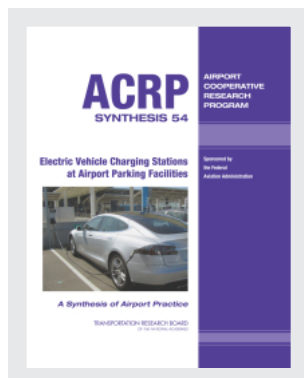


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AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP SYNTHESIS 54

**Electric Vehicle Charging Stations
at Airport Parking Facilities**

A Synthesis of Airport Practice

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WASHINGTON, D.C.
2014
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AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The ACRP was authorized in December 2003 as part of the Vision 100-Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), Airlines for America (A4A), and the Airport Consultants Council (ACC) as vital links to the airport community; (2) the TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academies formally initiating the program.

The ACRP benefits from the cooperation and participation of airport professionals, air carriers, shippers, state and local government officials, equipment and service suppliers, other airport users, and research organizations. Each of these participants has different interests and responsibilities, and each is an integral part of this cooperative research effort.

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Once selected, each ACRP project is assigned to an expert panel, appointed by the TRB. Panels include experienced practitioners and research specialists; heavy emphasis is placed on including airport professionals, the intended users of the research products. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, ACRP project panels serve voluntarily without compensation.

Primary emphasis is placed on disseminating ACRP results to the intended end-users of the research: airport operating agencies, service providers, and suppliers. The ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties, and industry associations may arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by airport-industry practitioners.

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Cover figure: EV charging station and vehicle (*credit: LeighFisher*).

FOREWORD

Airport administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to the airport industry. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire airport community, the Airport Cooperative Research Program authorized the Transportation Research Board to undertake a continuing project. This project, ACRP Project 11-03, "Synthesis of Information Related to Airport Practices," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an ACRP report series, *Synthesis of Airport Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

*By Gail R. Staba
Senior Program Officer
Transportation
Research Board*

The provision of electric vehicle (EV) charging at airports is a very new and evolving practice. EV charging technology and the costs associated with providing EV charging stations are still evolving and there are still many unknowns, conflicting information, and speculation about this new practice. Purchases of EVs are increasing throughout the United States, with the West Coast states accounting for a disproportionately high number. Research undertaken for this report has shown that at least 37 airports in the United States are providing EV charging stations, most commonly in short-term or long-term parking facilities, and usually with no fee for charging.

The report presents a primer on EV charging and includes information to understand the policy approaches, infrastructure needs, and funding mechanisms that airports have used in EV hosting. This report (1) summarizes the state of the EV industry and motivations for airport sponsors to provide EV charging stations, (2) identifies current EV charging technologies, and (3) describes effective practices for installing EV charging stations at airports in terms of finances, planning, implementation, and operation of the charging stations. This report is intended to help airport management staff, specifically those environmental, parking, and facilities managers who may be interested in installed EV charging stations.

Alice Richard, LeighFisher, Inc., Reston, Virginia, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

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Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

GLOSSARY OF TERMS, ABBREVIATIONS, AND ACRONYMS

Access fees—fees collected from electric vehicle users for the right to use charging stations, or for the cost of the electricity used.

American Recovery and Reinvestment Act (ARRA)—a U.S. law enacted in 2009, also known as the Stimulus, which provided government funding in areas such as healthcare, education, infrastructure investment, and energy efficiency and renewable energy research and investment.

ADA (Americans with Disabilities Act)—a U.S. law enacted in 1990 that prohibits discrimination based on disability in circumstances such as employment, public transportation, public accommodations and commercial facilities, and telecommunications.

Concessionaire—a firm that operates another party’s facility and in exchange pays a fixed sum or percentage of revenue to the owner of the facility.

Demand charge—an electrical utility fee, supplemental to actual electricity use charges, imposed on large, typically commercial users of electricity, which is calculated based on the peak amount of electricity used by the given customer in a given month.

Electric vehicle (EV)—a hybrid electric plug-in or fully electric plug-in automobile.

Electrical infrastructure—the electrical components required to provide the necessary electrical load to a given system; may include a transformer, circuit breaker, wiring, and conduit.

kW—kilowatt.

kWh—kilowatt hour.

Legacy chargers—EV charging stations designed prior to the development of the Level 1, Level 2, and Level 3 standards. They are usually compatible with a single manufacturer’s vehicle.

Level 1 EV charging station—a 1.4 kW EV charging station, which generally uses a standard 120 V electrical outlet. It typically provides about four miles of range for every hour charged.

Level 2 EV charging station—a 6.6 kW EV charging station that has an internationally recognized standard connector. It typically provides about 20 miles of range for every hour charged.

Level 3 EV charging station—sometimes referred to as a “DC fast charger,” it is a 50 kW EV charging station that has a manufacturer-specific charging connector (i.e., no standard). It typically provides about 150 miles of range for every hour charged.

Range—the distance an EV can travel on one full charge.

“Smart” charging station—a networked charging station connected to Internet applications, which may have capabilities to track usage and/or charge a fee for using the station through an access card system.

ELECTRIC VEHICLE CHARGING STATIONS AT AIRPORT PARKING FACILITIES

SUMMARY

The increasing number of electric vehicles (EVs) on the roads today, particularly since 2008, has led to airport sponsors adopting a new practice: installing EV charging stations for public use. EV charging technology and the costs associated with providing EV charging stations are still evolving and there are still many unknown factors, conflicting information, and speculation about this new practice. This ACRP project was conducted to synthesize the information found in published literature and gathered from airport sponsors with experience in EV charging. This report summarizes the state of the EV industry and the motivations for airport sponsors to provide EV charging stations; identifies current EV charging technologies; and describes effective practices for installing EV charging stations at airports in terms of finances, planning, implementation, and operation of the charging stations. This report is intended to help airport management staff, specifically those environmental, parking, and/or facilities managers who may be interested in installing EV charging stations.

Purchases of EVs are increasing throughout the United States, with the West Coast states accounting for a disproportionately high number of EVs on the road. Research undertaken for this report has shown that at least 37 airports in the United States are providing EV charging stations, most commonly in short-term or long-term parking facilities, and usually with no additional charging fee to customers. None of the airport sponsors interviewed reported the installation process as being particularly onerous, especially if up-front costs were alleviated by grants and if the existing electrical infrastructure was adequate to support the EV charger installation.

Many airport sponsors reported providing EV charging stations initially as an environmental initiative, with the expectation that the charging stations would convince parking customers to travel to the airport in clean EVs, and thus reduce emissions in the area. More recently, passengers as well as employees are beginning to request EV charging stations, indicating that they already have EVs and need a place to charge them. As a result, at many airports, providing this equipment has become not only an environmental initiative but also a customer service issue. With parking revenue often representing a significant portion of an airport's operating budget, increasing revenue is always important, and providing good customer service is a significant part of that equation.

Information for this report was gathered through a literature search and interviews with the environmental, parking, and other facilities management staff of 12 airport sponsors in North America (representing 18 airports) that have direct experience with the installation and management of EV charging stations. The 12 interviewees were chosen in an attempt to be geographically diverse and/or to collect stories from airport sponsors that were known to have had a particular experience. It should be noted that there are many policies, management concepts, and results reported at other airports in North America that are not included in this report.

The data collection response rate for the interviews was 100%—all 12 airport sponsors approached participated in one-hour interviews about their experiences and lessons learned. The investigation for this report, conducted in the summer of 2013, represents a snapshot of the current state of the industry. Both the literature search and interviews indicated that providing EV charging stations for airport passengers raises many challenges and considerations, some of which are of concern to all airports, some of which are unique to airports in areas that are more saturated with EVs, and some of which are unique to airports in areas that have seen slower EV integration.

All airport sponsors who either have installed EV charging stations or are planning to install them are concerned about such issues as future trends and technology, revenue potential or cost reimbursement possibilities, and the advantages and disadvantages of such installations. Airports reported an increase in EV charging station use over time, consistent with increasing EV sales; from January 2013 to July 2013, the registration of EVs increased by more than 50% in California, Washington, New York, and Florida. Only one of the 12 airport sponsors surveyed collects a fee for the use of EV charging stations; the other 11 airport sponsors do not impose an additional fee for using an EV charging station, so EV drivers pay the same parking rate as other users of the facilities. Revenue generation from access fees has not been reported as a primary consideration, although some airport sponsors have recognized that additional parking revenues may be generated from customers who choose airport parking facilities and/or upgrade to premium lots in order to use EV charging stations.

West Coast airports were among the first to provide EV charging stations and have installed the largest number of stations. This is not surprising, as 47% of the EVs in the United States are registered in California, Oregon, or Washington. With the increased number of EVs, some airports are finding that demand for charging stations is exceeding supply, and airport sponsors are challenged to determine how and where to expand the number of charging stations. In cases where demand is exceeding supply, airport sponsors have either installed additional stations according to need, increased the number of EV-dedicated parking spaces adjacent to existing EV charging stations, considered solutions such as valet management of EV chargers, and/or considered requiring EVs to be plugged in if they are parked near EV charging stations. When additional charging stations are required, the optimal number and location for the equipment has been determined by customer demand, funding availability, and/or average length of stay for customers.

Other airports, newer to the practice of installing EV charging stations, are focused on such challenges as choosing the number and location of charging stations that will meet demand and improve customer service; and technical issues such as equipment and electrical infrastructure requirements. The correct number of charging stations depends on the percentage of EVs in the service area of the airport, while the preferred locations are almost always close to the terminal building and highly visible to the traveling public. Many airport sponsors have chosen to begin with a small number of charging stations and increase the number gradually in accordance with demand.

Current EV charging station technology includes Level 1, Level 2, and Level 3 chargers. Level 1 chargers provide the slowest charge (four miles of range for every hour of charging) and typically use a 120V commercial grade wall outlet. Level 2 and Level 3 chargers are increasingly faster (20 and 150 miles of range for every hour of charging, respectively) and require more supporting infrastructure. While all EVs can use Level 1 and Level 2 chargers, Level 3 chargers are vehicle-specific, and EVs have to be properly equipped to use them.

Costs to install EV chargers have been reported as low as \$1,500 for one Level 1 station and as high as \$65,000 for a Level 3 station. The cost of equipment is expected to change over time, and project costs are highly dependent on the number of stations being installed. The availability of electrical infrastructure, such as substations, transformers, circuits, and panel boxes, is also integral to the cost to install EV chargers. Significant electrical infrastructure capacity might be needed in order to connect EV charging stations to the electrical grid. Therefore, there is wide inconsistency in the full costs of installing EV charging stations, given that some airports have excess electrical capacity and others will have to add electrical capacity by improving their electrical infrastructure. An analysis of existing electrical loads could allow airport sponsors to understand whether additional infrastructure will be needed and could minimize costs by identifying charging station locations with existing excess capacity.

CHAPTER ONE

INTRODUCTION

This ACRP Report provides insights and lessons learned that may be useful to airport sponsors interested either in installing plug-in electric vehicle (EV) charging stations for the first time or in adding to existing EV charging station initiatives. It is important to note that this is a nascent industry and therefore things are changing very rapidly. EV manufacturers and EV charging station manufacturers are still entering and exiting the arena relatively frequently. The business of charging EVs, including capital costs, potential profit, supply/demand, societal priorities, and potential liabilities, will continue to evolve well past the maturation of the industry.

The literature review conducted for this report was supplemented by interviews with personnel from 12 airport sponsors, representing 18 airports in the United States and Canada, that had direct responsibility for the installation or management of EV charging stations for public use. While the response rate was excellent—all 12 airport sponsors that were approached participated in one-hour interviews about their experiences and lessons learned—the information collected from these interviews is anecdotal and is expected to evolve with the industry. A list of all questions asked and a generalized summary of responses can be found in Appendix A. A list of U.S. and Canadian airports that were found to have EV charging stations can be found in Table 1, with those airports contacted so noted.

In recent years, the introduction of federal tax credits, state incentives for EV ownership, low lease rates, and new EV models from vehicle manufacturers have encouraged increased EV ownership. EV ownership comes with many advantages; however, charging EVs away from home can be a challenge, as they cannot be charged as quickly as conventionally fueled vehicles, or in as many places. If airports sponsors do not provide EV charging stations, fewer EV users will be able to travel to/from the airport. The range of each EV, the length of stay, and the distance traveled roundtrip to the airport determines whether an EV can be used for that trip. As a result, airports and other parking operators are trying to determine how best to support the increased use of EVs. For the purpose of this report, EVs are defined as both plug-in fully electric vehicles and plug-in hybrid electric vehicles. Vehicles that do not have an electric charging port do not qualify under this definition of EV. There is no discussion of legacy chargers, which are chargers used by EVs produced prior to 2008 and were designed to charge specific vehicles.

Federal, state, and local governments and airport sponsors often have policies that reflect sustainability goals. The operation of EVs in lieu of conventionally powered vehicles can support these goals by decreasing ambient air pollutants and greenhouse gas emissions. The installation of EV charging stations is one visible way to support the use of EVs and meet sustainability goals. Further, providing EV charging stations is increasingly seen as a service that is necessary in order to support customers who already own EVs. Parking facilities at airports are for-profit operations, so understanding the customer's needs is essential to revenue generation. (EV charging stations in public facilities can also be used to support airport-owned EV fleets, but the scope of this report focuses on providing EV charging stations for public use.)

In the United States, SAE and original equipment manufacturers (OEMs) have been working to establish EV charging standards. This report addresses EV charging technology that is used for 2008–2013 model year EVs, referred to as Level 1, Level 2, or Level 3. Level 1 chargers provide the slowest charge (four miles of range for every hour of charging), have a typical charging power of 1.4 kilowatts (kW) and uses a standard 120V outlet. Level 2 chargers are faster than Level 1 chargers (20 miles of range for every hour of charging), have a typical charging power of 6.6 kW, and use

TABLE 1
AIRPORTS WITH ELECTRIC VEHICLE CHARGING STATIONS

Airport Name	State
Baltimore/Washington International Thurgood Marshall	MD
Boston Logan International*	MA
Charlotte/Douglas International	NC
Chicago Midway International	IL
Chicago O'Hare International	IL
Dallas Love Field	TX
Dallas/Fort Worth International*	TX
Denver International*	CO
Detroit Metropolitan Wayne County*	MI
Fairbanks International	AK
George Bush Intercontinental/Houston*	TX
Hilo International*	HI
Honolulu International*	HI
John F. Kennedy International*	NY
John Wayne Airport-Orange County	CA
Kahului*	HI
Kona International*	HI
LaGuardia*	NY
Lambert–St. Louis International	MO
Lihue*	HI
Los Angeles International*	CA
Metropolitan Oakland International*	CA
Monterey Peninsula	CA
Norman Y. Mineta San Jose International	CA
Ontario International	CA
Phoenix Sky Harbor International	AZ
Portland International	OR
Quad City International	IL
Reno/Tahoe International	NV
Ronald Reagan Washington National	VA
Sacramento International	CA
San Antonio International	TX
San Diego International	CA
San Francisco International*	CA
Seattle–Tacoma International*	WA
Toronto Pearson International Airport*	Ontario
Vancouver International	British Columbia
Washington Dulles International	VA
William P. Hobby*	TX

Note: Airports included in the above list were determined through a literature review and a survey of airport websites. The list may not be all-inclusive.

*Indicates an airport that was included in the interviews associated with this report.

Source: LeighFisher (September 2013).

an industry standard connector. All EVs can use Level 1 and Level 2 charging. Level 3 chargers are the fastest chargers (150 miles of range for every hour of charging), and are also known as “DC fast chargers.” EVs have to be specifically equipped to use Level 3 chargers and there is no one standard connector in use at this time.

