with fleet operators to encourage charging behavior that attempt to manage the operators' fueling and costs, as well as create the most benefit to the system, while some fleet operators may not have flexibility to adjust its fleets. Public Service notes that a program designed for an EV fleet could be similar to existing load control programs where curtailment by one large industrial customer can be the equivalent to thousands of residential customers. Additionally, the larger battery capacity and regular driving schedule of fleet and heavy-duty EVs make them excellent candidates for demonstration and pilot projects as well as concentrated deployment of grid energy storage.

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[65] (Advanced Energy Economy (AEE), Sept 2018)

In contrast, the Joint Participants state that early benefits to the electricity system are more likely to accrue at scale in the residential segment, but that does not mean the Commission should not prioritize taking an inventory of C&I rates considering a utility's request to reform or replace those rates where necessary. They note that current rate structures were not designed with electric transportation in mind and in many cases, current C&I rate structures do not accurately reflect costs associated with all C&I fast charging, as well as EV fleet use-cases and can undermine or erase the fuel cost savings of transitioning to EVs. Working Group participant Regional Transportation District pointed to the fact that under its current Commercial rate structure, it is unable to make a business case for expanding its electric bus fleet.

Public Service recommends that the Commission could prioritize the expansion of time-differentiated rates for EV fleets either during utility rate cases or as stand-alone proceedings. For example, fleets that utilize on-route charging either at a depot or through a travel corridor might benefit from adopting a flat rate for energy use while fleets that utilize overnight charging would benefit from a TOU or a Real-Time Pricing rate to take advantage of off-peak pricing.[66] These larger loads are also ripe for high-impact managed charging programs. State regulators, utilities, and fleet managers are beginning to work together to discuss some potential approaches, such as offering to fleet customers, time windows excluding their loads from demand charge calculations when there is excess generation capacity on the grid.

ChargePoint responds to Public Service's comments on demand charges, stating Public Service is implying that fleet customers might get a discount that would result in cross subsidization through rates. ChargePoint notes that it is not that the loads themselves are excluded from demand charge calculations, but rather that utilities are beginning to explore and implement alternative rate structures for fleet chargers as an alternative to standard commercial rates with demand charges, but the load is still accounted for in terms of the utility's cost recovery and load forecasting.

Tesla states that any commercial EV charging rate should take into consideration the unique profiles of fleets, light-duty, and heavy-duty EV DCFC and focus on opportunities to reduce total cost of ownership to drive early adoption. In response, EVgo emphasizes that they are in agreement with Tesla and would recommend that the Commission explore case studies such as those in SCE territory

Greenlots adds that the Commission should not only deal with C&I and fleet topics via rate design issues, but also consider other market barriers. Fleet and transit operators, for example, may be experienced at running and maintaining their fleets but may be deterred from their electrification even if cost-competitive due to the charging infrastructure that is needed and their

[66] (Advanced Energy Economy (AEE), Sept 2018)

lack of experience in this area. Heavy duty trucking, in particular shorter-range activities that are common in industrial areas, will have viable electric alternatives in the near-term and represent an additional area that the Commission should consider. This would result in significant emissions reduction opportunities and corresponding human health benefits for urban areas, particularly low-income areas.

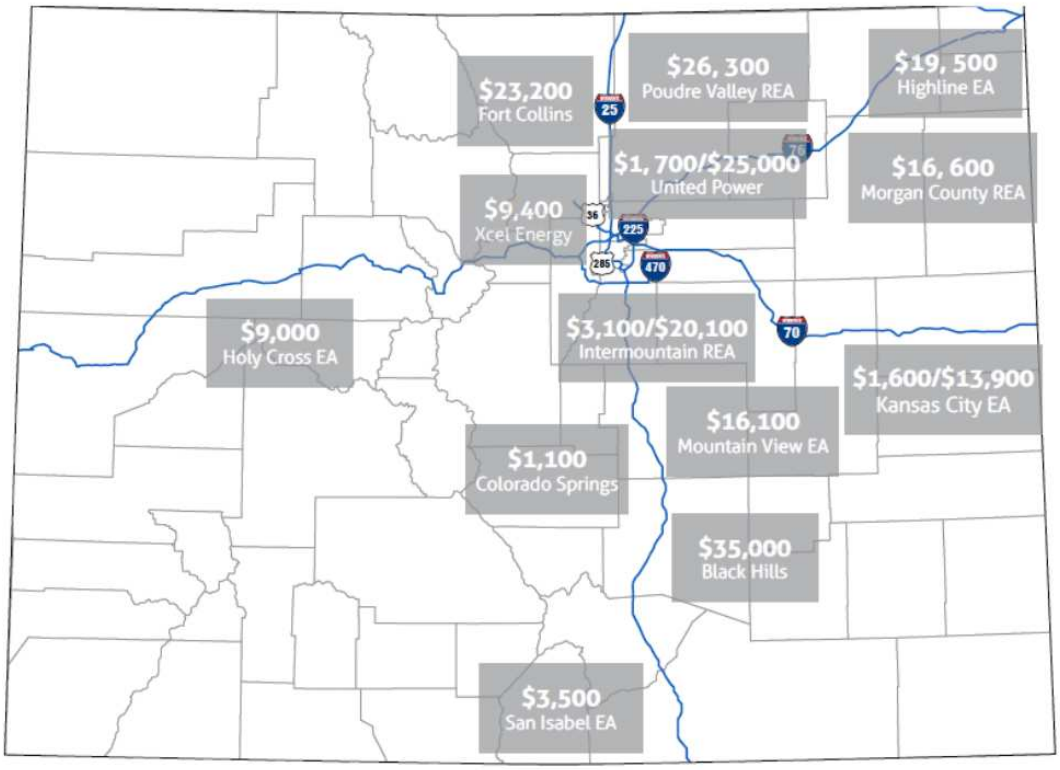
Creative Rate Design

Research from across the country, as well as Work Group participants' direct experience, has shown that utility demand charges are a significant barrier to the development of a viable commercial or public charging business model for the EV market. According to a recent analysis by RMI, demand charges are responsible for as much as 90 percent of a public charging station's monthly utility bill. A 2015 study commissioned by the New York State Energy Research and Development Authority (NYSERDA) also found that demand charges can present problems for commercial customers deploying Level II workplace or fleet charging.

In Colorado, the annual cost to operate a DCFC station varies by a factor of 35 across different utility service territories in Colorado.[67] A recent study undertaken by SWEEP states that underlying costs-of-service do not vary by this large a factor across the territories, suggesting that the economics of transportation electrification could be significantly improved simply by reforming C&I rates to be more cost-reflective. The figure below shows the wide range of utility bills for DCFC stations across the state.

[67] (Salisbury & Toor, Feb 2016)

Figure #17: Estimated Annual Electric Bill for a DCFC for Colorado Utilities[68]



Source: SWEEP RAQC/City of Denver study

To begin to deal with these high bill impacts, utilities, and regulators across the country are beginning to propose creative utility rate design to spur workplace Level II and DCFC deployment. These options include demand charge holidays, starting low and scaling up demand charges over time, shifting some cost recovery to volumetric charges initially, and using dynamic adders to recover the cost of providing service during system peaks. RMI research suggests that these innovative designs can accommodate the novel loads of public DCFC and fleet charging until the EV market matures.

Another option is to develop rates for EV charging infrastructure based on Economic Development Rates, which generally provide a reduced electric rate for a limited period to businesses to induce them to locate new facilities in the utility's service territory, or encourage them to expand facilities that already exist within the utility's service territory. CEO/RACQ state that these discounted rates can be justified because they support economic development that result in benefits for the state as a whole. Because the adoption of EVs and associated EV charging infrastructure can also provide a wide range of benefits for the state, a thoughtfully designed, time-limited reduced electric rate for new charging stations could be considered.

[68] For utilities with two estimated annual bills listed (United Power, Intermountain REA, Kansas City EA), the bills represent small commercial and large commercial classes

Public Service notes that Colorado's new economic development statute HB18-1271 has specific requirements for what types of customers can qualify for reduced rates. The requirements include: 1) the customer must be adding at least 3MW of load; and 2) the customer must demonstrate that the cost of electricity is a critical consideration in deciding where to locate their facilities. While HB18-1271 was generally targeted toward new stationary loads associated with new business development in Colorado, it may be applied to EV fleets if integral to a significant new business and load opportunity in the state.

RMI further states that if demand charges must be a feature of tariffs for EVs, then those charges should be time-varying and reflect actual system costs at a given time, in keeping with the principle of sending accurate price signals based on marginal costs.[69] In this way, if customers are able to reduce their demands on the system's transmission and distribution capacity by charging vehicles at times when there is spare grid capacity, they should be able to reduce their costs for making that effort.

Electric utilities can develop pilot programs to help them determine the best pricing options to offer charging station site hosts while optimizing grid benefits of transportation electrification. Pilot programs will also allow utilities to collect data on how charging behavior is affected because of different rates to inform them on how permanent rates can be developed to mitigate grid impacts of EV integration.

- **Minnesota:** Xcel filed an application with the PUC describing planned initiatives and pilot programs that will focus on three main areas:
    - Home charging: Xcel plans to offer a new subscription service that will provide drivers with a set bill for EV charging and equipment each month. In addition, Xcel will offer programs and options encouraging drivers to charge overnight when low-cost wind energy is available.
    - Public charging: Xcel proposes a DCFC corridor pilot that would "leverage public and private funds to increase the availability of fast charging stations on highways and other major corridors."
    - Fleet operations: work with customers like Metro Transit, the Minnesota Department of Administration and the City of Minneapolis to integrate EVs into their operation, as well as provide charging infrastructure for 200 ports for the state's vehicle fleet and 90 charging ports.
- **Hawaii:** In July 2013, the Hawaiian Electric Co.'s received approval to implement a five-year EV charging pilot, Schedule EV-F, where the demand charge is replaced with a higher TOU per kWh charge.

[69] (Fitzgerald & Nelder, 2017)

- **Connecticut:** In June 2014, the Public Utilities Regulatory Authority approved a five-year EV rate rider pilot for Connecticut Light & Power that replaces a demand charge with a higher per kWh charge.
- **Oregon:** In April 2017, PacifiCorp received approval in their transportation electrification proposal to implement a transitional demand charge approach for DCFC. The tariff offers an initial 100 percent discount on demand charges that step down to 0 percent by the end of the ten-year program to reduce barriers to DCFC deployment.
- **California:**
    - Southern California Edison: In their 2017 transportation electrification program SCE, implemented a moratorium on demand charges for their commercial rate program for the first five years, with a subsequent five-year phase-back. The demand charge at the end of the ten-year period will only be 60 percent of the current demand charge.
    - Pacific Gas & Electric: Recently proposed a new commercial EV charging rate using subscription fees rather than demand charges, and would offer two types of rates within that: one for customers with charging up to 100 kilowatts and one for customers with charging over 100 kilowatts. PG&E states that the proposal is similar to a smartphone data plan, which they call a "subscription charge." The subscription pricing will allow customers to choose the amount of power they need and is much lower than current demand charges, allowing customers to have simpler, more consistent monthly costs, but is still designed to recover all costs.
- **New York:** In April 2018, the New York Power Authority (NYPA) proposed to move DCFCs to rates without demand charges in the short-term and requested a longer-term plan for DCFC rate modifications that align with their low load factors and sporadic usage. NYPA said it has identified the first 32 locations for DCFC infrastructure as part of its EVolve NY program. The state has committed $250 million through 2025 for the initial rollout of the program.[70] NYPA and NY utilities have recently proposed a per plug incentive in the same case as a "consensus proposal."[71]

The Joint Participants note that commercial and industrial customers, including DCFC operating in Xcel's Minnesota territory are able to use a tariff structure that mitigates adverse bill impacts resulting from demand charges and low utilization. The tariff specifies: "In no month shall the billing demand be greater than the value in kW determined by dividing the kWh sales for the billing month by 100 hours per month."[72] This naturally shifts the relative portion of the bill resulting from demand charges as utilization grows. To illustrate the point, a 50 kW DCFC that

[70] (Advanced Energy Economy (AEE), Sept 2018)
[71] http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={376CAE1A-A552-4ECE-9FFC-7FC0D073D778}
[72] Northern States Power Company, Minnesota, Electric Rate Book, General Service rate structure (rate code A-14 on page 5-27

is used once per day would result in a bill that is 70 percent lower than it would have been without this provision. By the time the same charger is used five times per day, the provision no longer has any effect upon the bill. The Boulder also supports the position of the Joint Participants that creative rate design solutions are needed to address the near-term challenge presented by demand charges for DC fast charges with low utilization.

In addition to demand charge holidays, or scaling up demand charges over time, Public Service mentions that another way that utilities could reduce the impact of demand charges on DCFC stations is to offer a commercial tariff that has a lower demand charge but higher energy charges (Often, the energy charge is much lower for commercial customers who are assessed a demand charge). One example is Xcel's Secondary General Low-Load Factor commercial tariff, which compared to its Secondary General commercial tariff, offers a relatively low demand charge and higher per kWh prices. This type of rate structure may make economic sense for DCFC stations because they experience high spikes in demand but have relatively low energy consumption.[73] The Commission could also explore Critical Peak Pricing programs that place very high charges on a very small number of hours during the year. EV fleets that can avoid charging during 60 critical peak hours during the year can see very large savings on their electric bills under a rate like Public Service's Critical Peak Pricing.

Public Service notes that demand charges can provide an important price signal, and stakeholders should be cognizant of the implications of removing it and thus potentially being counterproductive to the promise of EVs' increasing system efficiency and putting downward pressure on rates. Therefore, technology-based alternative solutions such as smart charging and energy storage can also be considered, while being wary of rates that would represent a perverse incentive to consideration of such options, which account for and address grid demands and costs. As Greenlots suggests, an example of a compromise alternative that may be appropriate could be to offer time-limited temporary demand charge relief made contingent upon such entities and their respective utilities agreeing upon appropriate and potentially evolving technology-facilitated smart/managed charging plans that could then help mitigate the system costs seen by all ratepayers.

Tesla notes that smart charging and energy storage may only be applicable for certain charging use cases and the adoption of such technology today could be cost prohibitive in some cases especially for public DCFC.

[73] (Salisbury & Toor, Feb 2016)

Publicly Available Charging Stations

Public fast charging stations present a unique challenge from a rates perspective. These facilities can place large demands on the local distribution system for short periods. In addition, because these facilities tend to be located along travel corridors and drivers expect to charge at these sites when they need it, it may be difficult to manage the timing of charging. It is possible that the facility could be in use during critical system peaks, which could require incremental generation capacity to serve that load.

The business case for public fast charging is tied heavily to utilization of the charger. A large portion of the costs include utility demand charges that are meant to recover grid investments needed to serve customers with high power requirements. At low levels of usage, energy charges make up a very small part of the costs of operating DCFC, with demand charges forming the majority of total cost to charging. Traditional demand charges designed for C&I buildings with much higher load factors that allow costs to be spread over more kilowatt-hours make little sense for such low load factor uses and may not be cost-reflective.

Until the market for EVs matures such that public DCFC experiences substantially higher utilization rates, it may be necessary for utilities to offer special tariffs, or variations on existing tariffs, and make the business case for DCFC more compelling in Colorado, which will enable public charging for more EV drivers. In addition, public fast-charging stations are believed to be critical to the mass adoption of EVs in Colorado. Several participants made the argument that preferential rate treatment for public fast charging is not subsidization because of the value that mass EV adoption would bring to the system over time and given the unique load profile of DCFC stations under low utilization scenarios. CEC notes the temporal issue this argument creates; allowing today's non-EV users to subsidize the EV investment on the promise of benefits for all that may or may not accrue in the future.

Rural sites for DCFC are very likely to have even lower utilization that may be inversely proportional to their importance in the purchase decision if potential buyers want to be assured of access to far away locations. Because of the more difficult business case of fast-charging stations in rural areas, other states have invested in the deployment of stations in rural regions where lower utilization is expected. Washington, Oregon, and California in the United States have dedicated funding to complete the sections of the West Coast Electric Highway, providing drivers a continuous fast-charging network from Mexico to Canada, with funding focused on sections outside of major cities.[74] As mentioned in Section I, Colorado is already making efforts to expand its fast charging network along major corridors. Operating costs are also sometimes subsidized in more remote locations. For example, Maine offered to cover a percentage of

[74] Washington State Department of Transportation, 2014

operating costs in their Appendix D solicitation utilizing Volkswagen settlement dollars.[75] These uneconomic stations can also be supported with profits from other chargers in the same network if they share a common owner or by charger network membership fees. This would require a large network across the entire state or region.

Ideally, public charging stations should be sited for high utilization; however, there are many critical use cases for public charging where this will not be the case, at least initially. At this stage in the market, DCFC should be sited where utilization will be high and their grid impact will be low although as discussed in the previous paragraph some low usage sites are important to EV adoption. DC fast chargers are typically sited in shorter dwell-time locations such as retail centers, restaurants, gas stations, near airports, parking garages, on city or county owned properties, and other locations. In contrast, Level II chargers can be sited where drivers have a preference or ability to charge over a longer interval (*i.e.,* several hours), such as workplaces, residences, hotels, event centers, retail locations, or public parking with a longer dwell time. In these contexts, Level II can be a more cost-effective option, and easier to operate from a site host and grid perspective than DCFC. For these reasons, and because of the complexity of rate optimization, several site hosts opt for the DCFC provider to own and operate. High-traffic retail areas can support a mix of Level II and DCFC stations. Hubs that provide a combination of Level II chargers and DCFC are likely to be the best way to serve fleets, however, some use cases may require significantly more of one type, such as TNC or ridesharing applications requiring more DCFC.[76]

> Eversource has developed a two-year charging station demonstration project to collect data on public charging behavior to better inform utility decisions regarding public EV infrastructure deployment. The Eversource Charging Pilot provides participating municipalities and businesses with Level II charging stations in exchange for access to information collected by the meter on charging usage. Site hosts are responsible for charging station installation, maintenance, and the cost of energy consumed, but are able to choose charging rates.

Existing C&I rates can also undermine the economics of operating public DCFC stations for passenger vehicles, which are necessary to enable a mainstream EV market. As researchers from the Idaho National Laboratory note, "the availability of public infrastructure provides consumer confidence against 'range anxiety,' or the perceived fear by battery electric vehicle drivers of becoming stranded once the battery is depleted; however, this availability means that

[75] Maine Department of Transportation. https://www.maine.gov/mdot/vw/bmp/

[76] EVgo notes that in its discussions with TNCs and there is very little interest in Level II charging. They are finding that drivers need to be able to charge quickly because any time spent charging at long dwell locations mean they are losing the opportunity to earn money.

infrastructure must naturally precede the adoption of EVs."[77] As previously discussed, the downward pressure on electric rates that could result from widespread EV adoption that improves the utilization of the grid is not likely to materialize unless a sufficient public charging network is established. Moreover, public DC fast chargers address an important use-case for residents of multi-unit dwellings who do not have a dedicated parking spot or garage where they may be able to charge their cars in the evening.