Topics addressed in this report include overviews of:

1. **Current technology:** What models of EVs are available and what is the current state of the market? What are the current charging technologies and how are they used at airports? Chapter two summarizes the state of the EV market, EV technology, and EV charging station technologies.
2. **Business and policy issues:** What do charging stations cost and why should they be provided at airports? What fees are charged EV charging station users? What role does a third-party parking operator or concessionaire play? Chapter three reports policies, capital cost, grant opportunities, and rate structures.
3. **Planning requirements:** What types of facilities and resources will an airport need in order to install an EV charging station? What decisions will need to be made about location, number, type, and signage? How have other airport sponsors addressed these challenges? Chapter four presents information on customer needs, preferred locations, required electrical infrastructure, staff resources, and tracking usage.

CHAPTER TWO

TECHNOLOGY EVALUATION AND CURRENT STATE OF THE INDUSTRY

AVAILABILITY OF ELECTRIC VEHICLES

According to the DOE, 16 EV models were available for public purchase in the United States in fall 2013, including models from BMW, Chevrolet, FIAT, Ford, Honda, Mitsubishi, Nissan, Porsche, smart, Tesla, and Toyota (Figure 1). However, it is important to note that EV manufacturers are still entering and exiting the landscape relatively frequently. All of the currently available EVs can use the standardized charging systems defined by SAE as Level 1 and Level 2 chargers. From Figure 2, which illustrates the cumulative sales of EVs in the United States over the past three years, it is seen that roughly 130,000 EVs have been sold since December 2010, with 53,000 sold in 2012. Sales growth is expected to continue; a projection by Pike Research in September 2013 suggested that roughly 400,000 EVs would be sold in the United States each year by the year 2020. The use and availability of EVs also varies significantly depending on location, with metropolitan areas, particularly those on the West Coast, having the highest number of EVs on the road. Table 2 shows that in July 2013, approximately 40% of all EVs registered in the United States were registered in California.

Although the initial capital cost of an EV is higher than conventionally fueled models, financial incentives available through federal tax credits, state incentives, low lease rates, and fuel cost savings are having a positive impact on sales. Additional benefits of driving an EV include zero tailpipe emissions, in addition to locality-specific benefits such as free or premier parking, insurance discounts, electricity rebates, and restricted driving and parking access benefits similar to those provided high-occupancy vehicles.

The amount of electricity each vehicle draws per charge varies by model, but a typical Nissan LEAF will draw 8 to 20 kWh per session, and a Tesla Model S will draw approximately 65 kWh per session. At an average electricity cost of \$0.10 per kWh, the cost to fuel these vehicles is typically \$0.80 to



FIGURE 1 EVs in designated parking spaces at San Francisco International Airport. (Source: LeighFisher 2013.)

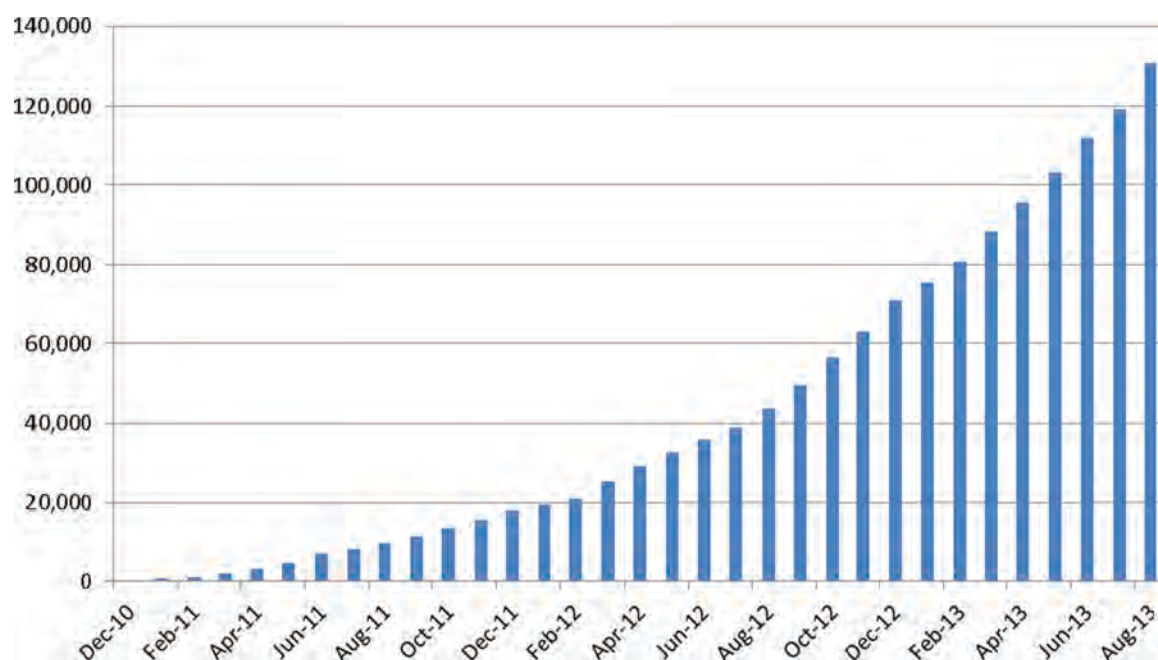


FIGURE 2 Cumulative plug-in electric vehicle sales in the United States. Note: Includes both plug-in hybrid and battery electric vehicles. (Source: LeighFisher, adapted from Electric Drive Transportation Association.)

TABLE 2
ELECTRIC VEHICLES REGISTERED IN THE UNITED STATES

State	January 2013	July 2013	% Increase
California	22,783	38,122	67.3
Washington	2,874	4,926	71.4
New York	2,598	4,198	61.6
Florida	2,454	3,976	62.0
Michigan	2,681	3,926	46.4
Texas	2,311	3,721	61.0
Maryland	1,624	2,616	61.1
Illinois	1,471	2,528	71.9
New Jersey	1,358	2,314	70.4
Georgia	1,124	2,273	102.2
Oregon	1,401	2,124	51.6
Pennsylvania	1,159	1,817	56.8
Minnesota	935	1,777	90.1
Massachusetts	1,104	1,766	60.0
Tennessee	1,293	1,672	29.3
North Carolina	1,091	1,615	48.0
Virginia	1,011	1,549	53.2
Arizona	1,066	1,524	43.0
Ohio	1,106	1,517	37.2
Colorado	788	1,376	74.6
Hawaii	821	1,300	58.3
Wisconsin	740	1,054	42.4
Connecticut	579	1,050	81.3
Missouri	453	760	67.8
Indiana	397	558	40.6
Nevada	315	532	68.9
Utah	295	510	72.9
Iowa	364	479	31.6
South Carolina	323	445	37.8
Oklahoma	390	439	12.6
New Hampshire	231	372	61.0

TABLE 2
(continued)

State	January 2013	July 2013	% Increase
Alabama	251	344	37.1
Maine	212	316	49.1
Nebraska	185	280	51.4
Kansas	178	268	50.6
Kentucky	174	258	48.3
Louisiana	165	255	54.5
New Mexico	161	255	58.4
Vermont	162	252	55.6
Montana	159	242	52.2
District of Columbia	95	229	141.1
West Virginia	111	174	56.8
Rhode Island	110	168	52.7
Arkansas	120	153	27.5
Idaho	90	132	46.7
Delaware	76	115	51.3
Mississippi	75	101	34.7
Alaska	47	58	23.4
North Dakota	46	50	8.7
South Dakota	35	39	11.4
Wyoming	20	35	75.0
Total	59,612	96,560	62.0%

Source: LeighFisher, adapted from data provided by ChargePoint, September 2013.

\$2.00 per session for a Nissan LEAF and \$6.50 for a Tesla Model S (source: U.S. Energy Information Administration 2013). Typically, a fully charged LEAF will have 75 miles of range, while a Model S can have up to 265 miles of range.

OVERVIEW OF CHARGING TECHNOLOGY

As previously discussed, currently available EV models can be charged using Level 1, Level 2, or Level 3 chargers. A summary of the technical information regarding these EV charging stations follows:

Level 1 Charging

The term “Level 1” was most often used to refer to 120V AC charging systems, such as typical household or industrial wall outlets, 120V outlets with dedicated circuits, and 120V outlets provided specifically for EV charging. One interviewee stated that it is important to ensure the electrical circuit hosting Level 1 charging has adequate capacity; otherwise, simultaneously using multiple outlets for EV charging could disrupt power by tripping circuits. An example of a Level 1 charging station installation project can be found at Denver International Airport (see case study). Figure 3 shows a typical Level 1 charging station, which has the following characteristics:

- Can be used by all EVs manufactured since 2008
- Provides four miles of range per hour of charge and requires up to 18 hours for a full charge (depending on vehicle)
- Usually requires the EV user to provide electrical cord
- Has a typical charging power of 12A to 16A and 1.4 kW, with a panel requirement of 1.8 kW to 2.4 kW (ChargePoint, Inc. 2013).

Level 2 Charging

Level 2 charging is used when the AC to DC conversion occurs in the vehicle and the input voltage is 208V to 240V (ChargePoint, Inc. 2013). Level 2 chargers have standard connectors and receptacles

CASE STUDY: Denver International Airport

The city of Denver Department of Aviation (DOA) was an early leader in providing EV charging stations for its customers. In 2001, a legacy charging station was installed that was compatible with the first generation electric Toyota RAV4. In recent years, customers have been accessing numerous 120V outlets throughout the parking garages by providing their own EV charging cords.

To meet public requests, the DOA is currently installing 10 Level 1 EV charging station, five on each side of the terminal building. The stations will be equipped with 120V retractable cords and will be located in daily long-term parking. The installation of the charging stations will not require additional electrical infrastructure, will be available for public use, and can be accessed without an additional fee. An example request for proposals for EV charging stations was provided by the DOA and can be found in Appendix B.

adopted by nearly all EV manufacturers in Japan, Europe, and the United States since 2009, and which meet the SAE J1772 specifications. These specifications describe the electrical requirements of Level 2 charging as well as the mechanical characteristics of the connector. Level 2 charging stations provide a greater rate of charge than Level 1 charging stations, although the exact amount of power depends on four components—the EV, the on-board charger, the size of the battery, and the maximum current supplied from the electrical grid. Figure 4 shows a typical Level 2 EV charging station, which has the following characteristics:

- Can be used by all EVs manufactured since 2008
- Provides an EV with 20 miles of range per hour of charge (ChargePoint, Inc. 2013)
- Has a typical charging power of 32A and 6.6 kW with a panel requirement of 8.3 kW (ChargePoint, Inc. 2013)
- Has an electrical cord and connector attached to the EV charging station.

There are Level 2 charging stations in the valet parking facility at Dallas/Fort Worth International Airport (see case study).



FIGURE 3 Level 1 charging station.
(Source: LeighFisher September 2013.)

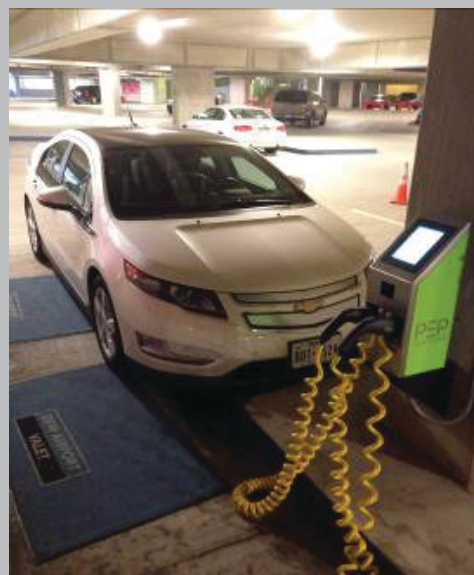


FIGURE 4 Level 2 charging station.
(Source: LeighFisher September 2013.)

CASE STUDY: Dallas/Fort Worth International Airport

Dallas/Fort Worth International Airport installed one dual-port Level 2 EV charging station in the valet parking area in September 2012. The charging station (produced by PEP Stations) can charge two vehicles simultaneously at 240V/30A, in compliance with SAEJ1772 Level 2 connectors (see photos). Valet customers are not charged an additional fee for using the charging station.

Installing the chargers in the valet parking area allows attendants to move EVs after charging is completed, which increases the number of vehicles that can be served by the charging station. The benefit of using Level 2 charging is that an EV can be charged in a matter of hours, rather than the extended charge time required for charging at Level 1 stations.



PEP EV Charging Station, DFW

Source: Dallas Fort Worth International Airport, 2013.



PEP EV Charging Connector, DFW

Level 3 Charging

Though it provides the fastest full charge of the three different technologies, Level 3 charging, also referred to as “DC fast charging,” lacks the universal standard and applicability of Level 1 and Level 2 charging stations, because it services EVs manufactured to use different Level 3 connectors. The three connectors used in the United States include the “CHAdemo” connector, which is the standard in Japan; the SAE combo connector; and the Tesla Supercharger, which is for proprietary stations and can only be used by Tesla EVs. Two of the three connectors are shown in Figure 5. Level 3 EV charging stations typically have the following characteristics:

- Can only be used by certain specifically equipped EV models
- Provide an EV with 150 miles of range per hour of charge, typically having the capability to charge an EV in 15 to 30 minutes (ChargePoint, Inc. 2013)
- Has a typical charge of 50 kW, with a panel requirement of 62.5 kW (ChargePoint, Inc. 2013).

The Port of Oakland is considering installing a Level 3 EV charger as part of its next round of installations at the Oakland International Airport (see case study). Table 3 provides a summary of Level 1, Level 2, and Level 3 technical characteristics.

Electrical Infrastructure

Electrical infrastructure refers to components such as substations, transformers, circuits, and panel boxes that are needed in order to provide electricity at the EV charging station. Depending on the charging station type and the electrical capacity of the parking facility, the electrical infrastructure needed to support that station will vary. An analysis of existing electrical capacity within parking facilities at an airport could allow the airport sponsor to determine whether additional infrastructure will be needed and thus can minimize installation costs by identifying charging station locations that have existing excess capacity.

It is important to note that the electrical load of each EV charger in a circuit is cumulative, and the electrical circuits are designed assuming that all EV chargers will be simultaneously drawing their peak load. In order to optimize peak electrical load with maximum EV charging capabilities, some manufacturers offer chargers that allocate electrical supply in a manner that prevents multiple EVs from simultaneously receiving peak electrical load. This is done using an algorithm that attempts to minimize delays in charging. With active management of the distribution of electricity, the capacity required from the electrical circuit will be less. This reduced loading can help minimize the electrical infrastructure required to support the electrical circuit.



FIGURE 5 Level 3 connectors: (Left) CHAdemo connector; (Right) Tesla Supercharger. Note: The SAE combo connector, a third type of Level 3 connector, is not shown. (Source: LeighFisher January 2014.)

CASE STUDY: Oakland International Airport

The Port of Oakland is committed to the principle of sustainability through adherence to the values of “environmental responsibility, economic vitality, and social equity.” The Port of Oakland’s sustainability policy is supported through a variety of environmental programs, including an initiative to provide free battery charging for EV users (categorized as an air quality and alternative fuel initiative). As a result, the Port currently provides a total of 21 EV charging stalls for use by its customers at the airport.

In addition to its dedication to sustainability, the Port of Oakland considers the installation of EV charging stations a matter of customer service, given that the San Francisco Bay Area has one of the highest concentrations of EV users in the nation. The Port installed the stations partly in response to off-airport parking operators and other airports in the region that were offering EV charging. Since the EV charging stations were installed, demand has increased substantially, sometimes exceeding supply. The Port has plans to install additional EV charging stations in 2014, possibly including a Level 3 fast charging station, as well as more chargers for airport employees.