Public Transit Agencies

A large number of transit agencies and school districts across the country are beginning to look at electrifying their bus fleets. Significant high upfront costs are a large barrier to adoption; however, transit agencies and school districts are working with a variety of stakeholders, including utilities to try to overcome these barriers. A recent report by the U.S. PIRG Education Fund (PIRG) states that electric transit buses cost roughly $200,000 more than diesel buses, but the lifetime fuel and maintenance savings of an electric transit bus amounts to around $400,000 and can save $170,000 over its lifetime.[78] According to the PIRG report, cities and counties across the U.S. are beginning to drive up procurement numbers, with several operators committing to shift their entire fleets to battery electric buses by a certain date. These locations include Los Angeles County (by 2030), Seattle (King County, by 2040), San Francisco (by 2035), and New York (by 2040).[79]

PG&E and the San Joaquin Regional Transit District (RTD) are collaborating on a pilot to test, analyze, and compare the economics for charging at various times of day with and without battery storage. PG&E will test how smart charging and battery storage can lower operating costs and maximize efficiencies for the agency. PG&E will test, analyze, and compare the economics for charging at various times of the day using different models with and without battery storage. As part of the pilot, PG&E will fund up to five new electric bus chargers and a battery energy storage system, and will fund and build the infrastructure from the electric grid to the chargers and storage system.[80]

The Joint Participants illustrate the urgency of addressing C&I rates, arguing that electric buses operated by RTD in Public Service's territory are subject to non-coincident demand charges based on their highest 15-minute period of demand during the month, regardless of grid conditions at the time that occurs. This provides RTD no incentive to avoid system-wide peak hours and to charge their buses when there is spare capacity on the system and the cost-of-service is lowest. Non-coincident demand charges do not reflect the actual cost of service

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[77] PlugShare, New Survey Data: BEV Drivers and the Desire for DC Fast Charging (March 2014)
[78] (US PIRG, 2018)
[79] *Ibid.*
[80] (Advanced Energy Economy (AEE), Sept 2018)

-- a customer's peak demand that occurs at 3 a.m. when the grid is significantly underutilized is not equivalent to a peak demand that coincides with system-wide peak demand. Moreover, such charges can erase the fuel cost savings upon which the economics of a decision to purchase electric buses or other fleet vehicles depend.

Several Work Group participants noted that without legislative authorization, subsidization of public EV fleets might violate § 40-3-106, C.R.S. However, even without legislative changes, the Commission could ensure that public EV fleets have access to attractive time differentiated rates that are not subsidized. Rate design variants can include modifications to fixed, demand and volumetric charges, and still recover costs without cross subsidies. For example, time-differentiated rates can provide price signals that encourage both public and private EV fleets to avoid peak demand hours, and reduce their bills without any subsidization.

TNC Fleets

There also may be a promising business case for dedicated charging to serve TNCs such as Lyft and Uber. According to AEE, data shows that TNC drivers can save $5,200 per year on average by owning an EV rather than an ICE vehicle. Depending on utilization rates, the TCO for shared fleets are already at cost parity in 2018 for some light-duty EVs.[81] As more public charging is made available, and more affordable long-range EVs enter the market, more business cases will open up, and this appears to be happening with GM's Maven program. Maven rents Chevrolet Bolt EVs to TNC drivers and has collaborated with EVgo to build dedicated fast chargers for the program due to high usage.[82] In many cases, TNC drivers do not have home charging and they typically drive many more miles per day than an average driver, often upwards of 50,000 miles per year. In markets where TNCs have begun to electrify, usage at public fast charging networks has grown exponentially. This increases the use of public charging and more fast-charging in urban areas in particular.

[81] *Ibid.*
[82] https://www.evgo.com/about/news/evgo-maven-gig-announce-nations-first-dedicated-fast-charging-network-demand-drivers/

Maven car-sharing service has found that ride-hailing services using their vehicles tend to charge at times of the day when existing DCFC networks have low utilization, often during peak solar and less in the mornings and evenings, as they are often driving commuters during these times. In a report from the California Public Utilities Commission entitled *Electrifying the Ride-Sourcing Sector in California,* "lack of access to fast charging was identified as the most significant barrier to EV use" for TNC drivers, and drivers with EVs "would have worked an additional 10 hours per week, on average, if they had access to faster and easier charging." DCFC owners could offer time-varying prices for using their chargers that would encourage drivers to charge at times of low demand, which would help fleet operators save money and help DCFC owners.

The TNC market could offer a particularly attractive opportunity for utilities. Utilities are exploring "charging depots" for such fleets where it is most advantageous to locate those considering implications for the grid and charging convenience for drivers. RMI states that if a utility or EV infrastructure provider can site an EV charging depot on a brownfield site where rents are low, which is also near a substation and a transit hub, it could serve a significant mobility load serving many commercial fleet vehicles and taxis at a competitively low cost.[83]

In addition to the Maven program, Evercar provides EVs and fast-charging services that drivers can use without actually owning the vehicles or being responsible for their maintenance and insurance. Drivers can drive three to eight hours on a charge (depending on the specific vehicle and driving circumstances), then stop for a brief recharge—included in the vehicle rental fee—at a DCFC charging station, then continue on. The system has been successful enough to warrant dedicated fast-charging stations for Maven drivers to reduce crowding at public stations. These are early projects and clearly deeper investigation into such cases is warranted.[84]

With the right set of policies and charging infrastructure in place, car sharing and ride sharing programs will likely shift to electrification faster than the vehicle market as a whole due to operational efficiencies and cost savings. They also provide a significant multiplying effect for EV awareness and resulting adoption, representing a significant opportunity for electrifying transportation in Colorado.

Recommendations

The Commission tasked the Working Group to provide recommendations as to whether the Commission should consider unique tariffs for corporate fleets and workplace and commercial

[83] (Nelder, Newcomb, & Fitzgerald, 2016)
[84] (Nicholas & Hall, July 2018)

EV supply equipment. The direction also including recommending policies, including modifying electric rate design for commercial and industrial customers (comprised of fleet operators of small, medium, and heavy-duty vehicles), as well as including as public charging.

- As a result of the many discussions and research provided by the Work Group, the assigned Staff agrees with many of the participants that public fast charging stations are critical to the mass adoption of EVs in Colorado. Because public DCFC charging in low utilization areas in particular suffers from an extremely difficult business case without subsidy, there is a need for deeper utility involvement to animate the market and provide and foster market opportunities. Research has shown that a smaller percentage of charging needs should be served by DCFC, but as previously mentioned, DCFC availability will allow for greater EV adoption. That greater adoption will lead to more residential charging, which can be managed as beneficial load growth resulting in greater off-peak consumption.

- Public Service notes that demand charge holidays may be difficult to justify in the context of § 40-3-106, C.R.S., as such rate discounts necessarily lead to subsidization arguments. A rate structure emphasizing energy charges and potential subscription fees rather than demand charges could be one option. In addition, traditional demand charges designed for C&I buildings with much higher load factors that allow costs to be spread over more kilowatt-hours may not make sense for low load factor uses and therefore are not cost-reflective. It will be important for the Commission to look at alternative rate designs discussed in this section, including;

    - The Commission should closely follow proposals of a portfolio of cost-based C&I rates filed by PG&E designed for transportation electrification use cases. SCE's rate was approved by the California Public Utilities Commission in 2018 and will be implemented in early 2019. Those rates are not subsidized, but could better reflect the flexible nature of EV loads and may significantly improve the economics of transportation electrification.

    - In addition, the Commission should examine a suite of C&I rates that PG&E recently proposed that likewise are not be subsidized, but will reflect the new costs and benefits associated with various transportation electrification use cases. Comments on this proposal will be filed in December and the Commission as well as stakeholders should pay close attention as the proposal moves through the CPUC process. Finally, rates that take into account varying and growing load factors should be part of the conversation to develop workable pricing for DCFC facilities.

- CEO/RAQC states in its reply comments that, in developing the ALT Fuels Colorado EV DC Fast-Charging Corridor program (EV Fast-Charging Corridor program), CEO spoke with numerous market stakeholders, many of whom expressed concerns about the ability to establish a viable business model for underutilized DCFC, especially in corridors where revenue is insufficient to cover operating costs, let alone recoup initial investments. The Commission could encourage Staff to continue to work with the Colorado Electric Vehicle Coalition in order to explore different structures.

- The assigned Staff agree with participants that appropriate time differentiated rate structures can and should be developed that will better reflect cost causation and will allow fleets such as RTD and public school districts to achieve fuel cost savings by managing the time at which charging takes place.

- Again, the assigned Staff see opportunity in developing pilot programs or basing full programs upon recognized results from utilities with more advanced expertise to help them determine the best pricing options to offer drivers while optimizing grid benefits of transportation electrification. Pilot programs will also allow utilities to collect data on how charging behavior is affected as a result of different rates to inform them on how permanent rates can be developed to mitigate grid impacts of EV integration. Pilot programs should also have a clear pathway to broader scale development of those that are proven successful.

VI) Education and Outreach

The Commission tasked the Working Group to answer several questions regarding the support of the EV market in Colorado. The research from industry experts, as well as state experiences across the country, has shown that developing the resources necessary for consumers to make informed decisions plays a critical role in encouraging EV deployment.