EV charging station, Oakland International Airport

Dual Chargers

Charging stations are commonly available in single- and dual-port styles. This means that there can be one station installed between two parking spaces, with EVs parking in each space, charging at the same time. Dual-port charging stations may have two Level 2 connectors or one Level 1 connector and one Level 2 connector, as shown in Figure 6.

Dual-port chargers that have one Level 1 and one Level 2 connector can be used either to access two parking spaces or to provide one space with the choice of Level 1 charging or Level 2 charging. However, interviewees reported that when Level 1/2 charging stations were provided, the Level 1 chargers were rarely used. In this case, it may be beneficial to post signage that requests EV users to use Level 1 charging if planning to park for more than one day.

Smart Charging

In 2012, the DOE defined “smart” charging stations as those that have such networking capabilities as payment card readers, billing software, advanced displays, wireless communication, automated

TABLE 3
SUMMARY ELECTRIC VEHICLE CHARGING

Vehicle Charging	Level 1	Level 2	Level 3
Charging capacity (miles of range per hour of charge)	4	20	150
Typical charging power (Amperes)	12	32	—
Typical charging power (kilowatts)	1.4	6.6	50
Panel Requirement (kilowatts)	1.8–2.4	8.3	62.5
Compatible vehicles	All EVs	All EVs	Select models

Source: ChargePoint, Inc. (September 2013).



FIGURE 6 Dual-port Level 1/2 EV charging station. (Source: LeighFisher September 2013.)

diagnostics, computer-controlled power flow, internal metering, and/or smart-grid capabilities. These charging stations are typically connected to the manufacturer's website and accessible by EV users' smart phones. Smart phone applications can indicate the location and availability of networked charging stations in real time; inform users about the status of their EVs' charge; and determine if their EV is disconnected while they are away from their car. These features are particularly useful for EV drivers in high demand areas.

Weather Issues

The performance of EV charging stations is not typically affected by extreme heat or extreme cold. However, there are still conflicting reports on how extreme cold can affect the capacity of an EV's battery and its ability to hold a charge. One interviewee (and EV user) located in a cold weather climate suggested that cold weather airports consider installing Level 1 charging stations in long-term facilities so that batteries would charge slowly and be kept warm, therefore replacing parasitic loss (loss of energy from the battery while the vehicle is not being used). However, other interviewees from cold weather airports reported concerns that Level 1 charging would not keep up with parasitic loss in some EVs, and therefore would not increase the charge on those EVs while parked. This continues to be discussed by users and manufacturers, but no airport sponsors interviewed reported having problems caused by extreme temperatures.

Airports that are located in extremely cold weather climates often have outdoor 120V outlets provided for vehicle block heaters. It should be noted that these outlets can be used for Level 1 charging, but the circuit supplying the electricity would not typically have the capacity necessary to support numerous EVs charging simultaneously. Therefore, airports with this type of infrastructure may find disruptions in service caused by EV charging.

BUSINESS AND POLICY ISSUES

Research has shown that the most common motivations for airport sponsors to install EV charging stations at parking facilities are to meet sustainability goals or to improve customer service. In some instances, the initiative is internal, with one or more members of the airport staff acting as a “champion” for the program; in others, sponsors may be responding to local government initiatives. In one case, an airport sponsor was compelled by law to provide EV charging stations (see State of Hawaii case study). Other factors may include public or employee requests or competitor’s actions, such as when nearby airports, peer airports, or off-airport parking operators offer EV charging stations.

When customer service is the motivator, it is important to understand the potential customer needs (see chapter four) and provide a service that will meet those needs. Whatever the impetus for considering EV charging station installation, airport sponsors must evaluate the costs to install and operate them; the benefits of installing them; and the potential for revenue or cost reimbursement. This chapter provides insight into how some airport sponsors have addressed these issues and others that arose during the strategic planning stages of EV charging station projects.

COST ISSUES

With the EV industry being as young as it is, costs are greatly variable and will continue to be unpredictable. The cost of installing just one EV charging station has three components: the cost of purchasing the charging station, the cost of installing the charging station, and the cost of providing the electrical infrastructure capacity needed to operate it. The cost of EV charging stations is well understood at this time; however, it is expected to change in the future as demand increases and the effects of government subsidies decrease (ChargePoint, Inc. 2013). The cost to install EV charging stations is also well understood, but is not expected to change greatly. The cost to provide electrical infrastructure capacity varies from airport to airport and is subject to economies of scale based on the capacity of existing electrical infrastructure and the number of stations being installed. If a project requires substantial electrical infrastructure construction, the cost can increase substantially. Table 4 shows typical equipment and installation costs provided by ChargePoint, Inc. for their equipment. Costs reported by airport sponsors interviewed were similar to those provided by ChargePoint, Inc., but did vary within each category of charging. An example of project costs was provided by the Houston Airport System (see case study).

Many airport sponsors interviewed considered the cost of operating and maintaining EV charging stations before deciding to install the equipment. Given that the equipment is relatively new, there were no reports of costs for maintenance, but many airport sponsors are concerned about equipment repair or replacement when the warranty expires. No unusual costs for operation have been reported, although

TABLE 4
TYPICAL COSTS FOR EV CHARGING STATION INSTALLATION

Costs	Level 1	Level 2	Level 3
Equipment	\$200–\$1,500	\$3,500	\$45,000
Installation	\$7,000	\$7,000	\$20,000
Electrical Infrastructure	Variable	Variable	Variable

Source: ChargePoint, Inc. (September 2013).

CASE STUDY: Houston Airport System

In 2012, the Houston Airport System (HAS) received a grant through the DOE American Recovery and Reinvestment Act for the installation of 15 EV charging stations at Hobby International Airport and 24 EV charging stations at George Bush Intercontinental Airport. The funding represents a portion of the approximately \$100 million grant that was awarded to Ecotality, the manufacturer of the EV charging stations for the project. The stations are located throughout the airport properties, including valet areas, short-term parking areas, economy lots, and in United Airline's employee parking lots.

At George Bush Intercontinental Airport, the grant covered the purchase cost of the charging stations plus \$2,250 in installation costs per station—the majority of the cost of the project. The remaining project cost was covered by HAS. The total cost for equipment purchase and installation of the 24 EV charging stations was approximately \$153,000, leaving approximately \$27,000 in matching costs covered by HAS.

there are costs involved in providing staff for EV charging stations located in valet lots, those manned by customer service agents, and minimal marginal costs for added janitorial or security needs.

COST REDUCTION STRATEGIES

Airport sponsors reported using creative solutions to reduce the cost of EV charging stations projects. These and other lessons learned regarding cost management are provided here:

- Install all electrical infrastructure at the same time. If future stations are anticipated in the same general location, upgrade the entire electrical infrastructure as part of the first project.
- Consolidate stations in a single area rather than installing the stations in numerous locations around the airport. This will allow the use of multi-port stations to reduce total electrical load and may also allow the simplification of the electrical infrastructure with associated cost savings.
- Use Level 1 charging stations whenever possible.
- Install conduits along walls or behind permanent barriers to reduce the cost of trenching underground.
- Use in-house electricians whenever possible to reduce installation costs (avoiding the need for contractors and requests for proposal).

GRANT OPPORTUNITIES

There have been a variety of state and federal grants available to assist with the capital costs of EV charging stations. The 2009 American Recovery and Reinvestment Act provided funding for the installation of thousands of EV charging stations throughout the United States. All grants through this program have been distributed, but additional federal grants may be available in the future.

Eight of the 18 airport sponsors surveyed received DOE grants that covered the cost of EV charging stations. Some airport sponsors were approached by manufacturers regarding grant opportunities, while others sought out the funding opportunities themselves. Some airport sponsors received funding as part of a larger effort by their city governments interested in installing charging stations at the airport in addition to other locations.

Some grants include restrictions that require that EV charging stations be placed in public lots and/or may prohibit the installation of the charging stations in valet lots. The amount of funding and eligible costs should also be analyzed before accepting grants, as in many cases the grant will cover the cost of the charging station but may not cover the full cost of installation or electrical infrastructure upgrades.

ACCESS FEES FOR THE USE OF ELECTRIC VEHICLE CHARGING STATIONS

An access fee for an EV charging station is defined in this report as either an additional flat fee for parking in an EV space or an additional fee to access the electricity. Eleven of the 12 airport sponsors interviewed do not collect access fees to use EV charging stations. The exception is the state of Hawaii's

Airports Division, which charges \$7.00 per charging session at four of its five airports, but does not collect parking fees from customers that have EV license plates. (In past years, Los Angeles World Airports offered free parking to customers with EVs at Los Angeles International Airport, but has recently reversed this policy.) All other airports were found to be collecting the same fees from EVs and their conventionally fueled counterparts.

Airport sponsors provided the following reasons for forgoing a fee for the use of electricity:

- Charging stations are in the most expensive parking facilities such as premium lots and valet lots, so it would be seen as “nickel and diming” a customer who may already be paying more than most customers with conventionally-fueled vehicles.
- The cost of the electric power being provided to EV users is considered minimal compared to parking revenue. One airport sponsor reported that the cost to provide electric power over five months was \$1,000, which equates to less than \$7 per day. It is not known whether the cost to collect fees for electricity use would justify the additional administrative expense.

Most airport sponsors interviewed agreed that the discussion of collecting access fees from customers should be ongoing. Even though most airports are not currently collecting a fee to access EV charging stations, those that have smart chargers have the capability to begin charging customers if the operator so chooses. As the use of EVs increases over time, it may become more feasible to collect fees for charging the vehicles in the future. One airport sponsor reported that the possibility has been discussed of imposing a fee of somewhere between \$1 and \$5 per EV charging session if demand continues to grow. In other sectors, public lots are charging access fees through a given manufacturer’s system, such as at the University of California, Los Angeles, where the EV fee for both Level 1 and Level 2 charging stations is \$2 per hour.

In deciding whether or not to collect fees for EV charging, it is important that an airport sponsor understand how the facility is charged for electricity and how much it pays for the electricity. Often airports have numerous electrical accounts that have various rates and charges. If electrical demand and charges will be affected by the increased electrical needs, this could have a much higher financial impact than if the airport is being charged solely on a usage basis per kilowatt, regardless of the type of EV charger used. Interviewees have suggested that individual airports consult their provider utility to determine how EV chargers will affect electricity costs.

ALTERNATIVE MANAGEMENT STRUCTURES

Many airport sponsors use third-party operators or concessionaires to manage their parking facilities, along with other operations and maintenance functions. These companies may perform individual functions such as fee collection, valet management, and/or janitorial services; or may have responsibility for the management of entire facilities. Hawaii’s Airports Division reported that its parking concessionaire was held responsible for installing chargers at five of its airports. Additionally, the concessionaire collects access fees (see state of Hawaii case study). Another airport sponsor suggested that it might be feasible to seek a concessions contract to provide EV charging stations separate from the management of the parking facility. Seeking proposals from companies that believe they can make a profit by providing EV charging stations at an airport could be one method of financing the installation of charging stations, and of providing additional revenue to the airport.

Tesla is currently in the process of installing Supercharger stations throughout the United States to provide free Level 3 charging exclusively to Tesla owners. One airport sponsor reported being approached by Tesla seeking permission to install a charging station on airport property. While having a Tesla Supercharger on site would provide Level 3 chargers to airport customers that drive the specially equipped Tesla Model S, it would not be compatible with all EV models equipped for Level 3 charging. However, this could be another creative way to provide Level 3 charging to some customers while reducing the financial risk. Many open questions remain concerning the business proposition, opportunity costs, and responsibility to customers, which can be expected to be answered as EV charging stations become more prevalent.

ELECTRIC VEHICLE PARKING POLICIES

In addition to discussions of motivation, costs, and fees, other parking policy considerations could include:

- What to do if a conventionally fueled vehicle parks in an EV-designated space? This is referred to as “icing,” and most airports have the ability to ticket, tow, or issue warnings for this action. However, there were no reported cases where conventionally fueled vehicles have been towed.
- Is it lawful to resell electricity? In those states that prohibit the resale of electricity, airport sponsors could potentially impose a service charge that includes the cost of electricity use at the charging station.
- Who is responsible for managing the EV spaces? In many cases, a third party contractor operates the parking facility and can be held responsible for installing EV charging stations, assisting customers, and maintaining the stations.
- Can the strategic location of EV charging stations reduce costs and increase revenue? If charging stations are located in valet lots, the capacity of the chargers is increased substantially, since EVs can be moved by attendants after charging. Additionally, this may draw EV users to more expensive parking facilities.
- Are there methods to recoup costs other than collecting fees for charging? Volta Industries, based in Honolulu, provides free charging to the public through sponsors who use the EV charging stations as advertising space.

CASE STUDY: State of Hawaii, Airports Division

In 2009, the State of Hawaii passed legislation that required all public, private, and government parking facilities used by the general public and having at least 100 parking spaces to designate 1% of their spaces to exclusive EV use (referred to here as EV-designated spaces). Additionally, at least one of the spaces has to be located near the facility entrance and equipped with an EV charging station.

As a result, the State of Hawaii, Airports Division was mandated to provide EV-designated parking spaces and provide one charging station at each of the five state-owned airports affected by this law (Hilo International, Honolulu International, Kahului, Kona International, and Lihue airports) by January 2012. At that time (and currently), the State of Hawaii Airports Division had concessionaires that managed and operated these parking facilities. As part of the concessionaires' agreements, they were responsible for adhering to all federal, state, and local laws and regulations pertaining to the operation of a parking facility. Therefore it became the concessionaires' responsibilities to post EV-designated signage and install the charging stations, which has since been completed. In addition to the mandates regarding EV-designated spaces, the State of Hawaii also declared that (1) EVs would receive free parking in these facilities and (2) conventionally-fueled vehicles found parking in EV-dedicated spaces would be cited.

At Honolulu International Airport there are 57 EV-designated parking spaces and one dual-port charging station in the International Garage. EVs are not charged for parking, no matter the length of stay, but there is a \$7.00 fee for the use of the charging station. This is also the case at Hilo, Kona, and Lihue airports. There is no fee for EV charging or parking at the Kahului Airport.



Dual-port EV charging station at Honolulu International Airport



EV-designated spaces at Honolulu International Airport

CHAPTER FOUR

PLANNING REQUIREMENTS: IMPLEMENTING ELECTRIC VEHICLE CHARGING STATIONS AT AIRPORTS

Airport parking facilities are good locations for EV charging stations because of the number of parking customers and the visibility of the stations to the traveling public. However, the airport's customers and employees, as well as its facilities, have unique characteristics that raise different challenges in planning for and installing EV charging stations than those associated with city centers, private employers, and commercial establishments.

UNDERSTANDING THE CUSTOMER

It is important to consider the characteristics of an EV user when trying to plan an EV charging station project. EV users are often well connected to each other and to infrastructure providers through social media, and useful information can be collected about the priorities of EV users from these sites. Some airport sponsors have found that monitoring these sites helps them understand which policies are working and which are not. Monitoring these sites can provide information on the percentage of the potential customers that are looking for inexpensive airport parking versus those looking for the best places to park (and don't mind paying the higher rates to park in the most convenient spaces). Research showed that EV users have used also social media to locate random standard 120V electrical outlets in parking garages, using them as EV chargers without the expressed consent of the airport sponsor.

Parking customers of each airport parking type (e.g., short-term, long-term, and employee) have differing needs and priorities. Each of these parking types provides different advantages and disadvantages in the use of EV charging station technologies (e.g., Level 1, Level 2, and Level 3). Some planning considerations of each airport parking type include:

- Short-term or daily parking spaces are typically the closest to the airport terminals and have the highest daily rates. Short-term parking customers typically spend one to three hours at the airport and are there to pick up or drop off travelers or do business at the airport. Customers parking for more than three hours are often allowed to park at close-in facilities with high daily rates and are typically looking for a premium parking experience with an emphasis on convenience rather than cost. Typical stays in these facilities are for 24 to 48 hours. Airport sponsors interviewed suggested that short-term or daily parking facilities are good candidates for Level 2 and Level 3 charging stations.
- Long-term parking customers usually park for 24 hours or more, and parking spaces are often within walking distance to terminals. Airport sponsors interviewed suggested that Level 1 charging stations should be considered for long-term facilities in order to minimize capital costs and to keep batteries warm in winter months. Also, it was suggested that the greater speed of Level 3 charging is not needed in these facilities.
- Remote long-term parking customers typically park for three days or more, with some stays exceeding two weeks. These parking spaces offer the least expensive rates and often require customers to ride shuttles to/from the terminal building. These spaces are typically among the least visible, and can be far away from buildings and infrastructure. Customers often allow more time to find parking spaces and tend to be cost-conscious. One respondent suggested that, as at standard long-term parking lots, Level 1 charging stations may be the preferred level of charging at remote lots in order to minimize capital costs.

- Valet parking, when offered, is the most convenient and most costly parking option at an airport. Customer service is a key priority in valet facilities, and passengers pay the highest prices to get fast service and to know that their vehicle is being looked after while they're away. Valet lots could be good candidates for Level 3 charging, if high demand is expected.
- Cell phone lots are for customers parking for a brief period while waiting for arriving passengers, and offer a convenient option to using terminal roadways for recirculation. Only one airport sponsor interviewed reported having EV charging in a cell phone lot, and it did not have data on usage patterns. Another airport sponsor suggested that airports should consider the distance to the community and how this might affect utilization in the cell phone lot. For example, an airport that is close to a community may experience EV users charging at cell phone lots when not on airport business, whereas an airport that is quite a distance from the community may not.
- Employee parking is often located at some distance from parking facilities serving airline passengers, and is not typically visible to the traveling public. Airport employees are often the most reliable and predictable customers, parking in the same parking lot for eight to 10 hours per day, five days a week; and traveling the same distance to work on a daily basis. Airport employees could easily be surveyed to determine who would be able to make use of EV charging if available, and who would consider the purchase of an EV if charging stations were provided. Many airport sponsors have reported getting requests for EV charging from pilots and other flight crew who want to park/charge their EVs for relatively long periods of time. In some instances, airlines manage their own parking facilities and could provide EV charging stations (rather than the airport sponsor). Employees of other tenants, such as concessionaires, security personnel, and FAA staff are likely to begin requesting access to EV charging stations in the future; however, no interviewees reported getting these requests or providing these services.

All of the airport sponsors interviewed have provided EV charging stations in the short-term, long-term, and valet parking facilities that are very close to terminals or elevator banks. Some have also provided EV charging stations at remote long-term facilities, cell phone waiting lots, and employee parking facilities.

PLANNING ISSUES

During the planning phase, it is important to include all relevant personnel in regular discussions. Essential team members include parking managers, environmental specialists, electricians, electrical engineers, maintenance staff, and/or project managers. Interviewees reported that significant staff efforts can be required for the first installation of EV charging stations, while subsequent installations take less time. Most airport sponsors used a request for proposal (RFP) process to select contractors for either purchase and installation of charging stations or for installation only.

Discussions that should take place during the planning phase include those pertaining to electrical infrastructure, the number and type of charging stations to be installed, siting issues, signage, and compliance with the ADA. These topics are addressed here:

Electrical Infrastructure

Planning for electrical infrastructure can be classified in either of two ways: considerations for existing facilities, and considerations for future parking facilities. As new facilities come online, future EV charging stations could be considered, either as part of construction or as a strategic design aspect in anticipation of future installations. Typically, the incremental cost of providing the required electrical capacity at the right location will be greatly reduced if planned for in the initial construction, as compared to adding it later.

As previously stated, for existing facilities, perhaps the most important consideration is the availability and accessibility of electrical infrastructure. It is essential to include electrical engineers and/or electricians from the very beginning of the planning phase. A thorough analysis of electrical capacity and loads can provide insight into the potential cost of the project and the most useful location for the EV charging stations.

Number and Type of Stations

The clustered nature of geographical EV popularity in certain urban areas of the United States should affect planning decisions when considering EV charging system installation. The appropriate number of charging stations at an airport will vary significantly by region, but a good rule of thumb is to exceed the ratio of EVs to traditional vehicles in the area. This could allow the facility to meet customer demand while encouraging future use.

Many airport sponsors have chosen to start with a small number of stations and gradually increase the number each year, ensuring that the existing charging stations are being frequently used before proceeding with the installation of additional charging stations. The initial number of stations is often dictated by grants or finances, and is usually based on the number of public requests for the charging stations.

The advantages of this kind of graduated approach are that constructions costs are distributed over multiple fiscal years; there is seldom any parking excess capacity; and a gradual introduction of facilities avoids any potentially adverse publicity associated with having underutilized charging stations. Disadvantages include more complicated budgeting and staff planning; the potential for underestimating demand, resulting in dissatisfied customers; and the necessity of a recurring cycle of plan/bid/build, requiring additional staff resources and construction zones to manage.

The Wayne County Airport Authority reported developing an approach that provided more time before additional EV charging stations were necessary: It simply increased the number of EV-dedicated parking spaces that had access to the original charging stations, increasing the potential utilization of the original EV charging stations (see Wayne County Airport Authority case study).

The deciding factors between installing Level 1 and Level 2 charging stations are usually cost and charging times. Level 1 charging is more appropriate for lots where airport passengers are parked for longer than 24 hours, while Level 2 charging is more appropriate for lots where airline passengers or employees are parked for approximately eight hours at a time. In cases where a mix of longer and shorter stays is common, airport sponsors may wish to install units that provide both Level 1 and Level 2 charging.

Siting Issues

Where to locate EV charging stations continues to be an evolving discussion, because each airport has different facility layouts and priorities. Some factors and strategies that have been considered by airport sponsors are listed here:

- **Visibility:** Locate all EV charging stations together in the most visible location close to terminal buildings, main walkways, and elevator banks. This improves awareness and can encourage the adoption of EVs.
- **Accessibility:** Locate a few charging stations in every facility or on each floor of a garage, providing equal access to all parking customers, terminal buildings, and airlines. This has been reported to provide convenience to EV users.
- **Utilization:** Locate charging stations in valet lots to ensure the highest use of each charger. This approach certainly provides the most convenience to parking facility operators, in that they have the keys to each car and can move them as needed.
- **Reimbursement:** Locate charging stations in high revenue parking facilities in an attempt to compensate for some of the capital costs. This has benefits to the airport sponsor and can increase revenues.
- **Infrastructure:** Locate charging stations where excess electrical capacity already exists. This approach reduces installation costs and may make funds available to install more chargers.
- **Connectivity:** Locate charging stations where there are wireless Internet signals or cellular services available to allow for connectivity to smart EV charging networks.

CASE STUDY: Wayne County Airport Authority

The Wayne County Airport Authority has four single-port and six dual-port EV charging stations at the Detroit Metropolitan International Airport. One of the dual-port stations is located in the South Cell Lot just west of the Eureka Road entrance in Romulus, Michigan. Another dual-port charging station is located in the Yellow Parking Lot, a quarter mile north of the North Terminal. The other stations, which were installed earlier, are divided equally between the Blue Deck at the North Terminal and the parking deck at the MacNamara Terminal. When use of these charging stations began to match demand, the Authority increased the number of EV-dedicated charging spaces by restriping the existing EV-dedicated spaces to increase the number of spaces that have access to the chargers. Initially the Authority installed a dual-port Level 1/2 charging station to accommodate two simultaneously charging EVs. The charging station was frequently used by long-term customers and it was found that EVs were parked for several days at a time, although a full charge requires only eight hours. Since charging cords were long enough to reach four spaces if the cars were parked appropriately, the two adjacent stalls were restriped as EV-dedicated spaces. The result has been successful and provides a way to meet increasing demands with minimal cost.



Signage and News Releases

All interviewees reported using signage to mark EV-dedicated spaces, while some have also chosen to paint the floor of parking spaces green. Effective signage is imperative, as it informs EV users where to find charging stations and discourages users of conventionally-fueled vehicles from accidentally parking in these spaces. Signs often mark each EV-dedicated space, and banners have been hung from light poles, parking garage columns, and the ceilings of parking garages. In addition to signage identifying EV-dedicated spaces, airport sponsors often post signs warning that conventionally-fueled vehicles may be ticketed or towed if parked in an EV-designated space. One airport sponsor interviewed is also considering distinguishing between “EV parking spaces” and “active charging spaces,” so that vehicles with high-capacity batteries that do not need to charge are not parked in charging spaces just to benefit from the proximity to the terminal. An example of EV signage advertising the presence of EV charging stations can be found in Figure 7.

Most airport sponsors have also reported the need for wayfinding signage to direct EV users to EV-dedicated spaces, although there are options for virtual wayfinding, including cell phone applications and digital message boards. The consensus is that wayfinding signage is very important, and many airport sponsors are considering adding more signage or including EV locations in advertising materials. However, a few interviewees reported that their EV customers are very well connected by social media with other EV owners, and will find the spaces with or without wayfinding signage. Wayfinding signage is often as simple as a symbol on parking facility signs, and may go as far as electronic boards that guide EV users to specific EV-dedicated spaces. The importance of signage and publication of charging station locations is amplified by the fact that customers of airport facilities are often seeking to locate a parking space quickly in order to catch a flight and do not use the facility on a daily basis.

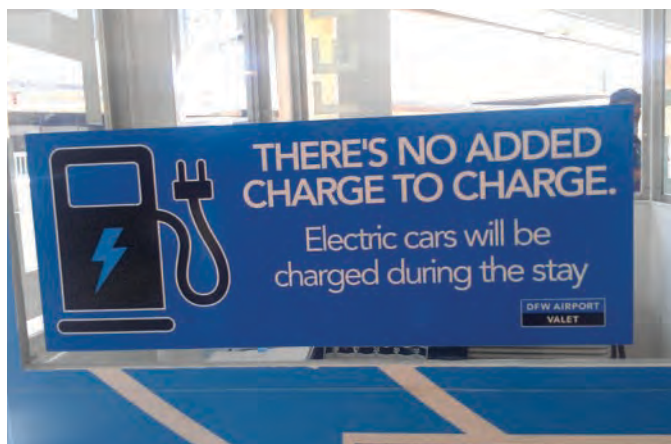


FIGURE 7 EV signage, DFW. (Source: Dallas/Fort Worth International Airport.)

Other options include signs on websites and inside terminal buildings that advertise the airport sponsor's support for EVs, new charging stations, charging locations, or free charging.

Some airport sponsors have made efforts to publicize the installation of EV charging stations; others have chosen to install them with little fanfare. Some airport sponsors have initiated a full public relations launch, including news articles, radio press releases, and news television events. In some cases, public officials, EV dealers, and charging station manufacturers have participated in such events. Information is also commonly published on the airport's website and/or airport brochures.

Compliance with the ADA

Many airport sponsors are providing EV charging stations in spaces that are ADA-compliant, such as the example shown in Figure 8. Currently, there is no guidance regarding EV charging stations



FIGURE 8 EV-charging ADA-compliant parking space at Oakland International Airport. (Source: LeighFisher September 2013.)

with regard to ADA-compliant parking spaces; however, airport sponsors are informally discussing this issue and making efforts to accommodate the needs of disabled customers. Current efforts are directed either at providing EV charging stations at ADA-compliant parking spaces, or making EV-dedicated parking spaces wider than standard and ensuring that charging stations are low enough to the ground to accommodate wheelchairs and other ADA equipment.

Suggestions have been made that dual signage could be developed for such spaces, or that notices could be added that state, “Please Use Last.” Additionally, some airports have charging stations that are located between ADA-compliant parking spaces and EV-designated parking spaces.

DESIGN AND CONSTRUCTION

An RFP to install EV charging stations requires detailed drawings of existing facilities, an electrical load analysis of the facility, and plans for implementation of the project. If future expansion of EV charging stations is anticipated, it may be beneficial to oversize the electrical capacity. An example of such an RFP is provided in Appendix B, and was provided by the city of Denver—Denver International Airport. It is important to note that some airport sponsors have chosen to assign installation responsibilities to staff electricians, which has worked out well; but can also delay the project because of their increased workload. However, the project to install Level 1 charging stations at Seattle–Tacoma International Airport was undertaken internally without added schedule delays (see case study). In some cases, a grant package may include prequalified installers to help streamline the RFP process.

While the duration of construction will vary depending on whether electrical infrastructure upgrades are required, on average, a typical Level 1 charging station was reported to be installed in two to three months from project inception. Level 2 projects were reported to take approximately six to eight months, with the majority of that time used to determine whether the project would be initiated. The level of effort on the part of airport sponsors varies by project but will typically involve the parking, environmental planning, engineering, and construction groups. Interviewees reported that construction phases usually went smoothly once the project had begun. Staff members involved in the process report spending between 80 and 120 hours to see it through to completion (if an outside contractor is used for construction). The schedule may be compressed significantly if an on-call or a prequalified contractor is in place, or if electrical upgrades are not required. Using internal resources will result in variable duration of design and construction.

CASE STUDY: Seattle–Tacoma International Airport

The Port of Seattle installed six Level 1 charging stations in 2010, six more in 2012, and an additional 12 in 2013. All stations are located in the parking garage at Seattle–Tacoma International Airport. In addition, four employee-dedicated EV parking spaces near existing 110V outlets were provided in 2012 in response to employee requests.

The construction of the Level 1 charging stations took less than a month, with installation requiring less than three weeks. All aspects of the project, including installation by electricians, signage, and striping by painters, were handled internally without the use of a contractor. Approximately 10 staff members were involved, including managers from landside operations, maintenance, and environmental programs. In all, approximately 300 hours were required for the installation of 28 Level 1 charging stations.

Liabilities

Some minor liability concerns were noted by interviewees but did not impede their providing charging stations. Trip and fall hazards were the most commonly reported concerns, resulting from charging cords that were not stowed properly. As a result, some airport sponsors have reported looking into retractable reels and asking janitors and security personnel to wind cords when they were found to be a hazard. It is expected that liabilities from trip and fall hazards would be covered under existing insurance coverage.

Accidental damage from vehicle traffic was also reported as a possible concern. Therefore, to prevent possible damage, bollard-type barriers are often installed in front of charging stations. Alternatively, wall-mounted charging stations may be chosen during the design phase to help alleviate the risk of vehicle damage.

As with many other issues regarding EV charging, potential liabilities will continue to emerge and will likely become a broader concern as the market matures. Airport sponsors have reported concerns about purchasing, installing, and operating EV charging stations and their possible responsibilities if equipment is defective. Additionally, airport sponsors are interested to know what their responsibilities are to provide a full charge if they advertise their product that way, or if access fees are collected. One airport sponsor is concerned about the implications of an EV owner returning to his/her EV and finding it does not have enough power to travel to the next charging station.

Airport sponsors reported that in most cases, the existing liability waiver that is accepted upon entering the parking garage is expected to cover any liabilities that might arise from the installation of charging stations. One airport sponsor suggested that it could be beneficial to amend liability waivers to include the release of any greenhouse gas credits that may be accrued by the EV user to the charging station owner. These and all other liability concerns are airport-specific, and only the airport sponsor's legal department can answer these questions.

IMPLEMENTATION

It is common for usage of EV charging stations to be low immediately following installation, as customers are not always aware of their existence. Advertising the availability of EV charging stations will increase usage rates in the first few months; and once the charging stations have been operating for several months, usage rates typically increase and continue to increase as additional EVs are bought.