The Education and Outreach Work Group was formed to help provide the Commission with recommendations on how to deal with issues surrounding customer awareness of EV choices and charging options. The Work Group was tasked by Staff to try to address several questions, including:

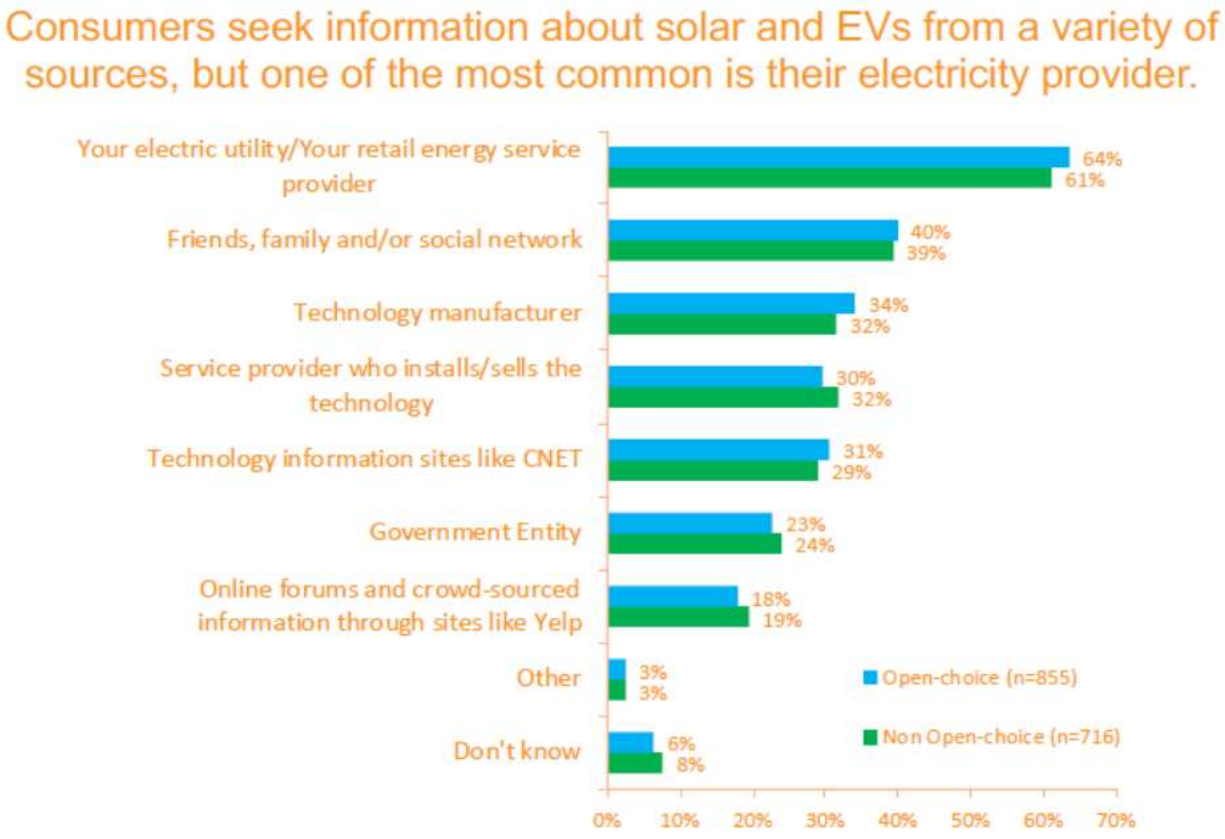
1. How should the Commission prioritize creative rate design versus the need for simplicity for potential customers?
2. How should the Commission and Utilities contribute to a statewide information database on EV and EV charging infrastructure?
3. How should the Commission evaluate utility spending on potential rebate programs (EV or charging infrastructure purchases) and marketing/outreach programs?
4. Should the Commission encourage the development of a low-income EV program?

It is apparent to the industry that the general public knows little about: EV options and availability; EV charging equipment types and requirements; the potential for a total cost of ownership benefit of an EV compared to a gasoline vehicle; and public benefits of EVs including emissions reductions. However, utilities can serve as a reliable and trusted source to provide understandable and relevant information on electric vehicle options and benefits. The utility-customer relationship can be leveraged to provide education on charging needs and available rates and programs. When utilities make this information readily available, customers may become more familiar with the concept of EVs and can gain a more comprehensive understanding of their potential benefits compared to the cost of owning a gasoline vehicle. Utilities across the country are considering investments in EV education and outreach. Likewise, utility commissions across the country will likely need to decide if and how the costs for such programs can be recovered.

Utilities have numerous advantages over other EV market participants in increasing customer education and awareness. To begin, electric utilities already have the necessary relationships with customers to support their evaluation of EVs, rate plans and programs, and charging infrastructure such as Make-Ready Infrastructure investments. Direct contact through the billing process also provides opportunities for the utility to educate the consumer through bill inserts and other customer service channels. In addition, many utilities already have account managers

who work with medium and large customers on a number of issues including rates and tariffs, energy efficiency, and renewable energy purchases. Those relationships would be very helpful in engaging with certain EV programs and fleet operators.

Figure #18: Solar and EV Consumer Survey



Source: SECC

Experience has shown that consumer education does not need to be undertaken exclusively by utilities. Consumer education and awareness efforts should be conducted in collaboration with automakers, dealerships, state and local governments, employers, and community groups, offering an opportunity for electric utilities to engage with broader market participants to expand their reach and increase customer exposure. For example, Plug In America, a non-profit advocacy group, provides consumer information on PEVs through websites, seminars, ride-and-drive events, and other outreach efforts.

Several states have recognized the need to provide consumers information regarding EV deployment. A California PUC rulemaking defined the role that utilities may play in education and outreach related to EVs, specifying that "customers should be aware of availability, cost, and environmental impact of [EVs] and available metering options, rate plans, and charging options," and noted that "proactive and targeted customer education" is necessary, including on load management communications.[85] However, the CPUC stated that the cost of marketing efforts was to be limited to "target customers with an interest in EVs" and done in a competitively neutral manner.[86]

> Kansas City Power & Light's innovative EV pilot utilized public outreach as a major factor of the pilot. The utility has a group of EV "ambassadors" who are drivers willing to answer questions about and advocate for EV ownership to other would-be customers, somewhat similar to community solar groups that help guide homeowners through the process. The utility is getting ready to move into a phase where the utility will partner with dealerships to educate drivers about EVs.

Simplicity of Rate Design

As noted in Sections IV and V, utility rate design will play an important role in how EVs are managed on the grid and how much EV owners will end up paying to charge their vehicles. The two Work Groups on Residential and the Commercial and Fleet sectors spent time discussing the importance of simplicity versus achieving the most accurate price signals for EV charging. The Education and Outreach Work Group also was tasked to expand on this issue. Most participants agreed that EV drivers, whether at home or at the workplace, likely will not want to think about what time is best to charge to maximize grid benefits -- they just want to "set it and forget it." There may be a need for a simple way for them to take advantage of the beneficial EV rates.

The Joint Participants state that the Commission should pursue rate options that include both simple rates that can be easily explained, understood, and acted upon, and more advanced forms of dynamic pricing and load management that rely upon technologies that optimize charging in response to evolving grid conditions without the need for continuous manual intervention. They add that the Commission should avoid the dangerous middle ground of rates that are too complicated for people to understand easily, but fall short of reflecting more dynamic marginal costs. For example, the Commission should avoid rates that include a "super-off-peak" TOU period in one season but not in another because customers are not likely to re-program their cars or their charging stations twice a year every year at some arbitrary date of which customers would likely be oblivious. Instead, the utilities should offer TOU rates with at least a 2:1 on-peak

[85] California Public Utilities Commission (CPUC) http://www.cpuc.ca.gov/general.aspx?id=7728
[86] *Ibid.*

to off-peak price ratio that allows customers to program their cars or their charging stations once and forget about it. Additionally, utilities could also pursue more dynamic forms of load management that let customers specify certain parameters and rely upon algorithms to optimize charging to maximize customer value.

Public Service explains that the typical Colorado energy customer pays a flat rate residential rate, and fuels their vehicle at their choice of gas stations with similar but varying prices. This process is well understood by the customer. Unfortunately, tiered rates currently in use for residential customers would penalize EV owners with higher charges for energy use over a monthly threshold, even if the customer charges during lower cost overnight hours. By contrast, the near-term future discussed in this Proceeding, and in many rate discussions in Colorado and nationally, foresees a different fueling experience. That experience involves a home under a time-differentiated electricity rate, an EV charged at home under that rate, and augmented EV charging at work or at public charging sites. Overall, a customer's energy bill for both transportation and home electricity will likely come down, perhaps considerably. However, the Company stresses this experience involves some degree of learning curve for energy consumers.

Public Service states that the customer learning curve should tilt the Commission toward relative simplicity in EV rate design. Public Service also notes the "participation factor" in voluntary rate designs where customers tend not to choose time varying rates when given the option. The Company's experience with voluntary rate design choices suggests that it is unlikely that more than 10 percent of customers will choose more complex rate designs. Default rate designs can address this limitation, while opt-out provisions and voluntary rate designs—potentially for more complex dynamic rates allow—for customer choice.

In summary, Public Service supports rates rooted in cost causation, with an increasing degree of time variation, that avoid negative unforeseen consequences and that are relatively simple. In addition, at this stage, it may be more appropriate to focus on pilot programs to test these questions, rather than to reach definitive conclusions.

Tesla agrees with the other participants that simplicity should be the primary objective. This can be done by operating within the boundaries of existing rates by making incremental changes to improve customer experience and refine price signals.

Greenlots offers a different opinion, stating that utilities can and should be striving to align system costs with customer costs as closely as feasible, while maintaining EV fuel cost savings. EV charging specifically is a single load that can and should be managed with technology, providing for a hands-off "set it and forget it" customer experience utilizing their pre-set preferences and needs. In other words, you can have rates and charging programs that both send accurate price signals that align charging behavior with the interests of the grid, and are simple

and hands-off for the customer to respond to. Greenlots submits that this is not a binary choice, and you can indeed accomplish both objectives at the same time with the same program if properly designed and utilizing readily available technological solutions.

Statewide Information Database

Based on some of the work done by the Colorado Electric Vehicle Coalition, the assigned Staff examined ways in which a statewide information database could help all stakeholders better understand the current EV market in Colorado.