Customer concerns regarding EV charging stations will vary by situation but may be associated with the location, process for accessing, or availability of the charging stations. Some airport sponsors keep email lists for advertising, coupon sharing, and short-term deals. These email blasts have been used to announce new EV services and encourage customer feedback. In addition, once charging stations are operational, airport sponsors can communicate with users by posting any relevant information or news updates to the airport website or through social media.

Issues voiced by EV users in customer feedback forums include:

- Requests for more EV charging stations
- Requests for EV charging stations in less expensive parking facilities
- Reports that EV users are parked in EV-dedicated parking spaces but are not charging
- Reports that smart networks will say that there are EV charging stations available when they are not
- Reports that conventionally fueled vehicles are parked in EV-dedicated spaces.

Concerns that are voiced by users of conventionally fueled vehicles in customer feedback forums include dissatisfaction that:

- EV users are given priority parking.
- EV users are being provided free electricity.
- EV parking spaces are rarely full and therefore take up capacity that users of conventionally fueled vehicles would be able to use.

TRACKING

Tracking the frequency with which EVs use charging stations is quite useful in accomplishing a variety of goals. Many EV charging projects start at a small scale, with airports intending to install additional charging stations when demand exceeds capacity. The use of tracking data can support installing additional charging stations, especially if justification is required prior to internal approval of capital budget for expansion.

Most base model charging stations track equipment use, however, “smart” charging stations can track more sophisticated data, such as unique identification numbers assigned to users, when a user arrives, and when that user leaves. Smart charging stations can also track quantities, such as the number of sessions, length of time people stay, and energy use in kWhs. For example, the Massachusetts Port Authority tracks the use of EV charging stations at Boston Logan International Airport to assess when demand for the charging stations has reached a point where additional stations may be needed (see case study). Smart charging stations can also provide real time information to the EV users, such as charger availability, status of a customer’s charge, and if the customer’s vehicle has been unplugged, through cell phone applications.

CASE STUDY: Boston Logan International Airport

The Massachusetts Port Authority has operated 13 dual-station Level 2 EV charging stations at public garages in the airport since January 2012. The stations are located in the long-term public parking garages, and were installed close to elevators to allow for ease of access and clear visibility.

The units are monitored online through ChargePoint, Inc.’s software, allowing the Port to track the number of unique users that have accessed the system. Monitoring the stations in this way has shown that usage has increased, both in total number of charges per day and in number of unique users. As a result, the Port has the capability to assess when the stations have reached maximum capacity, indicating when and where additional stations should be installed.

Energy data can also be used to estimate electricity costs and greenhouse gas reductions, although it is important to understand how the airport sponsor is charged for that electricity and where the electricity is coming from. Electricity costs and electricity sources vary across the country. Figure 9 shows the national average of electricity sources, and Figure 10 shows the national average for greenhouse gas emissions per vehicle for four different vehicle types. Electricity sources and vehicle emissions by zip code can be found on the DOE website.

One helpful piece of information is the length of time an EV is actually charging, which is useful in an assessment of how valet services could increase the capacity of a charging station.

DISCUSSION

It was determined that there were many topics that airport sponsors could not speak to specifically and questions that were not definitively answered by the literature reviewed. Many of the responses were anecdotal and therefore were not helpful as industry-wide advice. Additionally, many responses were geographically specific, with airports in areas that have strong and relatively more mature EV

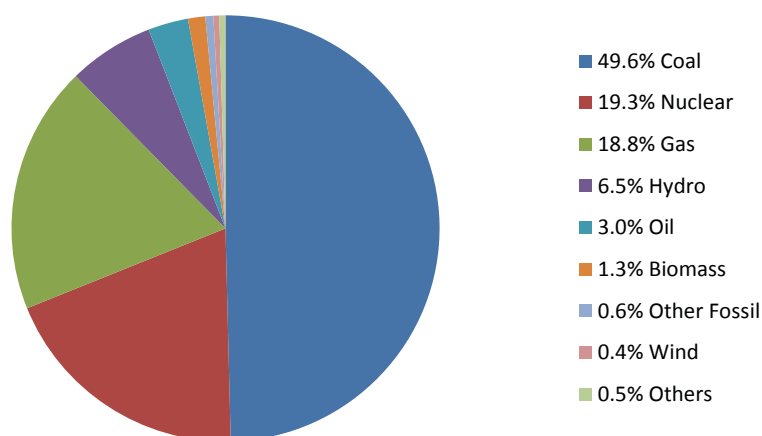


FIGURE 9 Sources of electricity generation, national average.
(Source: LeighFisher, adapted from U.S. Department of Energy, Nov. 2013.)

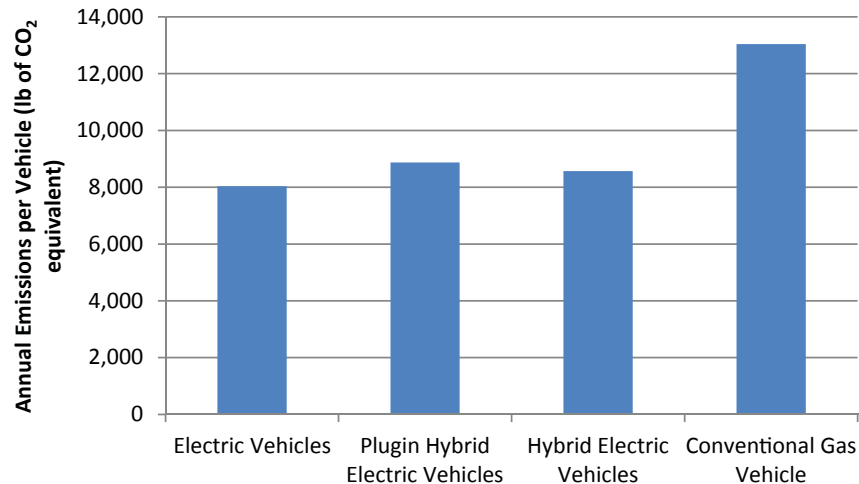


FIGURE 10 Annual emissions per vehicle, national average. (Source: LeighFisher, adapted from U.S. Department of Energy, Nov. 2013.)

communities having quite different responses than those in areas with limited numbers of EV users. In a new industry such as EV charging, anecdotal experience is often all that is available and may be very valuable to the next group of adopters. Definitive questions such as when EV charging stations were installed, why were they installed, and how many have been installed were easy to answer and produced excellent results. However, some interviewees might not have had any direct experience with issues addressed in particular questions, but recognized that they would likely face similar issues in the future.

Costs such as operation, maintenance, and staff resources were not well understood. Airport sponsors reported that making the decision to install EV charging stations was not difficult, but figuring out how to do so the first time was time-consuming. All airport sponsors interviewed agreed that installing a second group of EV charging stations would likely (or did) take a fraction of the time and staff resources required by the first. In contrast, operating and maintenance costs were reported to be minimal for the first group of EV charging stations, but interviewees reported concerns that costs would escalate with demand increases and after equipment warranties expired.

Liabilities were also of great concern to senior managers. Generally, interviewees reported little experience with these issues and no direct experience in any customer disputes. However, a few interviewees reported various concerns about the uncertain future of EV charging. Many questions addressed the local laws and regulations affecting airport sponsors; the legality and liability of collecting fees for electricity; the liability of installing and/or providing equipment for customer use that could be unsafe; the responsibility to assure customers that their EVs will be safe and fully charged when they return; and the airport sponsors' rights regarding the ability to tow or disconnect EVs that are plugged in.

Tracking and reporting EV usage and environmental benefits is a new process, and most airport sponsors have not yet determined how information will be used. Smart chargers have the ability to report the utilization of EV charging stations, and the amount of electricity consumed, which can then be used to estimate emission reductions from the use of EVs. However, questions remain as to the "owner" of those emissions reductions (i.e., whether those reductions should be credited to the EV user or to the electricity provider); how an airport sponsor should account for the increased electricity usage in airport emission inventories; and how the usage information should be reported to the public.

CHAPTER FIVE

CONCLUSIONS

Since late 2010, with the introduction of the Nissan LEAF and the Chevrolet Volt, an increasing number of airline passengers and airport employees have sought access to electric vehicle (EV) charging stations at airport parking facilities. The objective of this report was to gain an understanding of the business considerations and policies involved in initiating EV programs, and to evaluate the current state of technology and planning requirements for EV charging stations for public use.

Perhaps the most prevalent message throughout the information gathering was that the use of EVs and the resultant EV charging is in an embryonic stage. Everything from technology to policies to customer expectations and the business case for providing EV charging stations is expected to change drastically in the coming years. To date, government subsidies and venture capital have assisted in the recent increase in EV adoption; but it is unclear whether that assistance will continue, and if it does, what the duration and extent of that support will be. EV manufacturers and charging station manufacturers continue to focus on research and development. EV users and EV charging providers continue to evolve and find creative solutions to problem.

Requests for EV charging stations at airports are likely to continue to increase in response to EV sales. EVs are expected to become more common over time, and airports are expected to continue to provide charging stations to support sustainability initiatives and as a matter of customer service. West Coast airport sponsors interviewed reported having higher utilization rates than other airports in the United States, as was expected based on the EV ownership rates in West Coast states.

Given that EV ownership rates vary widely by geographic region, and that the future of the industry is expected to change more rapidly in some regions, airports weighing the implementation of EV charging stations should consider regional EV sales and customer feedback. Barriers to implementation may include budget limitations and lack of staff resources, but these have been overcome by some airport sponsors who planned for projects ahead of time and avoided quick turnaround installations; installed the appropriate number of charging stations based on customer demand; and considered siting criteria that minimized costs.

Airport sponsors are particularly interested in cost recovery opportunities, which also continue to evolve. Eleven of the 12 airport sponsors interviewed provide EV charging stations to customers for the same parking fee as other customers in the given facility, without an additional charge to access the EV charging station. However, airport sponsors often choose to locate EV charging stations in premium parking facilities in an attempt to encourage EV users to park in facilities with the highest daily rates.

Currently, Level 1 and Level 2 charging is well understood. For now, the costs, applications, and performance can be related to airport facilities fairly well. Level 3 charging has more nuances: Level 3 charging connectors are not yet standardized, and applicability for airport facilities is uncertain, as airport customers tend to park for longer periods of time and therefore may not need Level 3 charging.

The costs reported for EV charging stations ranged from \$1,500 for Level 1 charging stations to as much as \$70,000 for fully installed Level 3 charging stations. However, capital costs at some airports have been reduced through grant awards. Costs fluctuate greatly depending on the number of chargers being installed; the electrical infrastructure needed to support EV chargers; and the charging

technology chosen, as Level 3 chargers are substantially more expensive than Level 1 and Level 2 chargers.

Prior to construction, taking into account siting issues such as the presence of existing electrical infrastructure, visibility, connectivity, and accessibility can reduce costs and increase customer satisfaction with respect to the EV charging stations. Understanding the customer, such as the purpose for the visit and length of time the customer will be parked at a given facility, can provide insight into the appropriate level of charging to install. The construction duration varies, but Level 1 charging projects were reported to take approximately two to three months, while Level 2 charging projects typically have taken six to eight months, from inception to installation. Once the stations are installed, proper signage, wayfinding, and the use of cell phone applications allow EV users to locate the designated charging stations and prevent conventionally-fueled vehicles from parking in the designated spaces.

Suggested topics for further research with respect to EV charging stations at airport parking facilities include implications of collecting access fees and charging for electricity; potential liabilities specific to providing EV charging stations; and the development of innovative cost recovery strategies. Future research could also include effective practices for charging EVs that are parked for long periods of time; addressing such issues as the correct etiquette for other EV-users to unplug EVs when charging is complete; whether it is appropriate for airport staff or parking operator staff to unplug a customer's EV; the implication of locating chargers where they are less visible; and what is the most useful technology to meet the needs of EV users in each of the airport's facilities.

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APPENDIX A

SURVEY QUESTIONNAIRE AND RESULTS

A list of the interview questions and a summary of responses follow.

INTERVIEW QUESTIONS

- 1. How many chargers and what type (e.g., Level 1, Level 2, Level 3) have been installed at the airport? What is the location of the chargers (e.g., short term parking, long term parking, employee parking) and number in each location? In what year were they installed?**

A summary of the responses is found here:

Airport Name	Charging Stations
Boston Logan International	13 Level 2 dual-station units
Dallas/Fort Worth International	1 dual-station Level 2 charger
Denver International	10 Level 1 chargers, 1 legacy charger
Detroit Metropolitan Wayne County	4 single and 6 dual Level 2 chargers
George Bush Intercontinental/Houston	12 Level 2 dual chargers
Hilo	1 Level 2 dual charger
Honolulu International	1 Level 2 dual charger
John F. Kennedy International	5 Level 1/2 chargers
Kahului	1 Level 2 dual charger
Kona International	1 Level 2 dual charger
La Guardia	5 Level 1/2 chargers
Lihue	1 Level 2 dual charger
Los Angeles International	38 chargers (30 Level 2 and 8 legacy)
Metropolitan Oakland International	21 total stalls, mix of Level 1, 2, and legacy
San Francisco International	21 Level 2/1 chargers, 21 Level 1 outlets
Seattle–Tacoma International	16 Level 1 stalls
Toronto Pearson International Airport	2 Level 2/1 chargers
William P. Hobby	7 Level 2 dual chargers, 1 Level 3

Ten of 12 airport sponsors have at least one charging station in either a short term or long term lot. Two airport sponsors provide only valet parking for their public EV charging stations. All EV charging stations were installed between 2011 and 2013, with the exception of the legacy chargers installed at three airports.

- 2. What was the motivation behind installing EV chargers at the airport? Are there any plans to install additional chargers? Will they be located in the same parking facilities?**

The motivation cited by airport sponsors for installing EV charging stations include the following: (1) environmental stewardship, (2) providing a customer service, (3) requests from public and/or employees, (4) state mandate.

Many airport sponsors are considering the installation of additional EV charging stations, once demand is met. The potential locations of future charging stations include cell phone lots, garages, and employee lots.

- 3. How did you decide to locate the chargers in the parking facilities they are located in, and in the specific location within that facility? Was visibility, proximity to existing infrastructure, or proximity to wireless internet connection a major factor in the decision?**

The most common responses to the question of siting were (1) maximizing visibility, and (2) locating near existing electrical infrastructure. Another common siting criteria was to place the charging stations in high-revenue areas.

- 4. How long did the project take, in months, from project inception to first EV charged? How long was the construction process? Did the construction phase go smoothly, including the**

request for proposals process? If not, how were the problems resolved? How many staff members were involved, and what was the level of effort?

The construction process will vary depending on whether electrical infrastructure upgrades are required, but on average, a typical Level 1 charging station can be installed in two to three months from project inception, while a Level 2 project will take roughly six to eight months. The level of effort also varies by project but will typically require effort from staff members from parking, environmental planning, engineering, and construction groups. Research found that the construction phase went smoothly once the project had been initiated, because the installation process is relatively straightforward if there are no complications with the electrical infrastructure.

5. Specifically regarding signage, what lessons have you learned?

The airport sponsors surveyed emphasized the importance of signage in (1) allowing customers to locate the charging stations, and (2) preventing conventionally-fueled vehicles from parking in the EV-designated spaces. Many indicated plans to update signage, either to have more wayfinding signs or to state the authority to tow or ticket.

6. Are any of the stations ADA compatible? If there are ADA-compatible EV charging stations, what were some of the additional considerations that had to be made? Were any traditional ADA parking spots relocated in order to accommodate the EV charging stations?

Currently, there is no guidance regarding EV charging stations with regard to parking spaces that are ADA compliant. However, airport sponsors are discussing this issue and making efforts to accommodate any needs of disabled customers. Current efforts can be categorized in one of two ways, (1) providing an EV charging station at an ADA-compliant parking space, or (2) making an EV-dedicated parking space wider than standard and ensuring charging stations are low enough to the ground to accommodate ADA-accessibility. No ADA parking spots were relocated to accommodate the EV charging stations.

7. Were there any insurance liability issues during construction or for operation and maintenance of the chargers? If so, how were/are these handled?

Some minor liability concerns have been noted, which were discussed by airport sponsors but did not impede the ability to provide charging stations. During the construction process, no major liability concerns were noted. During the operation and maintenance of the charging stations, trip hazards and accidental damage were the most commonly reported concerns. These concerns were addressed by ensuring cord maintenance and by constructing bollards in front of the stations to act as barriers.

8. How are EV charging spaces managed? What are the duties of the contractor or employee managing the spaces?

Spaces are either managed by airport staff, third-party parking operators, or concessionaires. Duties vary from airport to airport but may include moving and charging the vehicles (if valet), ticketing or towing, minor cleaning, or the re-coiling of cords as needed.

9. Have you received any customer complaints? If so, what are the typical concerns? Are you aware of any public response to the offering of EV charging?

All airport sponsors reported receiving mostly positive feedback from the installation of EV charging stations. Negative feedback did include the following:

- Requests for additional charging stations
- Requests for a different type of charging station or that they be installed in a different location
- Complaints that EVs are parked but not using the charging stations
- Protests that EVs have preferred parking
- Trouble with tracking technology
- Conventionally fueled vehicles using EV-dedicated spaces

10. What were the electrical infrastructure requirements for the project?

The electrical requirements for Level 1, Level 2, and Level 3 chargers are 120V AC, 240V AC, and 400-500V DC, respectively. The requirement for additional infrastructure varies depending on what was in place at the time of installation. Approximately half of the airport sponsors interviewed had to install additional electrical infrastructure.

11. What was the approximate capital cost of the rechargers (listing equipment, installation, and infrastructure separately, if possible)?

Level 1 charging stations cost approximately \$1,500 each, which includes the cost of installation. Level 2 stations, before installation, cost approximately \$2,000 each but may require significant electrical infrastructure upgrades. Level 3 charging stations will be roughly \$20,000 to \$50,000 each before installation.

The cost after installation for Level 1 and 2 charging stations are approximately \$1,500 and \$10,000, respectively, including the cost of electrical infrastructure. However, these numbers are average values, and the cost of electrical infrastructure will vary significantly depending on existing conditions.

12. How did the airport provide the required funding for the project? Were grants involved? If so, what grant opportunity and for what amount?

Many airport sponsors received either federal grants through a manufacturer or a state grant in support of the charging stations. Eight of the 18 airports included in the survey received grants for charging stations. Most grants were for a set amount, such as \$2500 per station, which typically covered the equipment and part of the installation but would not necessarily cover any electrical infrastructure upgrades.

13. Do you charge for electricity?

All but one airport sponsor interviewed do not collect fees for the cost of electricity or for accessing EV charging stations, although some will consider charging in the future. The exception is the State of Hawaii, Airports Division, which collects \$7 per charging session at Honolulu, Hilo, Kona, and Lihue airports.

14. What is the rate the airport is charging to access the chargers? Is there a separate fee for the parking and the electricity use? Were there considerations of, or difficulties with, integrating the charging technology with the previously existing parking revenue management systems?

All but one airport sponsor interviewed are collecting the same parking fee from EV users who access the stations as all other users of the given lot or garage. The exception is the State of Hawaii, Airports Division, who by law cannot collect fees for EV parking at Honolulu, Kahului, Hilo, Kona, and Lihue Airports.

15. What are the operation and maintenance requirements and costs for the recharger system at the airport?

In general, operation and maintenance is minimal. In most cases, O&M is covered under the manufacturer's warranty. Internal airport departments are later responsible for maintenance once the contract has expired.

16. Do you have technology that tracks the usage or environmental benefits of the EV chargers? Is this information made available to the public? What specific vehicle data do you collect when the charger is being utilized? Do you report EV utilization for sustainability reporting, annual environmental reporting, etc.?

Details such as number of sessions, length of time EVs are at the station, energy use, and greenhouse gases avoided can be tracked by "smart" charging stations. Some airport sponsors are tracking the use of the charging stations, primarily with the intention of understanding the demand for the equipment. Once demand has reached capacity, the tracking data will provide impetus for supporting the purchase of additional chargers. Charging station usage has not been included in sustainability reporting or annual environmental reporting for the airports surveyed, but this type of environmental reporting may occur in the future.

Real-time charging station location and availabilities can be provided to the public through the use of technology provided by smart charging station manufacturers via social media.

17. Do you have an estimate of how frequently your chargers are being used? Has demand for chargers reached the supply of chargers? If so, how long did it take to get to that point and how is it dealt with? Have you had problems with icing? If so, how is this managed?

Is there a maximum amount of time that a vehicle may be kept in a charger-equipped parking space?

Charging station usage varies significantly by region, but in almost all cases, usage has increased over time. Once demand has been met, one airport sponsor reported restriping the number of stalls to add additional EV parking, prior to installing additional charging stations. No airport sponsors reported a significant problem with “icing”. No airport sponsor surveyed currently has a time limit on the amount of time a vehicle may be kept at an EV-dedicated space.

18. What would you say is the biggest challenge or lesson learned from the project?

Challenges and lessons learned are airport-specific, but the following were commonly cited: (1) interest in installing more charging stations once demand is met, (2) consideration of collecting a fee to charge, (3) importance of electrical infrastructure availability, (4) consideration of costs and grants, and (5) informing the public.

19. Could you share any published fee structures, policies, signage, instructions to customers and parking employees, etc., for publication in an appendix of the synthesis report.

An example request for proposals is provided in Appendix B.

APPENDIX B

REQUEST FOR PROPOSAL EXAMPLE

RETURN TO:
 Department of General Services PURCHASING DIVISION
 201 West Colfax Avenue Department 304, 11th Floor Denver, CO 80202
 Phone: (720) 913-8100
 FAX: (720) 913-8101

CITY AND COUNTY OF DENVER



Department of General Services
 PURCHASING DIVISION
www.denvergov.org/purchasing
 Buyer: Curtis Subia
 720-913-8152

FORMAL PROPOSAL

Request for Proposal No. **7109**

LEVEL 1 ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

SCHEDULE OF EVENTS

• Proposal Issued	June 24, 2013		
• Deadline to Submit Additional Questions	July 2, 2013	5:00 P.M.	Local Time
• Response to Written Questions	July 8, 2013		
• Proposal Due Date	July 15, 2013	4:00 P.M.	Local Time

Vendor offers to furnish to the City and County of Denver the materials, supplies, products or services requested in accordance with the specifications and subject to the Terms and Conditions described herein.

THIS PROPOSAL MUST BE RETURNED ELECTRONICALLY THROUGH THE ROCKY MOUNTAIN E-PURCHASING SYSTEM (BIDNET®).

Request for Proposal No. 7109

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Request for Proposal No. 7109

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT**SECTION A: GENERAL INFORMATION & PROPOSAL INSTRUCTIONS****A.1 BACKGROUND AND SCOPE:**

The City and County of Denver, hereinafter referred to as the City, desires to solicit proposals relating to the purchase of ten (10) **LEVEL 1 ELECTRIC VEHICLE CHARGING STATIONS IN THE COVERED PARKING GARAGE OF DENVER INTERNATIONAL AIRPORT.**

A.2 ROCKY MOUNTAIN E-PURCHASING (BidNet®):

The City is collaborating with Rocky Mountain E-purchasing System (BidNet®) in the advertisement and facilitation of Formal Bids and Requests for Proposals (RFP) administered by the City's General Services Purchasing Division.

It is a requirement of this Formal Bid / RFP that interested parties familiarize themselves and register with BidNet®; proposer/ contractors who do not register may be considered non-responsive.

Registration with BidNet® is available at NO CHARGE and allows proposers access to view governmental bids posted on BidNet®; they offer an additional notification service option with an associated fee. It is the responsibility of the proposer/ contractor to evaluate and select the service option of their choice.

The City is not responsible for the actions or lack thereof on the part of the proposer / contractor in regards to their interaction with BidNet®, or any other third-party bid notification service in relation to this Formal Bid/RFP.

More information is available at: www.rockymountainbidsystem.com or by calling 1-800-835-4603.

A.3 ELECTRONIC SUBMISSION OF PROPOSALS:

Submission of proposals for this solicitation may only be done electronically through BidNet®. Proposals must be submitted at www.rockymountainbidsystem.com, no later than the date and time indicated in the proposal.

Proposers who feel they are unable to prepare and submit an electronic submittal should submit a request in writing to the Buyer, no later than the Question due date, for permission and instructions for submitting a hardcopy proposal.

This process is subject to a public bid opening that is in compliance with the Schedule of Events.

A.4 PROPOSAL QUESTIONS:

The City shall not be bound by and the Vendor shall not request or rely on any oral interpretation or clarification of this RFP. Therefore any questions regarding this RFP are encouraged and should be submitted in writing by email to:

City Buyer: **Curtis Subia**
E-Mail: **curtis.subia@denvergov.org**
Phone: **720-913-8152**

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

Questions received up to deadline to submit questions in the Schedule of Events will be answered in writing per the Schedule of Events. Answers to questions from any Vendor will be provided to all Vendors.

All communications regarding this proposal shall only be through the City's buyer listed above. No communication is to be directed to any other City personnel.

A.5 ADDENDA:

In the event it becomes necessary to revise, change, modify or cancel this Proposal or to provide additional information, addenda will be issued and made available on BidNet®. It is the responsibility of the proposer/ contractor to confirm that they have acquired all addenda related to this solicitation and they have reviewed/ complied with the requirements therein.

A.6 ESTIMATED QUANTITIES:

The approximate quantities indicated for the material or equipment outlined herein are estimated as closely as possible. However, the City neither states nor implies any guarantee that actual purchases will equal the estimate. It is the intent of this proposal that the City will be supplied with more or less of the material or equipment according to actual needs.

A.7 ALTERNATE RESPONSES:

It is our intent to solicit proposals that afford the City the most cost efficient, technically responsive proposal for the acquisition of the subject matter of this RFP. However, we recognize that there may be arrangements different from that requested hereunder that would offer additional benefits to the City while satisfying the applicable requirements of this RFP. Accordingly, you may submit alternative proposals for consideration, which offer such additional benefits in addition to the requested baseline proposal. These alternatives will be evaluated in conjunction with the primary (baseline) approach for each proposal.

A.8 ACCEPTANCE PERIOD:

Proposals in response to this RFP shall indicate that they are valid for a period no less than 120 days from the closing date.

A.9 PRICING INSTRUCTIONS:

All prices quoted shall be firm and fixed. Pricing shall be in the format contained in the RFP. Alternative approaches for the pricing of the requested products and services may be provided; however, such alternate approaches shall be described separately and must be in addition to the format in the pricing section. Do not include cost or price figures anywhere except in the cost and pricing section.

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT**A.10 TECHNICAL REQUIREMENTS/STATEMENT OF WORK:**

Section B of this RFP contains our proposed Statement of Work and/or Technical Requirements. This document shall form the basis of a Purchase Order or Contractual Agreement covering the subject matter of this RFP. Exceptions or deviations to this proposal must not be added to the proposal pages, but must be on vendor's letterhead and accompany proposal. Any exceptions to this documentation will be taken into consideration when evaluating proposals submitted. The City reserves the right to reject any or all of your proposed modifications. The City welcomes cost saving proposals which still satisfy all technical and business objectives.

A.11 PROPOSAL CONDITIONS AND PROVISIONS:

This proposal must be signed by a duly authorized official of the proposing company. The completed and signed proposal (together with all required attachments) must be returned to the Department of General Services on or before the time and date of the deadline shown on page one. ***This proposal MUST be returned electronically through the Rocky Mountain E-purchasing System (BidNet®).***

All participating Vendors, by their signature hereunder, shall agree to comply with all of the conditions, requirements and instructions of this RFP as stated or implied herein. Any alteration, erasure or interlineation by the Vendor in this proposal shall constitute cause for rejection by the Manager of General Services. Exceptions or deviations to this proposal must not be added to the proposal pages, but must be on vendor's letterhead and accompany proposal. Should the City omit anything from this RFP which is necessary to a clear understanding of the work, or should it appear that various instructions are in conflict, then the Vendor shall secure written instructions from the Manager of General Services at least forty-eight (48) hours prior to the time and date shown in page one.

Typographical errors in entering quotations on proposal may result in loss of award of this proposal.

All Vendors are required to complete all information requested in this proposal. Failure to do so may result in the disqualification of proposal.

The City reserves the right to postpone or cancel this RFP, or reject all proposals, if in its judgment it deems it to be in the best interest of the City to do so.

Unit price for each item shall be shown and shall be for the unit of measurement indicated. In case of error in extension of prices, the unit price will govern.

The Manager of General Services reserves the right to waive any technical or formal errors or omissions and to reject any and all proposal(s), or to award contract for the items hereon, either in part or whole, if he deems it to be in the best interests of the City to do so.

The successful Vendor shall be in complete compliance with all of the specifications, terms and conditions of this proposal as outlined above. The City shall have the right to inspect the facilities and equipment of the successful Vendor to insure such compliance.

The City shall not be liable for any costs incurred by vendor in the preparation of proposals or for any work performed in connection therein.

A.12 GRATUITIES AND KICKBACKS:

It shall be a breach of ethical standards for any person to offer, give, or agree to give any employee or former employee (within six months of termination from City employment), or for any employee or former employee (within six months of termination from City employment) to solicit, demand, accept,

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

or agree to accept from another person, a gratuity or an offer of employment in connection with any decision, approval, disapproval, recommendation, preparation of any part of a program requirement or a purchase request, influencing the content of any specification or procurement standard, rendering of advice, investigation, auditing, or in any other advisory capacity in any proceeding of application, request for ruling, determination, claim or controversy, or other particular matter, pertaining to any program requirement or a contract or subcontract, or to any solicitation or proposal therefore.

It shall be a breach of ethical standards for any payment, gratuity, or offer of employment to be made by or on behalf of a subcontractor under a contract to the prime vendor or higher tier subcontractor or any person associated therewith, as an inducement for the award of a subcontract or order.

In the event that any gratuities or kickbacks are offered or tendered to any City and County of Denver employee, the proposal shall be disqualified and shall not be reinstated.

A.13 NON-COLLUSIVE VENDOR CERTIFICATION:

By the submission of this proposal, the vendor certifies that:

- A. The proposal has been arrived at by the vendor independently and has been submitted without collusion with any other vendor.
- B. The contents of the proposal have not been communicated by the vendor, nor, to its best knowledge and belief, by any of its employees or agents, to any person not an employee or agent of the vendor or its surety on any bond furnished herewith, and will not be communicated to any such person prior to the official opening of the proposal.
- C. No vendor shall submit more than one proposal for this purchase. It shall be the responsibility of each vendor to obtain the prior written permission of the Director of Purchasing before proposal opening in every situation in which the vendor, due to corporate association or other affiliation, may be found to be impermissibly associated with another vendor. Failure to observe this requirement could result in all such affiliated proposals being rejected.

A.14 AWARDS:

Award will be made on an "all or none" basis. Prices must be shown for each item listed. Proposals submitted without individual item prices listed will be considered as non-responsive and rejected.

A.15 BRAND AND/OR TRADE NAMES:

Brand Names: Where a manufacturer's brand name of merchandise is given in this proposal, it does not mean to construe or imply an endorsement by the City and County of Denver of this brand only, but is used as a norm of quality, type, etc.

A.16 PRODUCT/PERFORMANCE LITERATURE:

Complete manufacturer's literature and specifications must be furnished by each vendor on the brand name products he is quoting to furnish.

The successful vendor may be required upon request to furnish manuals and parts books on items proposed, plus current repair parts price sheets.