The Joint Participants and CEO/RAQC points to work in California with the Department of Motor Vehicles that can inform service planning. Public Service states that there are many databases already available on public EVSE charging stations that are robust, updated frequently, and feature easy-to-use interfaces including phone apps. The Company states that privacy issues may arise. For example, potential utility programs may request or acquire customer information on charging behaviors in exchange for rebates. Potential programs like these would need to be managed on a case-by-case basis and again with full respect given to customer privacy issues.

Tesla also argues that the Commission and utilities can support information on existing databases such as Plug Share and the Department of Energy's AFDC database. Utilities could also share valuable information from existing education and outreach programs such as what messaging may resonate with consumers on a statewide level. In addition, results could be aggregates from surveys regarding EV and EV charging infrastructure that has been distributed to its customers.

Outreach of Make-Ready Infrastructure Investments

During discussion of the Work Group on Make-Ready Infrastructure investments, participants offered recommendations on how to communicate the availability of investments by the utility to make an EV Charging location "stub-ready." Public Service restates that it has a lot of experience and many tools and methods for contacting its customers today. Many of these tools for reaching customers will be appropriate if Public Service offers a Make-Ready Infrastructure investment program. The Company's Account Mangers could receive training and help large customers understand if they are a good fit for the program, and their "Builders Call Line" can assist EV charging infrastructure developers in connecting to the system for the first time.

Public Service also recognizes that the transition to electricity for vehicle fuel is a big decision and requires more education to ensure the transition is successful. New trade ally efforts will also be important. To effectively reach EV drivers and fleet operators, the Company states that it has begun engaging with local auto dealers with information about electricity as a vehicle fuel and electricians that specialize in wiring homes and businesses for EVs.

Fleet education and awareness efforts would be a natural complement to a Make-Ready Infrastructure investment offering. One example Public Service has offered customers is a fleet vehicle electrification assessment. The Company also is hosting a three-part webinar for transit operators that will include: (i) the case for electrification of buses; (ii) the hardware requirements and the way the bus operating facilities would change to accommodate electric buses; and (iii) a discussion about electric rates, costs for fueling, and the importance of working with Public Service early in the transition from fossil fuel to electric fueled buses. The three-part series will be completed by the end of 2018.

Evaluation of Rebate Programs

The Education and Outreach Work Group gathered information on how to evaluate potential rebate programs proposed by utilities as an alternative or perhaps supplement to direct utility investment. Experience across the country has shown that rebates or other incentive programs for homeowners and businesses to install smart, networked Level II chargers are an effective way to satisfy charging needs while offering the greatest grid-interactive flexibility. Many utilities already offer rebates on home and workplace charging stations. With support from utilities and/or local governments, experience has shown it is within the reach of most homeowners and commercial businesses to install an appropriate number of charging stations to support their own personal needs or those of their employees and customers. Costs/benefit analysis could be used to set rebate amounts and other program budgets.

Potential forms of rebates, incentives, or assistance to facilitate EV ownership include:

- Expedited permitting and interconnection for home and workplace EVSE coordination with local authorities who regulate connections, license charge station installers, or issue permits;
- Aggregation of EV demand and implementation of smart charging programs via a rebate or incentive program;
- Rebates or grants for EV chargers at homes and workplaces.
- Rebates or grants to landlords and/or tenants for installation of EVSE in or near multi-unit buildings;
- Incentives to serve underserved/disadvantaged communities, including subsidized EV car-sharing service or other mechanisms to introduce EVs in low-income neighborhoods where conditions are not conducive to EV acquisition.
- Turnkey programs utilizing a deeper, more supportive utility role as likely is necessary for certain market segments, including multi-unit buildings, disadvantaged communities, and public charging. Turnkey programs are possible regardless of EVSE ownership structure.

As previously noted (Section IV), DCFC installations will need more than rebates; specifically, they will need larger amounts of "patient capital" to support their installation and operation for a decade or longer. DCFC installations will need patient capital until there are enough EVs on the road to significantly increase their revenue and shorten their path to profitability, and until the market for these chargers has grown sufficiently to drive down hardware and balance-of-system costs. Alternatively, deeper utility involvement and investment could also address this need. Beyond or in support of utility programs, potential financing solutions may be available from municipal bonds, green bonds, long-duration purchase agreements, and green bank investments.

Public Service states that they believe it is appropriate for utilities to spend on marketing and outreach, which may complement rate offerings, rebate programs, and other customer choice initiatives to encourage enrollment and inform customers about options. At a minimum, utilities should be allowed to invest in good customer service and educational resources, as customers seek a trusted source to understand electrical considerations for EV charging, new service processes, and best practices for realizing the benefits of fueling vehicles with clean, affordable electricity.

Public Service further states that the Commission should consider the current level of ownership of EVs, as well as realistic potential for adoption of the EVs in the future, including market size and segmentation. This can help to inform the scale of the investment, as well as the need to educate different EV drivers and owners, including daily commuters, business travel, public transit, car share, and more.

Tesla adds that funding for rebates should focus primarily on deployment of Level II EV charging infrastructure and do so in a cost effective manner that enables customer choice in technology, and does not mandate specific technology requirements without an assessment of whether customers will utilize capabilities associated with the requirements. While marketing and outreach are important, it should be an incremental allocation of utility spending and should leverage other education and outreach efforts already happening across Colorado.

Greenlots notes that marketing, education, and outreach investments create a unique additive effect that goes beyond the direct impact of the program itself and helps to grow the market and create market opportunities in ways other investments and programs do not. By increasing awareness and evolving the psychology and thinking of consumers, such investments can be one of the most effective means to overcome psychological barriers and create interest that leads to EV adoption decisions. Greenlots adds that a combination of well-designed turn-key EVSE programs, highly-visible public charging infrastructure and efficient, and targeted funds spent on education and outreach by utilities already holding powerful customer and community relationships together can create synergistic effects in breaking down market barriers.

Greenlots also comments that funding can be provided up front via a grant rather than an after-the-fact rebate, or taken off the top of the cost of charging infrastructure when there is a deeper, more turnkey utility program. They state that this can address significant barriers such as cash flow, and help ensure customers are choosing infrastructure that is prequalified to work with utility programs/systems, managed charging, submetering programs, etc.

Low-Income Programs

Utility investment in EV charging infrastructure could be used to help low-income individuals and communities benefit from broader EV market trends by supporting public charging options in their neighborhoods by increasing access to zero-emission transit and shared use mobility options, and by improving air quality in communities that are disproportionately burdened by dangerous pollution. This could include semi-private charging available to residents of multi-family dwellings, or a focus on community-based public charging stations in locations that serve these communities. In some cases, EV charging needs in these areas may not be sufficiently met by competitive charging companies that assess ideal locations on metrics such as past EV purchasing patterns. In addition, competitive companies may struggle to make a business case to install charging equipment in rental or community areas that do not have a site host willing to pay for infrastructure installation or maintenance. For these reasons, a deeper, supportive utility role is likely necessary to sufficiently address this critical market segment.

> Electrify America's California plan includes 25% of super-fast charging stations to be sited in communities representing the bottom quartile of income and environmental exposure (Electrify America). California investor-owned utilities pledged to site more than 10% of charging, including fast charging, in disadvantaged communities (California Energy Commission [CEC], 2017). An EVgo plan coordinated with government set a minimum of 20% of stations in disadvantaged communities. Programs such as these are important to provide a robust charging network that includes fast charging for all potential drivers.

The Joint Participants state that the Commission should encourage the development of programs to serve low-income and underserved communities. Utility programs should not be limited to individually owned light-duty vehicles, but should also accelerate the electrification of car-share and ride-share vehicles that serve these populations, and of medium and heavy-duty vehicles to reduce emissions of local air pollution that affects those communities disproportionately. Notably, of the nearly $1 billion in utility transportation electrification programs that have been approved in California, the majority are for medium- and heavy-duty vehicles. They further argue that the Commission should also be aware that at least $300 million of the $1 billion in approved programs will be invested in "disadvantaged" and low-income communities and that,

to this point, California's utilities are exceeding their disadvantaged and low-income community deployment goals.[87]

Public Service notes that the EV market should support creating utility cost efficiency benefits for those that do not own EVs, as well as the clearer benefit to EV owners. As EVs become more cost-competitive with equivalent internal combustion vehicles over time, lower income communities will benefit from more EV choices. Finally, the electrification of public transit, which is a strong early adoption market for EVs, can benefit low-income customers even if they do not own a personal vehicle. The Company states that it supports programs and rates that apply to all residential customers, but notes potential barriers to low-income participation such as inaccessibility to ride sharing networks that require smart phones and personal credit. Accordingly, the Company will monitor for opportunities to ensure fairness in access to the EV transition.

Tesla adds that providing access to charging infrastructure in low-income communities is just as important as providing access to general charging infrastructure. Greenlots specifies that utility investment in electric bus (especially transit) infrastructure is one of the clearest ways to support EV equity. Other opportunities include utility support for disadvantaged community electric car sharing or providing incentives to low-income ratepayers for leasing or buying new or used electric vehicles. Greenlots further argues that education and outreach efforts that specifically target disadvantaged communities can be valuable, in addition to a focus on medium and heavy-duty electrification as discussed earlier, the emissions from which disproportionately affects low-income and disadvantaged communities.

Recommendations

The Education and Outreach Work Group was tasked to: prioritize creative rate design vs the need for simplicity for potential customers; examine a statewide information database on EV and EV charging infrastructure; evaluate utility spending on potential rebate programs; and explore the development of a low-income EV program.

- Through discussions among the Work Group, many participants felt that utilities could serve as a reliable and trusted source to provide understandable and relevant information on EV options and benefits, including environmental benefits. The utility-customer relationship can be leveraged to provide education on charging needs and available rates and programs. Therefore, the assigned Staff conclude that utilities should make this information readily available so that customers may become more familiar with the concept of EVs and can gain a more comprehensive understanding of their potential

[87] California Air Resources Board (CARB). s://www.arb.ca.gov/msprog/lct/cvrp.htm

benefits compared to the cost of owning a gasoline vehicle. Utilities should also use utilities' existing account managers who work with medium and large customers to help customers navigate EV programs and engage with fleet operators.

- Consumer education and awareness efforts should be conducted in collaboration with automakers, dealerships, state and local governments, employers, and community groups, offering an opportunity for electric utilities to engage with broader market participants to expand their reach and increase customer exposure.

- If a utility provides a justifiable case during an application or other filing, it is reasonable to the assigned Staff for utilities to spend on marketing and outreach, which may inform customers about rate offerings, rebate programs, and other customer choice initiatives to encourage enrollment and inform customers about options. Utilities should be allowed to invest in and recover costs of customer service and costs to educate customers about utility programs, including for line extension, rebates approved Make-Ready Infrastructure programs, and to build awareness and participation in EV-related utility programs.

- Focusing on low-income issues is an important issue for both the Commission and further stakeholder interaction. Education and outreach efforts that specifically target disadvantaged communities can be valuable, in addition to a focus on medium and heavy-duty electrification, the emissions from which disproportionately affects low-income and disadvantaged communities. Electrification of public transport can benefit low-income communities, and any Commission approved utility investment in Make-Ready Infrastructure charging infrastructure should also be provided to multi-family housing that serves low-income communities, however, we note that additional support will likely be needed for these difficult-to-reach market segments.

VII) Conclusion

In addition to the recommendations requested by the Commission in Decision No. C18-0474-I, the EV Working Group initially began its discussions with a number of other questions that might be important to address in a stakeholder setting. With the limited time available to the Working Group before the submission of this report, a number of issues deserving a closer look in the near future were nonetheless identified.

Next Steps

A Next Steps Work Group was formed to address several questions, including:

1) Should a collaborative, stakeholder approach continue past the issuance of this report, and if so, where should it focus?
2) How should the Commission evaluate impacts to the distribution grid with increasing EV adoption?
3) How can performance-based incentives play a role in encouraging forward-looking investment in EV infrastructure?
4) Should the Commission request a transportation electrification plan/roadmap for each of the utilities in the future?

The issue of Interoperability and Communication standards also was discussed in the Make-Ready Work Group. After reviewing comments and concerns from a variety of perspectives held by the members of that Work Group, the assigned Staff felt it appropriate to move the discussion to the Next Steps section as this was an area that would require further discussion among stakeholders as any type of consensus recommendation to the Commission is not possible through this particular process and time allotted.

Stakeholder Outreach

The assigned Staff queried participants about the value of continuing this effort past the release of this report. Participants also initially explored methods for the Commission to work with other stakeholders to evaluate infrastructure gaps, particularly after the Volkswagen AG (VW) Mitigation Trust Funds had been dispersed. As this report has discussed, the EV market is fast moving, and is creating a multi-sided market. Traditional regulatory frameworks and processes may not be sufficient to address such a dynamic market. By continuing to be engaged in a stakeholder process, the Commission and utilities can begin to tailor solutions to local needs and unique planning regarding the EV market.

New, more proactive approaches will be required to allow learning through experimentation, including: more frequent, assertive use of scalable demonstration projects to test EV integration approaches; and more comprehensive consideration of EVs in distribution planning.

The Joint Participants believe that all Stakeholders should be engaged in the regulatory process to review EV proposals made by utilities in application filings. They present an option that could allow the utilities to establish working groups to discuss emerging issues and guide program implementation, similar to the stakeholder groups that arose out of the 2016 Tri-Proceeding settlement agreement approved in Consolidated Proceeding No. 16AL-0048E. The Joint Participants also suggest that the Commission and the utilities, in cooperation with other state agencies such as the CEO and the Colorado Department of Transportation, leverage the analytical tools built by the California Energy Commission and NREL to quantify infrastructure needs in multiple segments. California law now requires such an analysis.

Public Service states that whether or not the Commission extends its stakeholder activities, the Company intends to gather input from interested stakeholders before proposing significant next steps on EV market development. Public Service also agreed that the Commission could collaborate with the CEO to conduct an analysis on any potential infrastructure gaps.

Public Service further states that there are many databases already available on public EV charging stations that are robust, updated frequently, and feature easy-to-use interfaces including phone apps. The Company states that privacy issues may arise, for example, potential utility programs may request or acquire customer information on charging behaviors in exchange for rebates, for example, but these would need to be managed on a case-by-case basis and again with full respect given to customer privacy issues.

CEO/RAQC agree with the Joint Participants, but also recommend that the Commission and utilities continue to collaborate with the Colorado Electric Vehicle Coalition. As a forum for developing and sharing best practices as well as helping to meet the goals of the Colorado Electric Vehicle Plan, the group is well positioned to offer meaningful feedback and ideas on how to ensure that the goals of the proceeding are realized.

Tesla states that the current stakeholder approach has been beneficial and to some extent necessary in developing initial input that can provide expertise for any guidance issued by the Commission for the utilities on transportation electrification programs. Further, any continuation of the stakeholder approach outside of the normal regulatory process is dependent on the outcome of the report. If the Commission determines that such a stakeholder group should continue, clear timelines for the length of expected stakeholder engagement beyond the current process and clear goals would be useful to determine near term action. Tesla also recommended

that the Commission utilize the EVI-Pro tool developed by NREL as a starting point to assess future infrastructure needs.

Tesla also argues that the Commission and utilities can support information on existing databases such as Plug Share and the Department of Energy's AFDC database. Utilities could also share valuable information from existing education and outreach programs regarding what messaging may resonate with consumers on a statewide level and aggregate results from any surveys regarding EV and EV charging infrastructure it has distributed to its customers.

Greenlots recommends that the report, as well as any further stakeholder process should not only consider and evaluate options for accelerating the market that are possible under current statutory constraints, but also evaluate, discuss, and consider what is possible in an environment where these constraints are removed, such as a change to existing statutes. Greenlots states these areas would likely warrant focus in a continuation of this stakeholder process.

Boulder states that the EV community, customers, auto dealers, regulators, and utilities should work together to create an excellent customer experience and seamless transition to electric transportation. Efforts should be made to provide easy access to information about the features of an EV, the cost to charge an EV and where and how to charge an EV. They add that data collection and sharing between all parties (PUC, Department of Motor Vehicles, utilities, state and local government, auto dealers, infrastructure developers) is essential to deployment of cost-effective, highly utilized public charging infrastructure.

Utility Planning

As was discussed in Section II on Beneficial Electrification, the overall effect of EV charging at higher levels of EV deployment could lead to impacts on distribution networks, which in some cases, may not be designed to handle additional loads from EV charging infrastructure. Clustered charging could be a significant risk to local distribution infrastructure. As previously noted, uncontrolled, unregulated, or unscheduled charging can also result in large and undesirable peaks for the entire grid. Thus far, such disruptive impacts have not been observed in California, which has broadly encouraged EV growth. Nevertheless, utility planners will have to take into consideration these operating issues while developing both short- and long-term system development plans. Close monitoring of peak load forecasts, line, and equipment capabilities is required to avoid overloading facilities.

The Joint Participants recommend that the Commission may want to require the utilities to track impacts to the distribution grid associated with EV load, as the California PUC requires the utilities under its jurisdiction to do.

Public Service agrees it is likely that many EVs will cluster in neighborhoods and cities that could therefore necessitate extensive upgrades to the equipment that is close to the customer, such as transformers and services. Such cases may indicate opportunities for targeted load management programs. The Company states that it will monitor the impacts of EVs on the distribution system through its grid modernization efforts and through collaboration with other utilities that are also learning about EVs on their distribution systems. However, homeowners are currently not required to notify the utility if they buy an EV or install a charging system. The Commission could play an important role in helping to facilitate a process to encourage EV owners to notify utilities of new charging systems.

Public Service further states that the Commission's role should generally be to understand the investments that the utility will need to make to enable future adoption so the utility is not a barrier to increasing EV adoption. Finally, Public Service believes there are a few main considerations in the Commission's role for evaluating the impacts of EVs to the distribution grid. Unlike some other DERs, since EVs generate additional revenue for utilities, many of the distribution upgrades that enable EV adoption may be revenue justified. The Commission's role should be generally to understand the investments that the utility will need to make to enable future adoption so the utility is not a barrier to increasing EV adoption. The Company sees this as similar to how the Commission interacts with utility distribution investments today. Utilities may need to have some degree of control over EV charging to minimize negative impacts to the distribution system. The Commission could play an important role in creating programs and perhaps requirements through a rulemaking around the management of charging.

Tesla argues that the utilities currently lack visibility about who owns an EV in their service territory and how they are charging. Increasing visibility into EV ownership and charging behavior is important. They state that it is important for utilities to gain foundational insights into their own customers' EV trends, but those insights are also important for other stakeholders. Given privacy agreements between customers and auto manufacturers and retailers, one option Tesla suggests is that utilities can offer customers a nominal rebate for registering their EV with the utility as a way to increase visibility of EV location. Several utilities have implemented such programs through their websites, including ComEd in Illinois, Baltimore Gas and Electric in Maryland, and Salt River Project in Arizona.

It will be vital as the state moves forward to integrate EVs and EV charging infrastructure in the utility planning process. Apart from overall transportation policies at the state and local government level, utilities will need to make greater efforts to plan for EVSE loads in future planning processes. Utilities will need to start finding ways to incorporate these projected EVSE loads into their existing load forecasting models for integrated resource planning, or start a parallel planning process recognizing the unique features of the EVSE to be a flexible load integrated with the grid and capable for V1G and V2G services such as demand response, smart

charging, and distributed storage in certain cases. When utilities offer compelling EV/EVSE programs that engage customers and provide value, this will also take care of the issue of utilities having visibility into the location of EVs and of EV charging behavior.

As many states have already done for distributed generation, regulators in cooperation with utilities, can develop standardized and streamlined service requests associated with EV charging stations to help speed the process of connecting new EVSE to the grid, reduce interconnection costs, and avoid undue discrimination and expenses for charging infrastructure projects.

A comprehensive planning analysis conducted by the utility and stakeholders can ensure that charging stations are effectively sited, providing the best returns on investment while also meeting critical service requirements.

Performance-Based Incentives

While there is significant opportunity to leverage future performance-based incentives and mechanisms to support transportation electrification, the Commission's focus should be properly incentivizing utilities to accelerate the market, which is not adequately being done by other actors, rather than necessarily innovating in the manner or mechanism with which this is accomplished. One method of ensuring program simplicity is the use of direct incentives, or rebates, in exchange for vehicle charging data and load management (discussed further in Section IV). Under this program design, site hosts who participate in the program receive a utility incentive to purchase and install smart EV charging infrastructure that meets the utility program functional requirements – that is, being able to collect data and provide load management tools. Rebate programs have been utilized by Puget Sound Energy, AEP (Michigan), Sacramento Municipal Utility District, and Los Angeles Department of Water and Power. Other states with utilities considering such frameworks include South Carolina, Michigan and Massachusetts.

Transportation Electrification Plan/Roadmap

The Joint Participants stated that the utilities should be required to develop strategic transportation electrification plans, and note that Xcel has published a similar plan in Minnesota. However, they also state that the Commission should make it clear to the utilities that they are encouraged to bring proposed programs to the Commission in the near future, and do not need to wait until a comprehensive plan or roadmap is developed to begin investments in support of transportation electrification.

CEO/RAQC stated that they agree with the Joint Participants. The CEC comments did not directly address this question, but did state, "the Commission should evaluate any applications or other rate related filings on a case-by-case basis." There appears to be a broad consensus that

development of transportation electrification plans is appropriate, but that such a process should not delay the near-term ability for utilities to propose transportation electrification programs.

Public Service states that they have no position on the question, but intend to propose a plan and initial steps in the near future. Greenlots believes that such a plan, or a broader decarbonization plan that includes transportation electrification, could be helpful, but the Commission should make it clear that such a process should not delay utilities in bringing transportation electrification programs forward. Tesla also states that such a planning process may be useful, but should not overcomplicate the on-going effort to drive initial program proposals and investments by the utilities in charging infrastructure.

Interoperability and Communication Standards

Many states are beginning to deal with the issue of Interoperability and Communication among the network of EV charging infrastructure and between charging hardware and software. The existing network of charging stations has developed in a bottom-up fashion through the independent efforts of numerous companies and governments, and has largely not been planned with interoperability and cohesive communication capabilities in mind. Because EV technologies are still emerging, state-of-the-art technology evolves quickly and standards are often poorly defined or vary widely among regions. This uncertainty can discourage investment from utilities in programs that fall outside of their traditional business model.[88] In order for regulators to have active discussions on interoperability and communication standards for publicly funded infrastructure, these terms should first be fully defined.

Clear guidance from regulators for any publicly funded infrastructure may allow utilities to offer solutions with confidence and collaborate with other stakeholders, and lead to a more unified system for EV customers. This barrier can be found in the existence of multiple networks for customer transactions, which can diminish the customer experience for the EV driver. Roaming across networks can be difficult for drivers because the networks lack cooperative billing agreements and have not supported standards for executing transactions and settlements. Making it easy for a driver to charge at any station anywhere in the country is a large challenge facing the EV charging industry. European utilities and infrastructure companies in Europe, especially in the Netherlands and Germany, have advocated for communications standards to allow network interoperability and driver "e-roaming" between charging station networks, including the Open Clearing House Protocol and Open Charge Point Interface in many countries.[89]

Hardware/software interoperability is another important consideration. Interoperability can be considered at the front and back end to enable opportunities for simple billing, roaming across

[88] (Cohen, 2017)
[89] (Lawrence Berkeley National Laboratory (LBNL), 2018)

networks, and potential facilitation of swapping out components between various operators. In designing program requirements for publicly funded networks, utilities can evaluate what best meets customer needs in terms of interoperability. Greenlots notes that at its core, utilizing open standards, such as Open Charge Point Protocol (OCPP, for front end and back end interoperability across both hardware and software means that chargers and hardware can be easily swapped out with any other OCPP compliant device, and that any software or network services provider can be easily swapped out for another. This both protects investments and promotes competition and innovation across both hardware and software.

Through the VW mitigation funds, Electrify America is building out the first for-profit national charging system in the country and has made interoperability a key criterion of its grant making for EV infrastructure deployments for workplace charging and multi-unit dwellings in 15 metropolitan areas. Specifically, Electrify America requires vendors to use the OCPP and OpenADR, noting that utilities and vendors are gravitating toward a market for hardware/software interoperability.

The Joint Participants stated that the Commission should provide the utilities guidance as to the desired end result but should generally allow utilities to determine which technologies or practices will best achieve that result. For example, the Commission could indicate that anyone should be able to use any public charging station deployed pursuant to a utility program with public funds and easily know what it will cost to charge without the need to enroll in a proprietary network or use proprietary smart phone applications. Likewise, the Commission could indicate that utility investments for charging infrastructure such as utility owned chargers or publicly accessible chargers supported by ratepayer funds should use open standards and protocols for interoperability, but direct the utility to determine what standards and protocols meet those requirements.

Public Service points to its support of open standards as part of the Company's grid modernization efforts[90] and will embrace them as the EV market and technology develop as well. Given that standards and protocols are still emerging and will continue to change rapidly over the coming years, Public Service believes it will be difficult for the Commission to stay current and enforce the many standards and a more appropriate Commission role here would be to ensure that any utility investments appropriately consider interoperability.

Tesla points to the work by California's Vehicle-Grid Integration Communication Protocol Working Group draft report that found it is premature to mandate any specific communication standards or protocols as the costs and benefits to customers are still largely unknown. The Working Group is an ongoing process and no final report has been issued. Further, Tesla

[90] Proceeding No. 16A-0878E

believes that no Public Utility Commission in North America has adopted a specific interoperability standard or "single-protocol" for charging stations.

In response to both Public Service and Tesla, Siemens notes that California has mandated that OpenADR be used for demand response programs, which would include EV related pilots.[91] For example, a Southern California Edison pilot leverages the demand response and EV infrastructure industry's two *de facto* open standards, OpenADR 2.0b and OCPP, to manage EV loads without requiring separate systems for charging management. The pilot aims to inform future EV charging initiatives in many key areas.[92] In addition, Nevada has mandated interoperability and required OCPP compliance for VW Appendix D Settlement-related expenditures.[93] Electrify America already mandated OCPP and OpenADR for their chargers across the country.

Greenlots supports the Commission encouraging or requiring open standards such as OCPP and OpenADR. They argue that proprietary networks in publicly funded programs unjustifiably risk that infrastructure investments could become stranded assets that do not meet evolving needs, and that vendor lock-in results could result in higher operating costs, all while stifling innovation and competition across charging hardware, software, and services. Greenlots adds that the adoption of open protocols and standards is essential to support transportation electrification, grow the market for EVs and EV charging products and services, enhance the driver/customer experience, integrate with the electricity system, and lower the cost of ownership of both EVs and EV charging infrastructure. Siemens also signaled support for these positions as well.

Ford agrees that interoperability and communications standards among the network of EV charging infrastructure is key for EV adoption and should be prioritized for future discussion.

The assigned Staff concludes that as Interoperability and Communication standards and protocols are still emerging and may continue to change rapidly over the coming years, it will be difficult for the Commission to stay current and enforce the many standards. A more appropriate Commission role here would be to ensure that any utility investments appropriately take standards and interoperability into consideration, similar to the approach for Public Service's grid modernization efforts through its AGIS application.

This is an area where stakeholders participating in a litigated proceeding such as an Application to approve Make-Ready Infrastructure investments would need to propose their own perspectives and solutions.

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[91] OpenADR Alliance http://www.openadr.org/index.php?option=com_content&view=article&id=81:openadr-and-title-
[92] OpenADR Alliance http://www.openadr.org/index.php?option=com_content&view=article&id=132:greenlots-
[93] Nevada Governor's Office of Energy, "Notice of Nevada Electric Highway Funding Opportunity",

http://energy.nv.gov/uploadedFiles/energynvgov/content/Programs/Notice%20of%20Funding%20Opportunity.pdf

Areas for Further Research Based on EV Working Group Discussion

As the CoPUC EV Working Group has identified, the electrification of the vehicle fleet raises a number of opportunities and challenges for the Commission and Colorado's electricity grid. To address such a potentially disruptive market development, the Commission should continue to examine EV issues in collaboration with stakeholders.

As mentioned above, more frequent, assertive use of scalable demonstration pilot projects to test EV integration approaches may be warranted. Experimentation through demonstration projects gives regulators some assurance that larger utility investments in the future will not negatively impact ratepayers or lead to other unintended consequences, and enables utilities to experiment with quickly evolving technologies before making more significant investments.

The impact of charging infrastructure investment on electricity rates is a key concern of utilities, regulators, advocates, and consumers. There are several approaches to recovering the costs of infrastructure investments that are cautious about increasing electricity costs while also honoring the regulatory requirement that a utility have the opportunity to earn a fair rate of return on its investment. For example, utilities could recover a portion of the investment costs from electricity customers, a portion from a charging infrastructure site host, and a portion from EV drivers. MJ Bradley has identified several utility programs that recover costs from charging infrastructure users using a variety of payment structures. These could be explored further by a stakeholder group and include membership models that provide customers access to a network of charging locations for a fixed monthly or annual fee. In some fixed fee models, a driver pays a fixed amount to enter a charging location, as well as usage-based fees that charge customers based on the amount of energy consumed, perhaps varying by time of day or location. There could be an option for free charging, most often associated with workplaces or other places that provide charging as a benefit to employees or customers, as well as additional hybrid models.

Another key area to explore is more comprehensive consideration of EVs in utility planning. The utilities need to plan for this increased EVSE load, and their impacts on the integrated grid. The Commission can set forth guidelines and metrics for such planning for increased EVSE deployments and loads, and perhaps link these efforts to distribution resource planning for increased DERs in the grid. Utilities will need to start finding ways to incorporate these projected loads into their existing load forecasting models for integrated resource planning, or start a parallel planning process recognizing the unique features of the charging infrastructure to be a flexible load integrated with the grid and capable for EV services such as demand response and potentially distributed storage in certain cases.

Load forecasting is another key element that underpins a utility's investment plans. Forecasts should include granular projections of EV potential and expected customer adoption on different parts of the system, and the resulting effects on load, including the effect on system wide peak and distribution system peaks, especially when EVs are clustered. These granular forecasts will also be of increasing importance to regional transmission and wholesale market capacity planning. Another advantage to a robust utility role is the need for a strong planning function in which the utility can coordinate the type, location, and power requirements of the EV infrastructure in the utility system, to ensure least-cost highest value investments for all utility customers.

Consumer protections, rate design, and bill payment assistance programs may help increase EV use among low-income consumers and encourage continued EV use by these consumers after they purchase or lease vehicles. However, many low-income consumers, absent a subsidized EV acquisition program, will either not be able to afford to transition to an EV or will be unable to afford a private vehicle at all. EV programs also could include a focus on replacing diesel engines with EVs in disadvantaged communities that are disproportionately impacted by fine particulates pollution. Utilities could consider collaborating with third parties to explore and support advanced mobility projects in their service territory. Examples include EV car sharing, EV TNCs, transit integration including traditional (*e.g.,* buses) and non-traditional services (*e.g.,* dynamic shuttles), and many others.

EV programs should also consider rural areas. This might mean a commitment to a "minimum basic network" of charging throughout the utility service territory. This might mean supporting DC fast charging corridors that bring service everywhere. This might mean an effort to identify economically beneficial use cases in rural areas such as vehicle fleets. There is currently too little data to determine the best ratio of charging stations to electric vehicles. In the absence of evidence, utilities, charging station owners, and other stakeholders should collect and share data about infrastructure utilization early and often. Special attention should be given to sites that provide charging services to meet unique needs, such as transit corridors and multifamily dwellings

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Appendix

Participants in EV Workgroups

Asterisk (*) indicates that the organization was part of the October 31st filing of joint responses to Commission questions in 17I-0692E. Ampersand (&) indicates that the organization supported the Statement from PUC EV Work Group Members on Make-Ready Infrastructure filed on October 11th.

Organization	Name	Participation in Sub-topic Work Groups					
		I Rate Design - RES	II Rate Design - COM	III Make-Ready Invest	IV Beneficial Electrification	V Education and Outreach	VI Next Steps
Industry							
Alliance for Transportation Electrification&	Phil Jones			Yes			
	Nick Nigro		Yes				
Auto Alliance*&	Steve Douglas	Yes	Yes	Yes	Yes	Yes	Yes
	Dan Bowerson	Yes	Yes	Yes	Yes	Yes	Yes
BYD North America*	Zachary Kahn						
ChargePoint*&	Scott Dunbar	Yes	Yes	Yes	Yes	Yes	Yes
	Anthony Harrison	Yes	Yes	Yes	Yes	Yes	Yes
	Shaun Caldwell	Yes	Yes	Yes	Yes	Yes	Yes
Electrify America	Michael Tubman		Yes	Yes	Yes		Yes
	Jigar Shah		Yes	Yes	Yes		Yes
eMotorWerks*	David Schlosberg	Yes			Yes	Yes	
	Marc Monbouquette	Yes	Yes	Yes	Yes	Yes	Yes
EV Box*	Megha Lakhchaura	Yes	Yes	Yes	Yes	Yes	Yes
EVGo*&	Jonathan Levy		Yes				Yes
	Sara Rafalson		Yes	Yes	Yes		Yes
	Adam Mohabbat		Yes				Yes
FHueng Engineering	Rachel Ackermann		Yes		Yes	Yes	Yes
Ford	Rebecca Shelby	Yes	Yes	Yes	Yes	Yes	Yes
	Steve Henderson	Yes	Yes	Yes	Yes	Yes	Yes
	Deb Heed						
GM*	Jamie Hall	Yes	Yes	Yes	Yes	Yes	Yes
	Britta Gross	Yes	Yes	Yes	Yes	Yes	Yes
Greenlots*&	Erick Karlen	Yes	Yes	Yes	Yes	Yes	Yes
	Thomas Ashley	Yes	Yes	Yes	Yes		Yes
National Car Charging*&	RJ Harrington	Yes	Yes	Yes	Yes	Yes	Yes
Proterra*&	F. Kent Leacock		Yes	Yes			Yes
Siemens*&	Chris King	Yes					Yes
	Bonnie Datta	Yes					Yes
Tesla&	Thad Kurowski	Yes	Yes	Yes	Yes	Yes	Yes
	Francesca Wahl	Yes	Yes	Yes	Yes	Yes	Yes
	Junaid Faruq	Yes	Yes	Yes	Yes	Yes	Yes

Organization	Name	Participation in Sub-topic Work Groups					
		I Rate Design - RES	II Rate Design - COM	III Make-Ready Invest	IV Beneficial Electrification	V Education and Outreach	VI Next Steps
Government							
Boulder County*&	Susie Strife	Yes	Yes	Yes		Yes	
Boulder&	Matthew Lehrman	Yes	Yes		Yes		
BW Energy Law	*Chris Colclasure*	Yes	Yes	Yes	Yes	Yes	Yes
CDOT	Michael King			Yes		Yes	
CDPHE (Air Pollution)	*Chris Colclasure*[94]	Yes	Yes	Yes	Yes	Yes	Yes
	Garrison Kaufman	Yes	Yes	Yes	Yes	Yes	Yes
	Doug Decker	Yes	Yes	Yes	Yes	Yes	Yes
	Christine Hoefler	Yes	Yes	Yes	Yes	Yes	Yes
CDPHE (Mobile Sources Program)	Phil vonHake			Yes		Yes	
CEO	Lindsey Stegall	Yes	Yes	Yes	Yes	Yes	Yes
	Zachary Owens			Yes		Yes	
	Maria Eisemann	Yes	Yes	Yes			
	Christian Willis				Yes		Yes
CU Boulder&	Brian Lindoerfer		Yes				
	Heidi VanGenderen			Yes			
Denver*&	Elizabeth T. Babcock						Yes
	Michael Salisbury	Yes	Yes	Yes	Yes	Yes	Yes
Lakewood	Jonathan Wachtel						
RAQC	Steve McCannon	Yes	Yes	Yes	Yes	Yes	Yes
	Matt Goble	Yes	Yes	Yes	Yes	Yes	Yes
RTD*&	Carly Macias		Yes	Yes	Yes		Yes
	William Weidenaar		Yes	Yes	Yes		
Summit County&	Kate Berg						
Non-Profit							
Colorado Energy Consumers	Michelle King	Yes	Yes	Yes	Yes	Yes	Yes
Dietz and Davis	Mark Detsky	Yes	Yes	Yes	Yes	Yes	Yes
Earthjustice	Michael Hiatt	Yes	Yes	Yes	Yes	Yes	Yes
Grid Alternatives	Tom Figel	Yes	Yes	Yes	Yes	Yes	Yes
	Vicky Mandell	Yes	Yes	Yes	Yes	Yes	Yes
NRDC*&	Max Baumhefner	Yes	Yes	Yes	Yes	Yes	Yes
RMI*	Chris Nelder		Yes				Yes
	Chuck Ray		Yes	Yes		Yes	
Sierra Club*&	Zach Pierce			Yes	Yes		Yes
	Joe Halso			Yes	Yes		Yes
SWEEP* and NRDC*&	Sarah Keane			Yes	Yes	Yes	Yes
SWEEP*&	Will Toor		Yes	Yes			
Vote Solar*&	Rick Gilliam	Yes	Yes	Yes			
WRA*&	Erin Overturf	Yes	Yes	Yes	Yes	Yes	Yes
	Gwen Farnsworth	Yes	Yes	Yes	Yes	Yes	Yes

[94] Moved to BW Energy Law

Organization	Name	Participation in Sub-topic Work Groups					
		I Rate Design - RES	II Rate Design - COM	III Make-Ready Invest	IV Beneficial Electrification	V Education and Outreach	VI Next Steps
Utilities							
Black Hills	Ann Hendrickson	Yes	Yes	Yes			
GCEA	Mike McBride	Yes				Yes	
Public Service	Jack Ihle	Yes	Yes	Yes	Yes	Yes	Yes
	Kevin Schwain			Yes			
	Steven Wishart	Yes	Yes		Yes		
	Beth Chacon				Yes		
	Erick Van Orden					Yes	
Tri-State	Thomas Dougherty			Yes	Yes	Yes	Yes
	Shaun Mann						
	Myles Jensen	Yes	Yes		Yes		
Colorado PUC							
	James Lester	Yes	Yes	Yes	Yes	Yes	Yes
PUC support							
	Drew Bolin						
	Rebecca Lim						