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT**A.17 GREENPRINT DENVER POLICY AND GUIDANCE:**

The City & County of Denver, through its Greenprint Denver action plan, is committed to protecting the environment, and the health of the public and its employees. In accordance with this policy, City agencies are directed to procure cost-competitive products and services that minimize resource consumption and negative impacts on the environment and human health.

In requesting proposals for the City, when specifically required in the evaluation criteria, expects all responsive proposers to demonstrate commitment to and experience in environmental sustainability and public health protection practices applicable to their line of services. The City during its evaluation processes will actively assess the quality and value of all proposals.

Vendors, when applicable, are to follow standards and recommendations of the United States Environmental Protection Agency EPP program, the Green Seal organization, and standards and practices specified by the U.S. Green Building Council, including the Leadership in Energy and Environmental Design (LEED) program.

A.17.a Environmentally Preferable Purchasing (EPP) Guidance and Prohibitions:

The City defines Environmentally Preferable products and services as having a lesser or reduced effect on human health and the environment when compared with competing products and services that serve the same purpose. The City's EPP evaluation may extend to raw materials acquisition, energy consumption in manufacturing and transport, packaging, recyclability, waste disposal, and many other factors.

A.18 DISCLOSURE OF CONTENTS OF PROPOSALS:

All proposals become a matter of public record and shall be regarded as Public Records, with the exception of those specific elements in each proposal which are designated by the proposer as Business or Trade Secrets and plainly marked "Trade Secrets", "Confidential", "Proprietary", or "Trade Secret". Items so marked shall not be disclosed unless disclosure is otherwise required under the Open Records Act. If such items are requested under the Open Records Act, the City will use reasonable efforts to notify the proposer, and it will be the responsibility of the proposer to seek a court order protecting the records, and to defend, indemnify, and hold harmless the City from any claim or action related to the City's non-disclosure of such information.

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT**SECTION B: SCOPE OF WORK AND TECHNICAL REQUIREMENTS****B.1 SCOPE OF WORK:**

The City and County of Denver's Aviation Department (the City) desires a vendor to furnish multiple Level 1 electric vehicle charging stations in covered areas in the parking structures of Denver International Airport (DIA). These stations can be free standing or attached to wall surfaces.

The City will install the Level 1 Charging Stations in accordance with the successful vendor's installation instructions. It will also be responsible for supplying power. This power supply will conform to all applicable building codes and standards. The City will secure all required permits and inspections

The Level 1 charging station should conform to these standards:

B.1.a Charging Equipment Requirements:

- 120 VAC, 16 A maximum
- SAE J1772 plug standard
- Wiring; 3 x #12 (hot, neutral and ground)
- Safety interlocks as specified by UL2594
- Easily navigated operator interface with clear indication of charging system status
- Durable exterior designed to withstand outdoor environment and normal wear expected in a public, commercial application
- Access to inside of the charging unit as may be necessary for routine maintenance and repairs
- Designed for solid anchoring to floor or wall
- Safety certified and tested by UL or an accredited certification body such that equipment is eligible to bear the ETL/cETL Listing Mark
- 12.5' feet of EVSE retractable cable
- Operator interface with LED's
- NEMA 3R Enclosure
- UL 2594 Certified for EVSE commercial use

B.1.b : Technical Requirements:

All items submitted must meet the following Applicable Technical EVSE specifications, listing and testing such as:

SAE Standards

- SAE J551 Electromagnetic compatibility standards
- SAE J1772 Conductive 5-pin coupling for EVSE
- SAE J1850 Communication network between EVSE and the EV
- SAE J2178 Message format for the communication network
- SAE J2293 Energy transfer system, umbrella document for EV standards
- SAE J2294 Onboard power charger quality
- SAE J2836 Digital communications use case between EVSE and vehicle
- SAE J2847 Digital communications specifications

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT**UL Listed/Tested**

- UL 2202 Safety of EVSE
- UL 2231 Shock prevention measures for EVSE safety of cord set
- UL2251

Disclaimer: This list is not comprehensive, as other existing and future industry standards, recommended practices, and regulatory requirements may apply.

Does the proposed equipment meet these requirements? YES / NO

B.2 DISCOUNTS (PAYMENT):

Vendor offers a prompt payment discount of _____ % _____ days to apply after receipt of invoice or final acceptance of the products, whichever is later. Notwithstanding the fact that a blank is provided for a cash discount, discounts offered for payments within less than thirty (30) calendar days ***or payments thirty (30) calendar days or more*** will not be considered in evaluating offers for award ***unless the same is specifically set forth in the Specific or Additional Conditions of this proposal.*** Discounts of less than thirty (30) days will be taken if payment is made within the discount period even though not considered in evaluation of the proposal. The term "prox" is not considered to meet the requirements of 30-day criteria as noted above.

B.3 PAYMENT CONDITIONS:

Progress payments are not authorized in this procurement. Payment will be made upon final delivery and acceptance of the supplies or service by the City.

Under no circumstances will the vendor receive payment for work which was not authorized by the Manager of General Services or his/her authorized representative. Such notice will be in writing, or by assignment of a Purchase Order number by the Purchasing Department and will be given only after the vendor and a designated representative of the Department of General Services have generally defined the scope of work to be accomplished. Separate orders to proceed will be given for each specific task.

Final Inspection: Should final inspection reveal that work accomplished under any resulting Purchase Order or Contractual Agreement is incomplete, or has not been made in accordance with drawings, specifications and authorized changes thereto, then the vendor shall be required to correct or complete the project before final payment will be made.

Final payment for work accomplished will not be considered until final inspection and approval by the City.

B.4 PATENTS:

Seller agrees to defend the City and County of Denver at seller's own expense, in all suits, actions or proceedings in which the City and County of Denver is made a defendant for actual or alleged infringement of any United States of America or foreign letters patent resulting from the City and County of Denver's use of the goods purchased as a result of this Invitation for Proposal. Seller further agrees to pay and discharge any and all judgments or decrees which may be rendered in any such suit, action or proceeding against the City and County of Denver.

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

Seller agrees to indemnify and hold harmless the City and County of Denver from any and all license, royalty and proprietary fees or costs, including legal costs, which may arise out of the City and County of Denver's purchase and use of goods supplied by the seller.

It is expressly agreed by seller that these covenants are irrevocable and perpetual.

B.5 COOPERATIVE PURCHASING:

The City and County of Denver encourages and participates in cooperative purchasing endeavors undertaken by or on behalf of other governmental jurisdictions, pursuant to Denver Revised Municipal Code Sec. 20-64.5. To the extent other governmental jurisdictions are legally able to participate in cooperative purchasing endeavors, the City and County of Denver supports such cooperative activities. Further, it is a specific requirement of this proposal or Request for Proposal that pricing offered herein to the City and County of Denver may be offered by the vendor to any other governmental jurisdiction purchasing the same products.

The vendor(s) must deal directly with any governmental agency concerning the placement of purchase orders, freight charges for destinations outside of the Denver Metro area, contractual disputes, invoicing, and payment. The City and County of Denver shall not be liable for any costs, damages incurred by any other entity.

B.6 F.O.B. POINT:

Prices quoted shall be F.O.B. Denver International Airport, 8500 Pena Blvd. Denver, CO 80249, unloaded.

B.7 DELIVERY CONSIDERATIONS:

When a date is set for the delivery of merchandise or the performance of work, said merchandise must be delivered or work performed in accordance with the specifications or description herein contained on or before said date, or the order to the delinquent party may be cancelled and awarded to the next lowest vendor. In such case, the City and County will have the right to buy such articles at market prices for immediate delivery, and an excess in cost of same over price named hereon is to be paid by the vendor under this Purchase Order or Contractual Agreement, or deducted from any money due or hereafter coming to him.

B.8 DEFECTIVE MATERIAL:

The successful vendor shall agree to accept, for full credit and return shipping charges, the return of any item received which is found to be deficient in quality or defective in packaging so as to render the item unusable for its intended purpose. Merchandise so designated shall be replaced at the full expense of the vendor within seven (7) calendar days.

B.9 WARRANTY GUARANTEE:

The vendor warrants and guarantees to the City and County of Denver that all equipment and materials to be furnished under this proposal are free from all defects in workmanship and materials. The vendor further warrants, guarantees and agrees to remedy all such defects and to replace at vendor's expense and at no expense to the City and County of Denver any or all labor, transportation, part or parts of the equipment or materials to be furnished under this proposal which are or become defective due to such

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

defects within twelve (12) months after date of receipt by the City and County of Denver or Manufacturer's Warranty guarantee, whichever is longer.

B.10 PALLET CHARGE:

All pallets supplied shall be non-returnable, no deposit.

B.11 PRE-DELIVERY:

Prior to delivery, new units of equipment must be completely serviced in accordance with the manufacturer's specifications.

B.12 PROPOSER QUESTIONS AND REQUIREMENTS:

Your proposal must specifically address each of the questions/issues that are listed below. These questions are being asked to aid DIA in determining if the proposed station will meet its needs. **To standardize the format of all proposals, Proposers are required to respond to all questions in the order given and to list the item number and restate the question prior to giving their answer.**

B.13 VENDOR QUESTIONS AND SUBMITTALS:

VENDORS ARE **REQUIRED** TO SUBMIT ALL TECHNICAL LITERATURE FOR PROPOSED EQUIPEMENT. ALL TECHNICAL LITERATURE MUST BE SUBMITTED ELECTRONICALLY VIA BIDNET. HARD COPIES OF TECHNICAL LITERATURE MUST BE PROVIDED UPON REQUEST.

ADDITIONALLY, VENDORS MUST ANSWER THE FOLLOWING QUESTIONS.

1. Please discuss how durable your station is and how it has been used in similar situations to those that an airport may experience.
2. Why is the station you are proposing the best answer for meeting DIA's needs?
3. Please provide among the references in section E.1 someone who has installed several of the proposed station (please indicate which reference meets this request).
4. Provide the standard maintenance requirements for your equipment in Years 2-5.
5. Provide the process of software upgrade (if applicable).
6. List the currently available electric vehicles that your equipment is compatible with.
7. List the currently available electric vehicles that your equipment is **NOT** compatible with.
8. What is the projected lifetime of the equipment proposed?

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT**SECTION C: PRICING****C.1 PRICING INFORMATION:**

This section shall include a description of the proposed costs and prices. All pricing information shall be limited solely to this section of your proposal. This section should address all requirements set forth in Section B as well as any other items pertinent to your proposal pricing such as additional discounts for increased quantities, prompt payment, etc. The requirements have been developed to allow the City to uniformly evaluate prices submitted for the work. Accordingly, you should follow these instructions carefully and provide all data requested in the formats specified herein and in any referenced attachments.

Any omissions in this proposal shall be identified by each Vendor and incorporated into their proposal including any omissions for software, hardware, support etc. which is necessary to the success of the project and must be identified as a separate line item with pricing and included as part of this proposal. The City will not increase the contract or any purchase order (either dollar amount or time) for items not included in the submitted proposal documents. The City reserves the right to purchase part or the entire proposal.

C.2 PRICING:

All prices quoted shall be firm and fixed.

In the event the market price on any item is reduced during the period of the resulting Purchase Order or Contractual Agreement, the successful vendor for that item shall reduce the proposal price to the City accordingly.

All pricing will be per unit pricing for the unit and all accessories needed to bring the unit into normal operation. The City will determine the best utilization mix of the equipment proposed.

Request for Proposal No. 7109

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

ITEM	QTY.	UOM	DESCRIPTION	UNIT COST	TOTAL EXTENDED COST
1.	1	Each	AC Level 1 EVSE Pedestal Mount Base Unit MFG.: Model:	\$ _	\$ _
1.1	1	Lot	Applicable Fees: List All Fees & Rate	\$ _	\$ _
1.2	1	Each	Retractable Cord MFG.:	\$ _	\$ _
2.	1	Each	AC Level 1 EVSE Pole Mount Base Unit MFG.: Model:	\$ _	\$ _
2.1	1	Lot	Applicable Fees: List All Fees & Rate	\$ _	\$ _
2.2	1	Each	Retractable Cord MFG.:	\$ _	\$ _

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT**C.3 PROPOSAL ITEMS:**

ITEM	QTY.	UOM	DESCRIPTION	UNIT COST	TOTAL EXTENDED COST
3	1	Each	AC Level 1 EVSE Wall Mount Base Unit MFG.: Model:	\$ _	\$ _
3.1	1	Lot	Applicable Fees: List All Fees & Rate	\$ _	\$ _
3.2	1	Each	Retractable Cord MFG.:	\$ _	\$ _
4	1	Each	AC Level 1 EVSE Ceiling Mount Base Unit MFG.: Model:	\$ _	\$ _
4.1	1	Lot	Applicable Fees: List All Fees & Rate	\$ _	\$ _
4.2	1	Each	Retractable Cord MFG.:	\$ _	\$ _

Additional Options: % off attached MSRP

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ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

ITEM	QTY.	UOM	DESCRIPTION	UNIT COST	TOTAL EXTENDED COST
5	1	Each	Extended Warranty Extension Length:	\$ _	\$ _
6	1	Each	Maintenance Contract Coverage Length: Maintenance Contract Includes:	\$ _	\$ _

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT**SECTION D: GENERAL CONDITIONS OF PURCHASE****D.1 NON-EXCLUSIVE:**

This Purchase Order is non-exclusive. City does not guarantee any minimum purchase other than as provided herein

D.2 INSPECTION AND ACCEPTANCE:

Vendor shall perform all services in accordance with the standard of care exercised by highly competent vendors who perform like or similar services. City may inspect all goods/services prior to acceptance. Payment does not constitute acceptance. Vendor shall bear the cost of any inspection/testing that reveal goods/services that are defective or do not meet specifications. City's failure to accept or reject goods/services shall not relieve Vendor from its responsibility for such goods/services that are defective or do not meet specifications nor impose liability on City for such goods/services. If any part of the goods/services are not acceptable to City, City may, in addition to any other rights it may have at law or in equity: (1) make a warranty claim; (2) repair and/or replace the goods or substitute other services at Vendor's expense; or (3) reject and return the goods at Vendor's cost and/or reject the services at Vendor's expense for full credit. Any rejected goods/services are not to be replaced without written authorization from City, and any such replacement shall be on the same terms and conditions contained in this Purchase Order.

D.3 SHIPPING, TAXES AND OTHER CREDITS AND CHARGES:

Vendor shall procure all permits and licenses; pay all charges, taxes and fees; and give all notices necessary and incidental to the fulfillment of this Purchase Order and all cost thereof have been included in the prices contained herein. City shall not be liable for the payment of taxes, late charges or penalties of any nature, except as required by D.R.M.C. § 20-107, et seq. The price of all goods/services shall reflect all applicable tax exemptions. City's Federal Registration No. is 84-6000580 and its State Registration No. is 98-02890. All pricing is F.O.B. destination unless otherwise specified. Shipments must be marked with Vendor's name, the Purchase Order number, and contain a delivery or packing slip. Vendor shall not impose any charges for boxing, crating, parcel post, insurance, handling, freight, express or other similar charges or fees. Vendor shall notify City in writing of any price decreases immediately, and City shall receive the benefit thereof on all unshipped items. Vendor shall comply with any additional delivery terms specified herein. Vendor shall be responsible for the cleanup and reporting of any contamination (environmental or otherwise) or spillage resulting from the delivery and/or unloading of goods within twenty-four (24) hours of the contamination or spillage or sooner if required by law. Vendor shall pay all sales and use taxes levied by City on any tangible personal property built into the goods/services. Vendor shall obtain a Certificate of Exemption from the State of Colorado Department of Revenue prior to the purchase of any materials to be built into the goods/services and provide a copy of the Certificate to City prior to final payment.

D.4 RISK OF LOSS:

Vendor shall bear the risk of loss, injury or destruction of goods prior to delivery to City. Loss, injury or destruction shall not release Vendor from any obligation hereunder.

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT**D.5 INVOICE:**

Each invoice shall include: (i) the purchase order number; (ii) individual itemization of the goods/services; (iii) per unit price, extended and totaled; (iv) quantity ordered, back ordered and shipped; (v) an invoice number and date; (vi) ordering department's name and "ship to" address; and (vii) agreed upon payment terms set forth herein.

D.6 PAYMENT:

Payment shall be subject to City's Prompt Payment Ordinance D.R.M.C. § 20-107, et-seq. after City accepts the goods/services. City's payment obligations hereunder, whether direct or contingent, shall extend only to funds appropriated by the Denver City Council for the purpose of this Purchase Order, encumbered for the purpose of this Purchase Order and paid into the Treasury of City. Vendor acknowledges that: (i) City does not by this Purchase Order, irrevocably pledge present cash reserves for payments in future fiscal years; and (ii) this Purchase Order is not intended to create a multiple-fiscal year direct or indirect debt or financial obligation of City. City may setoff against any payments due to Vendor any claims and/or credits it may have against Vendor under this Purchase Order.

D.7 AMENDMENTS/CHANGES:

Only the Manager of General Services or his delegate is authorized to change or amend this Purchase Order by a formal written change order. Any change or amendment that would cause the aggregate payable under this Purchase Order to exceed the amount appropriated and encumbered for this Purchase Order is expressly prohibited and of no effect. Vendor shall verify that the amount appropriated and encumbered is sufficient to cover any increase in cost due to changes or amendments. Goods/services provided without such verification are provided at Vendor's risk. The Vendor has no authority to bind City on any contractual matters.

D.8 WARRANTY:

Vendor warrants and guarantees to City that all goods furnished under this Purchase Order are free from defects in workmanship and materials, are merchantable, and fit for the purposes for which they are to be used. For any goods furnished under this Purchase Order which become defective within twelve (12) months (unless otherwise specified) after date of receipt by City, Vendor shall either, at City's election and to City's satisfaction, remedy any and all defects or replace the defective goods at no expense to City within seven (7) days of receipt of the defective goods or accept the defective goods for full credit and payment of any return shipping charges. Vendor shall be fully responsible for any and all warranty work, regardless of third party warranty coverage. Vendor shall furnish additional or replacement parts at the same prices, conditions and specifications delineated herein.

D.9 INDEMNIFICATION/LIMITATION OF LIABILITY:

Vendor shall indemnify and hold harmless City (including but not limited to its employees, elected and appointed officials, agents and representatives) against any and all losses (including without limitation, loss of use and costs of cover), liability, damage, claims, demands, actions and/or proceedings and all costs and expenses connected therewith (including without limitation attorneys' fees) that arise out of or relate to any

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

claim of infringement of patent, trademark, copyright, trade secret or other intellectual property right to this Purchase Order or that are caused by or the result of any act or omission of Vendor, its agents, suppliers, employees, or representatives. Vendor's obligation shall not apply to any liability or damages which result solely from the negligence of City. City shall not be liable for any consequential, incidental, indirect, special, reliance, or punitive damages or for any lost profits or revenues, regardless of the legal theory under which such liability is asserted. In no event shall City's aggregate liability exceed the agreed upon cost for those goods/services that have been accepted by City under this Purchase Order up to the Total Purchase Order Amount. Notwithstanding anything contained in this Purchase Order to the contrary, City in no way limits or waives the rights, immunities and protections provided by C.R.S. § 24-10-101, et seq.

D.10 TERMINATION:

City may terminate this Purchase Order, in whole or in part, at any time and for any reason immediately upon written notice to Vendor. In the event of such a termination, City's sole liability shall be limited to payment of the amount due for the goods/services accepted by City. Vendor acknowledges the risks inherent in this termination for convenience and expressly accepts them. Termination by City shall not constitute a waiver of any claims City may have against Vendor.

D.11 INTERFERENCE:

Vendor shall notify the Director of Purchasing immediately of any condition that may interfere with the performance of Vendor's obligations under this Purchase Order and confirm such notification in writing within twenty-four (24) hours. City's failure to respond to any such notice shall in no way act as a waiver of any rights or remedies City may possess.

D.12 VENUE, CHOICE OF LAW AND DISPUTES:

Venue for all legal actions shall lie in the District Court in and for City and County of Denver, State of Colorado, and shall be governed by the laws of the State of Colorado as well as the Charter and Revised Municipal Code, rules, regulations, Executive Orders, and fiscal rules of City. All disputes shall be resolved by administrative hearing, pursuant to the procedure established by D.R.M.C. § 56-106. Director of Purchasing shall render the final determination.

D.13 ASSIGNMENT/NO THIRD PARTY BENEFICIARY:

Vendor shall not assign or subcontract any of its rights or obligations under this Purchase Order without the written consent of City. In the event City permits an assignment or subcontract, Vendor shall continue to be liable under this Purchase Order and any permitted assignee or subcontractor shall be bound by the terms and conditions contained herein. This Purchase Order is intended solely for the benefit of City and Vendor with no third party beneficiaries.

D.14 NOTICE:

Notices shall be made by Vendor to the Director of Purchasing and by City to Vendor at the addresses provided herein, in writing sent registered, return receipt requested.

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT**D.15 COMPLIANCE WITH LAWS:**

Vendor shall observe and comply with all federal, state, county, city and other laws, codes, ordinances, rules, regulations and executive orders related to its performance under this Purchase Order. City may immediately terminate this Purchase Order, in whole or in part, if Vendor or an employee is convicted, plead nolo contendere, or admits culpability to a criminal offense of bribery, kickbacks, collusive bidding, bid-rigging, antitrust, fraud, undue influence, theft, racketeering, extortion or any offense of a similar nature.

D.16 INSURANCE:

Vendor shall secure, before delivery of any goods/services, the following insurance covering all operations, goods and services provided to City. Vendor shall keep the required insurance coverage in force at all times during the term of the Purchase Order, or any extension thereof, during any warranty period, and for three (3) years after termination of this Purchase Order. The required insurance shall be underwritten by an insurer licensed to do business in Colorado and rated by A.M. Best Company as "A-VIII" or better. Each policy shall contain a valid provision or endorsement requiring notification to the City in the event any of the required policies be canceled or non-renewed before the expiration date thereof. Such written notice shall be sent to the parties identified in the Notices section of this Agreement. Such notice shall reference the City contract number listed on the signature page of this Agreement. Said notice shall be sent thirty (30) days prior to such cancellation or non-renewal unless due to non-payment of premiums for which notice shall be sent ten (10) days prior. If such written notice is unavailable from the insurer, contractor shall provide written notice of cancellation, non-renewal and any reduction in coverage to the parties identified in the Notices section by certified mail, return receipt requested within three (3) business days of such notice by its insurer(s) and referencing the City's contract number. If any policy is in excess of a deductible or self-insured retention, City must be notified by Vendor. Vendor shall be responsible for the payment of any deductible or self-insured retention. The insurance coverages specified in this Purchase Order are the minimum requirements, and these requirements do not lessen or limit the liability of Vendor. Vendor shall provide a copy of this Purchase Order to its insurance agent or broker. Vendor may not commence services or work relating to the Purchase Order prior to placement of coverage. Contractor certifies that the attached certificate of insurance attached to the Purchase Order documents, preferably an ACORD certificate, complies with all insurance requirements of this Purchase Order. The City's acceptance of a certificate of insurance or other proof of insurance that does not comply with all insurance requirements set forth in this Purchase Order shall not act as a waiver of Vendor's breach of this Purchase Order or any of the City's rights or remedies under this Agreement. The City's Risk Management Office may require additional proof of insurance, including but not limited to policies and endorsements. Vendor's insurer shall name as Additional Insured to its Commercial General Liability and Business Auto Liability policies the City and County of Denver, its elected and appointed officials, employees and volunteers. Vendor's insurer shall waive subrogation rights against the City. All sub-contractors and sub-consultants (including independent contractors, suppliers or other entities providing goods/services required by this Purchase Order) shall be subject to all of the requirements herein and shall procure and maintain the same coverages required of Vendor. Vendor shall include all such entities as insureds under its policies or shall ensure that they all maintain the required coverages. Vendor shall provide proof of insurance for all such entities upon request by City. For Worker's Compensation Insurance, Vendor shall maintain the

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

coverage as required by statute for each work location and shall maintain Employer's Liability insurance with limits of \$100,000 for each bodily injury occurrence claim, \$100,000 for each bodily injury caused by disease claim, and \$500,000 aggregate for all bodily injuries caused by disease claims. Vendor expressly represents to City, as a material representation upon which City is relying, that none of the Vendor's officers or employees who may be eligible under any statute or law to reject Workers' Compensation Insurance shall effect such rejection during any part of the term of this Purchase Order, and that any such rejections previously effected, have been revoked. Vendor shall maintain Commercial General Liability coverage with limits of \$1,000,000 for each occurrence, \$1,000,000 for each personal and advertising injury claim, \$2,000,000 products and completed operations aggregate, and \$2,000,000 policy aggregate. Vendor shall maintain Business Auto Liability coverage with limits of \$1,000,000 combined single limit applicable to all owned, hired and non-hired vehicles used in performing services under this Purchase Order. For Commercial General Liability coverage, the policy must provide the following: (i) That this Purchase Order is an Insured Contract under the policy; (ii) Defense costs in excess of policy limits; (iii) A severability of interests, separation of insureds or cross liability provision; and (iv) A provision that coverage is non-contributory with other coverage or self-insurance provided by City. For claims-made coverage, the retroactive date must be on or before the first date when any goods or services were provided to City. Vendor must advise the City in the event any general aggregate or other aggregate limits are reduced below the required per occurrence limits. At their own expense, and where such general aggregate or other aggregate limits have been reduced below the required per occurrence limit, the Contractor will procure such per occurrence limits and furnish a new certificate of insurance showing such coverage is in force.

D.17 SEVERABILITY:

If any provision of this Purchase Order, except for the provisions requiring appropriation and encumbering of funds and limiting the total amount payable by City, is held to be invalid, illegal or unenforceable by a court of competent jurisdiction, the validity of the remaining portions or provisions shall not be affected if the intent of City and Vendor can be fulfilled.

D.18 SURVIVAL:

All terms and conditions of this Purchase Order which by their nature must survive termination/expiration shall so survive. Without limiting the foregoing, Vendor's insurance, warranty and indemnity obligations shall survive for the relevant warranty or statutes of limitation period plus the time necessary to fully resolve any claims, matters or actions begun within that period. Bonds shall survive as long as any warranty period.

D.19 NO CONSTRUCTION AGAINST DRAFTING PARTY:

No provision of this Purchase Order shall be construed against the drafter.

D.20 STATUS OF VENDOR/OWNERSHIP OF WORK PRODUCT:

Vendor is an independent contractor retained on a contractual basis to perform services for a limited period of time as described in Section 9.1.1E(x) of the Charter of City. Vendor and its employees are not employees or officers of City under Chapter 18 of the D.R.M.C. for any purpose whatsoever. All goods,

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

deliverables, hardware, software, plans, drawings, reports, submittals and all other documents or things furnished to City by Vendor shall become and are the property of City, without restriction.

D.21 RECORDS AND AUDITS:

Vendor shall maintain for three (3) years after final payment hereunder, all pertinent books, documents, papers and records of Vendor involving transactions related to this Purchase Order, and City shall have the right to inspect and copy the same.

D.22 REMEDIES/WAIVER:

No remedy specified herein shall limit any other rights and remedies of City at law or in equity. No waiver of any breach shall be construed as a waiver of any other breach.

D.23 NO DISCRIMINATION IN EMPLOYMENT:

Vendor shall not refuse to hire, discharge, promote or demote, or to discriminate in matters of compensation against any person otherwise qualified, solely because of race, color, religion, national origin, gender, age, military status, sexual orientation, marital status, or physical or mental disability; and Vendor shall insert the foregoing provision in any subcontracts hereunder.

D.24 USE, POSSESSION OR SALE OF ALCOHOL OR DRUGS:

Vendor shall cooperate and comply with the provisions of Executive Order 94. Violation may result in City terminating this Purchase Order or barring Vendor from City facilities or from participating in City operations.

D.25 CONFLICT OF INTEREST:

No employee of City shall have any personal or beneficial interest in the goods/services described in this Purchase Order; and Vendor shall not hire or contract for services any employee or officer of City which would be in violation of City's Code of Ethics, D.R.M.C. §2-51, et seq. or the Charter §§ 1.2.8, 1.2.9, and 1.2.12.

D.26 ADVERTISING AND PUBLIC DISCLOSURE:

Vendor shall not reference the goods/services provided hereunder in any of its advertising or public relations materials without first obtaining the written approval of the Manager of General Services.

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

SECTION E: ADDITIONAL REQUIRED INFORMATION

E.1 REFERENCE LISTING:

Vendors shall furnish the names, addresses and telephone numbers of a minimum of three (3) firms or government organizations:

<hr/>	
Company Name	
Address	
<hr/>	
Reference	
Reference Email Address	
Telephone Number	
<hr/>	
Project Name	
Value	\$
<hr/>	
Company Name	
Address	
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Reference	
Reference Email Address	
Telephone Number	
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Project Name	
Value	\$
<hr/>	
Company Name	
Address	
<hr/>	
Reference	
Reference Email Address	
Telephone Number	
<hr/>	
Project Name	
Value	\$

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT**E.2 VENDOR'S CHECK LIST:**

The following check list should be used to ensure required documentation is attached to the proposal. If a document is not required for your proposal, write n/a in the blank.

- _____
1. Have you signed the front page of the proposal?
- _____
2. Have you reviewed all proposal prices, checked unit costs, extensions and totals?
- _____
3. Have you included manufacturer's names and reference numbers, as applicable?
- _____
4. Have you supplied any alternatives or additional information on separate headed note paper?
- _____
5. Have you responded to or completed and included in your response **all** of the City's requirements, questions, forms, including the vendor sustainability form and other city requests?
6. Have you assured that there is sufficient time to transmit this proposal?
- _____
7. Have you enclosed relevant technical literature or samples (where applicable)?

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

E.3 GREENPRINT DENVER VENDOR SUSTAINABILITY:

The City encourages vendors to demonstrate a commitment to and experience in environmental sustainability and public health protection practices applicable to its line of products and/or services being procured in this proposal. See Section A of this proposal for the Greenprint Denver Policy and Guidance. The following are areas that may be addressed.

Explain how your products and/or service supports the City’s goal of environmentally preferable purchasing.

- Manufacturing Process
 - Product Content
 - Transportation
 - Packaging
 - Performance
 - End of Life
 - Third Party Certification (Green Seal, Eco Logo, Design for the Environment, etc.)
-
-
-
-
- Other

ELECTRIC VEHICLE CHARGING STATIONS FOR DENVER INTERNATIONAL AIRPORT

E.4 VENDOR INFORMATION

[illegible]

Ordering Email (If different from above)

Remittance Name

Vendor Entity Type (check one)

Remittance Address

City, State, Zip

Dun & Bradstreet Number

SIC Code and/or NAICS Code

Disadvantaged Business Enterprise (DBE)

Yes

No

Certification Source

Type (check all that apply)

DBE

Disadvantage Business Enterprise

MBE

Minority Business Enterprise

WBE

Women Business Enterprise

Certification Number

SBE

Small Business Enterprise

Certification

SBEC

Small Business Enterprise Concessions

Beginning Date

ACDBE

Airport Concession Disadvantage Business Enterprise

Certification

Other:

Expiration Date

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Abbreviations used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI-NA	Airports Council International-North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation