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Workplace Charging Barrier Study

Columbia-Willamette Clean Cities Coalition

Developed For

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Executive Summary

State policies on greenhouse gas emission reductions are increasing rapidly throughout the country and one of their main targets is the decarbonization of the transport sector. With electrification of vehicles as one of the main solutions, the limited availability of chargers creates a barrier for EV adoption.

Workplace charging is one solution to the problem. Workplace charging offers employees the opportunity to charge their vehicles in a place that they frequent and park for many hours at a time. Additionally, workplace charging increases equity in the transportation electrification sector by providing employees without access to at-home charging infrastructure the opportunity to access dedicated charging.

To better understand the barriers to adoption of workplace charging, Cadeo conducted a literature review and performed interviews with subject matter experts and diverse market stakeholders to identify the barriers to workplace charging adoption and offer solutions to overcome them.

Findings from this research include the following technical, economic, and achievable barriers:

Barriers	
Lack of building/parking facility ownership	Ongoing costs
Supply chain issues	Funding conditions
Lack of skilled workforce	Remote working
Unclear and long permitting process	Equity considerations
Complex process	Lack of awareness of incentives
Upfront costs	Lack of knowledge
Low return on investment	Vandalism

The proposed solutions to these barriers are listed below:

Recommendations
Options for Employers Leasing Facilities
Streamline the permitting process
Workforce training and development
One-stop shop for information

Dedicated technical assistance to oversee the project
EV provisions in building codes
New business models for downsized office spaces
Private Partnerships
Charging a fee for charging
Raise awareness of the equity impacts of workplace charging

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Section 1 Introduction

Insufficient charging infrastructure is a well-documented deterrent to electric vehicle (EV) adoption, with nearly half of U.S. consumers stating that battery or charging issues are their primary concerns when deciding whether to buy an EV.[1] Historically, privately owned EV charging has largely taken place at owner's residences.[2] However, home charging typically requires dedicated garage space where charging equipment can be easily installed, which is not possible on all properties. For instance, residents of multifamily units often do not have the ability to install dedicated chargers due to limited or no parking spaces. And, depending on typical commuting distances, home charging alone might not be enough to remedy range anxiety—another big barrier to EV adoption—especially for more rural communities or individuals who commute long distances to and from work each day.

Given these challenges, workplace charging stands to play an important function in the rapid transition from internal combustion engine (ICE) vehicles to EVs. Workplace charging reduces range anxiety, provides a dedicated place to charge, and reduces inequality of charging infrastructure allocation. Despite its importance, however, workplace charging faces several barriers when it comes to actual adoption.

This study identifies key barriers to workplace charging adoption and makes recommendations on how to address them. The report is divided in six sections:

- Section 1 Introduction starts with the background on deployment of EVs in the United States and the role of workplace charging in advancing transport electrification.
- Section 2 Methodology offers a description of the methodology and resources used to conduct the research and identify key barriers.
- Section 3 Overview of Workplace Charging provides an overview of the workplace charging market, such as saturation, technical configurations, costs, and ownership models. This section also highlights key issues related to equity in workplace charging.
- Section 4 Workplace Charging Enablers and Market Opportunities covers market and policy enablers that contribute to adoption of workplace charging.
- Section 5 Barriers to Workplace Charging Adoption identifies the barriers to adoption and provides insight into the significance of each barrier, including equity considerations.
- Section 6 Recommendations recommends policy and programmatic interventions that can help increase adoption of workplace charging in the United States.

[1] McKinsey & Company. "Building the Electric Vehicle Charging Infrastructure America Needs." McKinsey & Company, October 2020. https://www.mckinsey.com/industries/public-and-social-sector/our-insights/building-the-electric-vehicle-charging-infrastructure-america-needs.
[2] International Energy Agency. Global EV Outlook 2022: Trends in Charging Infrastructure. Paris: IEA Publications, 2022. https://www.iea.org/reports/global-ev-outlook-2022/trends-in-charging-infrastructure.

1.1 Background

Plug-in electric vehicles, including plug-in hybrid vehicles and battery EVs, are crucial for transportation decarbonization efforts across the United States. Although the current market share for these vehicles is small, it is expected to grow substantially over the next decade, with estimates as high as 32 percent total market penetration by 2030.[3] Significant federal and state policy efforts in recent years aim to support such optimistic forecasts. The federal government has set a target for half of all new vehicles sold in the United States in 2030 to be zero-emissions vehicles and to build a national public charging network of half million chargers to encourage transition from conventional ICE vehicles.[4,5] U.S. automakers have announced similarly strong commitments to reaching 40 to 50 percent EV sales share in 2030.[6] Landmark federal legislation, such as the Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA), will create additional programs, funding, and incentives to support aggressive transportation electrification.

Despite strong market and government incentives for transportation electrification, there are several barriers that prevent individual consumers from making the switch from ICE vehicles to EV at scale. These barriers include, but are not limited to:

- **Purchase Cost.** EVs on average are more expensive to purchase than comparable ICE vehicles, despite being cheaper to fuel and maintain over the car's lifetime. Nevertheless, EV tag prices are expected to trend downward as more car manufacturers ramp up EV production and battery technology evolves.[7] In the short term, however, purchase cost is a significant barrier to adoption.
- **Range Anxiety.** Beyond cost, range anxiety is a top concern when it comes to EV ownership. Unlike gas stations, EV charging is still in its nascency and is not readily available to support rapid EV market growth. EV owners need access to reliable charging to be comfortable owning and using their EV for any duration trip. Currently, the most reliable form of charging for personal vehicles is overnight at-home charging. However, this leaves out many city dwellers who do not have dedicated parking spaces to charge EVs. In addition, home charging might not effectively address the distance challenges of

[3] Statista. Projected U.S. electric vehicle market share between 2030 and 2035. https://www.statista.com/statistics/744946/us-electric-vehicle-market-growth/
[4] The White House. "Fact Sheet: President Biden Announces Steps to Drive American Leadership Forward on Clean Cars and Trucks." August 5, 2021. https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/05/fact-sheet-president-biden-announces-steps-to-drive-american-leadership-forward-on-clean-cars-and-trucks/.
[5] The White House. "Fact Sheet: The Biden-Harris Electric Vehicle Charging Action Plan." December 13, 2021. https://www.whitehouse.gov/briefing-room/statements-releases/2021/12/13/fact-sheet-the-biden-harris-electric-vehicle-charging-action-plan/.
[6] Ibid.
[7] Natural Resources Defense Council. "Electric vs. Gas: It's Cheaper to Drive an EV." NRDC, accessed May 14, 2023. https://www.nrdc.org/stories/electric-vs-gas-it-cheaper-drive-ev.

rural dwellers or individuals with long commutes, both of which are associated with underserved populations.

Workplace charging is part of the solution to overcome EV adoption barriers. Though it doesn't address the high cost of purchasing an EV, workplace charging can alleviate range anxiety thereby encouraging EV adoption across diverse segments of population. Based on the 2016 Workplace Charging Challenge survey distributed by U.S. Department of Energy,[8] there are tangible benefits from workplace charging that extend beyond greenhouse gas (GHG) emissions. By providing reliable dedicated charging, employers can encourage employees who otherwise have no access to charging to make the switch to EVs. Workplace charging can nearly double an EV's daily commuting range, considerably alleviating range anxiety. Additionally, workplace charging allows employers to meet sustainability goals and demonstrate corporate and community leadership.

Workplace charging can further ameliorate unequitable distribution of charging infrastructure when sited in underrepresented and overburdened communities. Charging deserts, or neighborhoods with no EV chargers available, tend to mostly affect Black and Latino communities.[9] Workplace charging that becomes available to the public during nonbusiness hours could provide the only viable charging opportunity to neighborhood residents in the short term.

To support deployment of workplace charging, Cadeo conducted market research to better understand workplace charging market in the United States and its current adoption characteristics. An initial literature review provided the context for understanding the existing market conditions and the barriers to widespread adoption of workplace charging. We then completed interviews with EV subject matter experts and a plethora of stakeholders in the workplace charging space. This report presents our research results.

[8] U.S. Department of Energy. "2016 Workplace Charging Challenge Annual Progress Report." DOE Workplace Charging Challenge, January 2017. https://www.energy.gov/sites/prod/files/2017/01/f34/WPCC_2016%20Annual%20Progress%20Report.pdf

[9] The Washington Post. "'Charging Deserts' Could Slow the Transition to Electric Cars." The Washington Post, December 9, 2021. https://www.washingtonpost.com/business/2021/12/09/charging-deserts-evs/.

Section 2 Methodology

Cadeo's research included two phases: (1) a literature review of published reports, policies, and technical specifications of electric vehicle supply equipment (EVSE), and (2) workplace charging market stakeholder interviews to understand current barriers for workplace charging adoption.

2.1 Literature Review

Cadeo reviewed relevant and current plans, white papers, and studies related to transportation electrification and workplace charging. This included publications and case studies from the Alternative Fuels Data Center, as well as documents from other academic, governmental, and private institutions. Most current literature focuses on exploring the benefits of workplace charging and the challenges that can arise, such as managing charging behavior to recoup return on investment and maximizing benefits to employees.

2.2 Stakeholder Interviews

To gather stakeholder perspectives on workplace charging barriers, our team interviewed individuals across the EV workplace charging space including subject matter experts and employers who have implemented workplace charging.

Given the broad, high-level perspective of the interviews and nascency of workplace charging, Cadeo implemented a targeted interview strategy - working with Columbia-Willamette Clean Cities to identify and recruit individuals familiar with workplace charging that would provide a range of perspectives. We targeted a balanced, but limited, sample spread across several market actor groups, broken out across categories shown in Table 1: . We also attempted to identify and interview employers who had considered but not implemented workplace charging, but relevant candidates were hard to identify and recruit.

We interviewed 20 stakeholders in total, detailed in Table 1 below. Each interview covered a variety of topics, including process of developing workplace charging solutions, obstacles, and opportunities. Findings from literature review were discussed and validated against the perspective of stakeholders where relevant.

Table 1: Stakeholder Interview Sample Frame

Category	Rationale
Workplace charging experts	Gain insight into workplace charging best practices, market status, and drivers.

Employers who deployed workplace charging	Understand the motivation and hurdles faced by employers during the decision-making and installation processes.
Employers who did not deploy workplace charging	Understand motivation for workplace charging and identify factors that prevent employers from moving forward.
Network service providers	Collect information on workplace charging trends, types of technology installed, services offered by network providers, solutions pursued by employers, and types of companies pursuing workplace charging.
Workplace charging Installers	Collect information on type of chargers being installed, need for infrastructure upgrades, process pain points, and type of companies adopting workplace charging.
Utilities	Provide perspective on utility programs supporting workplace charging and experience working with employers.
Community-based organizations/Nongovernment Organizations	Gather information on barriers for workplace charging adoption in different communities, discuss equity aspects, learn of support provided to employers.

Section 3 Overview of Workplace Charging

To better understand the barriers for workplace charging, we needed to understand the current market context. Context for workplace charging includes the market penetration of workplace charging, the available charger types and benefits of each, the costs dominating adoption, and the process of adoption. This section will shed light on all these topics.

3.1 Market Saturation and Potential

According to research from the International Council on Clean Transportation (ICCT), workplace charging is currently accessible to approximately one-third of EV owners and is expected to grow to approximately 50% by 2030 as more people without access to at-home chargers purchase EVs. Based on PlugShare data and U.S. Department of Energy data, the ICCT estimates that the United States had 87,000 workplace chargers in 2020, making up approximately one-third of non-home chargers. That is expected to increase to 1,310,000 chargers by 2030, making up approximately 60% of non-workplace chargers.[10] Similarly, Wood Mackenzie's base-case scenario predicts that there will be between 375,000 and 680,000 workplace charging points in North America by 2025.[11]

Workplace chargers are expected to account for most of non-home chargers for two main reasons. First, employees park their cars for hours a day, providing ample opportunity for adequate charging time (the second-longest period of time after at-home charging). Second, most people work during the day, which is consistent with off-peak load and a higher share of renewables, resulting in reduced cost and carbon emissions.[12] For instance, Szinai et al. findings show how managed charging can save the California grid up to 10% (hundreds of millions) in operating costs annually and reduce curtailment of renewable energy to approximately 40% when compared to unmanaged charging.[13]

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[10] International Council on Clean Transportation. "Charging up America: Assessing the Growing Need for U.S. Charging Infrastructure Through 2030." ICCT, December 2019. https://theicct.org/publication/charging-up-america-assessing-the-growing-need-for-u-s-charging-infrastructure-through-2030/.

[11] Wood Mackenzie. "Europe and North America Will Have Over 1 Million Workplace EV Chargers by 2025." Wood Mackenzie, February 13, 2020. https://www.woodmac.com/press-releases/europe-and-north-america-will-have-over-1-million-workplace-ev-chargers-by-2025/.

[12] International Council on Clean Transportation. "Charging up America: Assessing the Growing Need for U.S. Charging Infrastructure Through 2030." ICCT, December 2019. https://theicct.org/publication/charging-up-america-assessing-the-growing-need-for-u-s-charging-infrastructure-through-2030/.

[13] Zia Wadud, David H. Greene, and Shahana Samiullah. "Electric Vehicles: Dynamics of Technology, Infrastructure, and Market Growth." Energy Policy 135 (2019): 110955. https://www.sciencedirect.com/science/article/pii/S030142151930638X?via%3Dihub

Studies have also shown that when EV owners have access to workplace charging, they use it. According to a study from Idaho National Lab, 30% of EV drivers with access to workplace charging charged only at work on most days, while 40% relied on workplace charging at least once a month to complete their daily commute. Even when customers had access to both workplace charging and at-home charging, they still completed between 32% and 39% of their total charging at work.[14] Additionally, other research has shown that workplace charging can increase EV adoption by a factor of six.[15]

3.2 Technical Overview

This section describes the different technologies available for workplace charging, their characteristics and limitations. Table 2 below summarizes the technical specifications of each charging type available in the market.

Table 2: Technical Specifications of Available Charging Types[16]

Parameters	Level 1	Level 2	Direct Current Fast Chargers
Power source (volts)	120	240 (res) – 208 (com)	400 – 1000
Power output (kilowatts)	1.4 – 1.9	6.6 – 19.2	50 – 350
Range per hour of charge (miles)	5	25 – 70	150 – 1,000
Equipment needed	Level 1 outlet / EVSE charging station	Level 2 outlet / EVSE charging station	EVSE charging station
Amps	15 – 20	30 – 80	300

3.2.1 Level 1 Chargers

Level 1 (L1) charging is the simplest charging solution. It provides charging through a common residential 120-volt (V) alternating current (AC) outlet and can provide around 5 miles of range per hour of charging, assuming a power output of 1.9 kilowatts.[17] Employees parking their car for 6 to 8 hours can replenish 30 to 40 miles of driving range, which is sufficient for the workday

[14] Idaho National Laboratory. "Plugged In: How Americans Charge Their Electric Vehicles." Department of Energy, Advanced Vehicle Testing Activity, October 2015. https://avt.inl.gov/sites/default/files/pdf/arra/PluggedInSummaryReport.pdf.
[15] Plug In America. "Workplace Charging." Accessed May 14, 2023. https://pluginamerica.org/why-go-plug-in/workplace-charging/.
[16] Literature shows variations of power output ranges for each charging level, especially for L2 chargers. The values used in this study are reference throughout.
[17] Alternative Fuels Data Center. "Electricity Infrastructure Analysis." U.S. Department of Energy, accessed May 14, 2023. https://afdc.energy.gov/fuels/electricity_infrastructure.html.

travel of 90% of commuters (90% of employees in the United States commute less than 35 miles a day).[18]

In addition to the outlet, L1 charging requires a cord set that is provided with the vehicle or by a permanently installed charging station. To ensure safety and abide best practices, employers should ensure the L1 charger is a National Electrical Manufacturers Association commercial-grade outlet connected to a dedicated circuit breaker.[19] Based on these minimal requirements, this charging option is available in nearly any parking spot with an outlet, making it an easily accessible charging solution. L1 charging is also the easiest option to implement because it doesn't require major electrical work, such as trenching or utility upgrades.

However, L1 charging does have serious limitations. The most significant limitation is the slower rate of charge, which results in limited range rate and congestion at chargers.[20] As such, L1 charging could be a near-term solution for smaller worksites, especially cost-constrained facilities, where employees can be certain of charger availability and do not rely on their vehicles throughout the workday.[21]

3.2.2 Level 2 Chargers

Level 2 (L2) chargers use 240V (in residential applications) or 208V (in commercial applications) electrical service when equipped with an appropriate plug connection to deliver AC power to EVs. L2 chargers are available as either single plug-in wall or pedestal units with multiple ports. These chargers can deliver varying degrees of power, ranging from 6.6 to 19.2 kilowatts,[22] resulting in faster charging than L1 for the same battery size. L2 charging adds 25 miles of range in an hour, assuming a power output of 6.6 kW.[23] In other words, an 100-mile battery could be replenished in 4-5 hours.[24] This also means L2 chargers provide higher benefits at workplaces as they can serve multiple vehicles throughout the day if cars are moved when charging is complete. Unlike L1 chargers, L2 charging in public or commercial locations requires the

[18] Alternative Fuels Data Center. "Level 1 Charging at the Workplace." U.S. Department of Energy, accessed May 14, 2023. https://afdc.energy.gov/files/u/publication/WPCC_L1ChargingAtTheWorkplace_0716.pdf.
[19] Alternative Fuels Data Center. "Electricity Charging at the Workplace." U.S. Department of Energy, accessed May 14, 2023. https://afdc.energy.gov/fuels/electricity_charging_workplace.html.
[20] Wu, Tianyang, and Guoyuan Wu. "Modeling the Spatio-Temporal Dynamics of Plug-In Electric Vehicle Charging Demand in the Workplace: A Microsimulation Approach." University of California, Davis, Institute of Transportation Studies, September 2018. https://itspubs.ucdavis.edu/publication_detail.php?id=3224.
[21] City of Boston. "Workplace Charging: How to Increase Workplace Charging in Boston." March 2020. https://www.boston.gov/sites/default/files/file/2020/03/1527-03%20-%20Workplace%20Charging.pdf.
[22] Lee, Y.-H. Henry, and Christopher R. Knittel. "Can Public Information Help Reduce Gasoline Consumption? Evidence from a Field Experiment." Harvard Kennedy School, November 2018. https://projects.iq.harvard.edu/files/energyconsortium/files/rwp18-026_lee_1.pdf.
[23] Alternative Fuels Data Center. "Electricity Infrastructure Analysis." U.S. Department of Energy, accessed May 14, 2023. https://afdc.energy.gov/fuels/electricity_infrastructure.html.
[24] ChargePoint, "Level Your EV Charging Knowledge," ChargePoint Blog, accessed May 14, 2023, https://www.chargepoint.com/blog/level-your-ev-charging-knowledge#:~:text=Level%202%20charging%20adds%20about,it%20won't%20attract%20them.

installation of electric vehicle service equipment (EVSE). This will require the installation on a dedicated circuit by a qualified electrician, which can involve additional wiring extensions and trenching. The installation of more than one L2 EVSE might trigger a utility infrastructure upgrade, as several L2 chargers operating simultaneously on the same circuit may place the existing transformer at risk of overloading.[25] Based on our literature review L2 chargers are the most prevalent EVSE found in workplaces.

3.2.3 Direct Current Fast Chargers

Direct current fast chargers (DCFC) are the fastest chargers available. They provide direct current (DC) power directly to the vehicle.[26] DCFC chargers have a power output of 50 to 350 kilowatts, use DC current of 400 to 1,000 volts, and can provide between 150 and 1,000 miles of range in 1 hour of charging.[27] Of the three charging options, DCFC often has the most complex installation process, requiring permits and discussions with the utility.[28] Fast charging also has more limited use cases in workplace charging when compared with L2 charging. For instance, DCFC could make sense in a workplace where charging events must happen very quickly, where employees must travel throughout the day in their personal vehicles or in the case of a large workforce with high EV charging needs. In a workplace with a typical 8-hour workday where employees are parked for extended periods of time the level of investment that DCFC requires might not be justifiable. Another limitation of DCFC is that they are not compatible with most plug-in hybrid vehicles.[29]

3.2.4 Associated Technologies

In addition to these three charging technologies, there are also associated technologies that enable charging in nontraditional work settings where grid connection may not be feasible.

3.2.4.1 Off-Grid Solar and Battery Powered

Non-grid-tied solar powered charging stations that rely on batteries provide charging infrastructure where grid connection is not feasible or unable to support EV load. These EV

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[25] Lee, Henry, Wei Peng, Kung-Ming Tiong, and Zhongying Wang, "Policy and Planning Considerations for EV Charging Infrastructure," Harvard Kennedy School, February 2018, https://projects.iq.harvard.edu/files/energyconsortium/files/rwp18-026_lee_1.pdf.
[26] ENERGY STAR, "Electric Vehicle Scoping Report," U.S. Environmental Protection Agency, March 2013, https://www.energystar.gov/sites/default/files/asset/document/Electric_Vehicle_Scoping_Report.pdf.
[27] Ryan Fisher and Nic Lutsey, "The Cost of Fast Charging: Estimating the Economic Impact of EV Fast Charging Stations," International Council on Clean Transportation, August 2019, https://theicct.org/sites/default/files/publications/ICCT_EV_Charging_Cost_20190813.pdf.
[28] ENERGY STAR, "Electric Vehicle Scoping Report," U.S. Environmental Protection Agency, March 2013, https://www.energystar.gov/sites/default/files/asset/document/Electric_Vehicle_Scoping_Report.pdf.
[29] U.S. Department of Transportation, "Charging Speeds," EV Toolkit, accessed May 14, 2023, https://www.transportation.gov/rural/ev/toolkit/ev-basics/charging-speeds#:~:text=Direct%20Current%20Fast%20Charging%20(DCFC)&text=DCFC%20equipment%20can%20charge%20a,not%20work%20with%20fast%20chargers.

chargers have the advantage of requiring no additional construction or electrical work so they can be placed anywhere with adequate parking space and sun. The leading product on the market is the EV ARC from Beam Global, which has a 4.3 kilowatts solar array and up to 44 kilowatt-hours of battery storage and can charge up to 265 driving miles in a day on a L2 charger.[30] Beam's largest customer is New York City, which has over 100 EV ARCs installed throughout the city. California recently signed a contract with Beam which is mandatory for all California state departments and is also available for use by local government agencies and government entities in other states. The contract allows to purchase Beam products at the California negotiated price, avoiding any lengthy procurement or technology review process.[31]

3.3 Ownership and Business Models

There are two common EVSE ownership models when it comes to workplace charging:[32,33]

1 | Businesses can purchase chargers outright and pay for the installation, which gives them the most control of the revenue and management of the charging stations. In this case, worksites can provide in-house maintenance and operations of EV chargers or outsource this service via a contract for maintenance and operations. Equipment warranty often lasts between 1 and 3 years, covering the repair and/or replacement of any part if needed.

2 | Businesses can lease chargers from EVSE providers instead, which could reduce the upfront investment costs, but according to some of our interviewees, this is not necessarily a cheaper option in the long run. The biggest appeal to leasing is the ease of maintenance and management of charging equipment as these providers often offer turnkey services.

A third option was identified through interview with utilities offering workplace charging programs, where utilities own, install, and maintain all charging equipment while the employer operates chargers. This option shifts the burden of installation and operations and maintenance

[30] Paul Fosse, "Beam Global's Off-Grid EV Chargers Now in 100 Municipalities," CleanTechnica, November 30, 2021, https://cleantechnica.com/2021/11/30/beam-globals-off-grid-ev-chargers-now-in-100-municipalities/.

[31] "Beam Global Awarded New State of California Contract for Rapidly Deployed, Sustainable EV Charging Infrastructure Products," The EV Report, November 17, 2021, https://theevreport.com/beam-global-awarded-new-state-of-california-contract-for-rapidly-deployed-sustainable-ev-charging-infrastructure-products.

[32] Atlas Public Policy, "Public EV Charging Business Models for Retail Site Hosts," April 2020, https://atlaspolicy.com/wp-content/uploads/2020/04/Public-EV-Charging-Business-Models-for-Retail-Site-Hosts.pdf.

[33] Brian Monbouquette, "Electric Vehicle Charging Stations: Buy or Lease?," Wolf & Company, August 12, 2021, https://www.wolfandco.com/resources/insights/electric-vehicle-charging-stations-buy-or-lease/.

away from the employer but comes with limitations in terms of quantity and types of chargers that can be installed.

Regarding charging business model, owners rely in two main approaches:[34]

1 | **Free charging.** Employers can offer charging for free as a benefit for employees.
2 | **Paid charging.** Employees and others will pay to charge their cars. This model can be set up in different ways, which could entail a flat rate per hour or day or a payment based on usage.

Additional approaches include a combination of the two, where a business establishes certain time slots for free charging (especially if renewable energy is produced on site) and certain periods for paid charging. Chargers could be open to the public outside of working hours to collect extra revenue, which could be combined with employee free access or access at a discount rate. There are many possibilities depending on the company's goal (offer free charging, recover investment, or make a profit) and financial needs.

3.4 Network Connectivity

One important consideration is whether to install chargers with network connectivity. Networked charging stations connect to an online EVSE network and have access to management tools. For this to happen, the EVSE needs to have integrated technology that allows connectivity to the network.[35] An employer can choose a bundle of hardware and software or buy the chargers (with integrated technology) and add the software piece later. The network provider will manage and administer the charging stations for a monthly charge.[36]

Perks of networked charging stations include: [37]

- *Data accessibility*. Network charging stations can be managed remotely, with precise data on station usage available in real time. In fact, they will store the station's usage data, including the number of charges per day/time, time-of-use, electricity consumed per charge, and more.

[34] EVBox. "The Workplace Charging Business Model: What Works and What Doesn't." EVBox Blog. https://blog.evbox.com/workplace-ev-charging-business-model.
[35] Blink Charging. "Understanding Networked vs Non-Networked Chargers for Host Locations." Blink Charging Blog. https://blinkcharging.com/understanding-networked-vs-non-networked-chargers-for-host-locations/?locale=en.
[36] Joint Venture Silicon Valley. "Best Practices for Workplace Charging." Joint Venture Silicon Valley. https://jointventure.org/images/stories/pdf/Best_Practices_for_Workplace_Charging.sflb.pdf.
[37] Blink Charging. "Understanding Networked vs Non-Networked Chargers for Host Locations." Blink Charging Blog. https://blinkcharging.com/understanding-networked-vs-non-networked-chargers-for-host-locations/?locale=en.

- *Potential revenue generation*. Owners of networked charging stations can charge a fee to users for the electricity consumed.
- *Easy maintenance*. Issues can be troubleshooted remotely, reducing the downtime of the charging station.
- *Control of operating hours, charging time, and access*. This feature can be important for non-employee use and restricting usage.
- *Remotely stop and start charging*. Charging can be optimize to reduce GHG emissions, to charge when the electricity prices are cheaper and to participate in demand response programs.

On the other hand, nonnetworked chargers are stand-alone units that cannot be accessed remotely.[38] Therefore, maintenance requires a technician on site to troubleshoot and fix the problem, which can reduce the availability of the chargers and thus employee satisfaction. Another disadvantage is the lack of internet connection, which reduces the data outputs that can be gathered in this type of equipment. The data in this case will be limited to total electricity consumed during a specific period and no real time data will be available. Lastly, this type of charger is limited to flat fees only and cannot set up a payment structure based on usage, which limits the business model options of the employer.[39]

Different factors determine what is best for a given workplace. For instance, a few nonnetworked L2 stations might be sufficient for a small business with few employees driving electric cars, which would reduce upfront costs for the company. Networked charging infrastructure might be preferred in large workplaces where charging a fee and managing charging behavior are important considerations for deploying charging infrastructure and maintaining employee satisfaction.

3.5 Costs

This section describes the costs associated with different technologies available for workplace charging. This includes equipment, installation, utility upgrades, insurance, warranty, and maintenance costs. Table 3 below summarizes the costs associated with each charging type available in the market.

Table 3: Costs for Available Charging Types

Costs	Level 1	Level 2	DCFC
Equipment[1]	$300–$831	$1,182	$28,401–$140,000
Network	n/a	$1,945	included
Installation[1,2]	$200–$3000	$4,145	$45,506–$65,984

[38] Ibid.
[39] Ibid.

Labor	n/a	$2,471	$19,200–$27,840
Materials	n/a	$1,235	$26,000–$37,700
Permit	n/a	$283	$200–$290
Taxes	n/a	$156	$106–$154
Maintenance/Warranty	n/a	$400/year	$300–$3,000/year
TOTAL COST (excl. annual costs)	$500–$3831	$7,272	$73,907–$205,984

Source: Modified from ICCT research. ICCT research did not provide installation costs for Level 1 in commercial sectors, only residential without disaggregation between hardware and installation and the components of the latter. Therefore, a unique value installation cost for L1 is given based on case studies gathered by the Alternative Fuels Data Center. https://afdc.energy.gov/files/u/publication/WPCC_L1ChargingAtTheWorkplace_0716.pdf Maintenance and warranty costs were obtained from https://projects.iq.harvard.edu/files/energyconsortium/files/rwp18-026_lee_1.pdf.

[1] Equipment and Installation costs shown for one charger per pedestal (as well as outlet upgrade for L1). The cost per charger reduces as more charges are installed per pedestal (for equipment) and on site (for installation costs).

[2] Installation costs shown for L2 correspond to California; outside California, the installation cost decreases by about $1,200 with lower labor, permitting, and tax costs. Nevertheless, depending on the current infrastructure, number of chargers and power output of the chargers being installed, labor and materials costs can be significantly higher.

3.5.1 Equipment Costs

For the commercial of public charging, the cost of an L1 outlet is insignificant but an L1 charger with pedestal costs about $831. The more chargers the pedestal has, the lower the price per charger. In the case of L2, the cost for a charger with pedestal is $1,182 with no network. An L2 charger with network (with communication or collection of payment features) will double the price of the equipment, adding up to $3,127 for one charger. DCFC chargers are all networked and the cost for a 50-kilowatt charger is about $28,401; $75,000 for a 150-kilowattcharger; and $140,000 for a 350-kilwatt charger.[40]

3.5.2 Installation Costs

Comprising labor, taxes, permitting, and materials, installation costs can vary between cities. Research conducted by ICCT across several metropolitan areas concluded that workplace charging costs are about 43% hardware and 57% installation cost. Labor takes the largest share of installation costs, accounting for 53% to 60% of installation costs, followed by materials costs at 30% to 39% and permit and taxes, which make up less than 12%.[41] Specific costs for each charger type are described Table 3. In this study, the authors included utility upgrades under "material costs" based on upgrades incurred in Southern California. They also noted the fact that utilities might pay a certain portion of the upgrades needed by the site. There are mainly two types of service upgrades:

[40] International Council on Clean Transportation. "Electric Vehicle Charging Costs: Pricing, Demand Charges, and Business Models." The ICCT. https://theicct.org/sites/default/files/publications/ICCT_EV_Charging_Cost_20190813.pdf

[41] Ibid.

1 | Panel upgrades, which include a new panel, an additional panel, or reconfiguration of the panel to add breakers.
2 | Service upgrades (i.e., replace service wires feeding the site or distribution lines upgrades or transformer replacements).

While the panel upgrade (in Southern California) can fall within the range of $60 to a few thousand dollars ($2,000), the service upgrade can range from $200 to $33,000, with an average of approximately $2,000 for service line upgrades and $7,000 for distribution line upgrades.[42]

3.5.3 Electricity Costs

The costs of electricity will vary significantly depending on the geographical location and the rate under which the employer operates (residential or commercial). Often, commercial rates are lower in a per-kWh cost than residential rates, but commercial rates include demand charges that can significantly increase the total cost of electricity if EV charging if left unmanaged. Demand charges are determined by the highest demand in a 15-minute period within a month and are set at a dollar per kW basis.[43] The larger the power output of the charger, the higher the demand charges will be. Demand charges can be EV-specific, which would require a separate meter for EV charging infrastructure, or can be seasonal, meaning that if the utility hits peak demand in the summer, a higher rate would apply during summer months.

Some utilities offer EV specific time varying rates to encourage EV charging outside periods of peak demand. Xcel Energy in Wisconsin and National Grid in New York both offer EV time-of-use rates.[44,45] Xcel Energy in Colorado offers EV critical peak pricing for commercial customers. [46] By charging higher rates during critical peak pricing events, the utility encourages customers to charge EVs outside peak events periods, giving customers the opportunity to save money while supporting the grid.

Overall, electricity costs will vary based on EVSE types, charger use, charging behavior, electric rates, and management.

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[42] UCLA Luskin Center for Innovation. "Overcoming Barriers to EV Charging in Multi-unit Dwellings: A Westside Cities Case Study." UCLA Luskin Center for Innovation. https://innovation.luskin.ucla.edu/sites/default/files/Overcoming%20Barriers%20to%20EV%20Charging%20in%20Multi-unit%20Dwellings%20-%20A%20Westside%20Cities%20Case%20Study.pdf
[43] Lee, Jisung. "Is There an EV Charging Infrastructure Problem? And if so, Who Faces It?" Harvard Kennedy School. https://projects.iq.harvard.edu/files/energyconsortium/files/rwp18-026_lee_1.pdf.
[44] Xcel Energy. "EV Accelerate at Home." Xcel Energy. https://ev.xcelenergy.com/ev-accelerate-at-home-wi.
[45] National Grid. "Time of Use." National Grid. https://www.nationalgridus.com/Time-of-Use.
[46] Xcel Energy. "EV Critical Peak Pricing." Xcel Energy. https://co.my.xcelenergy.com/s/business/rate-plans/ev-critical-peak-pricing.

3.5.4 Additional Costs

Warranties for EV charging infrastructure typically cover between 1 and 3 years.[47] After the warranty period concludes, the owner is responsible for charger repairs, which can be costly. Employers deploying charging infrastructure can decide whether they will have in-house expertise to maintain the chargers or outsource this service. Maintenance and warranty costs can vary significantly, especially for chargers with higher output. While maintenance and warranty cost for L2 chargers can be around $400 per year, this number varies greatly for DCFC, ranging from $300 to $3,000 annually, with an average of $2,500 per year.[48]

3.6 Equity Considerations in Workplace Charging

As discussed previously and supported by recent research by the National Renewable Energy Laboratory, low-income individuals, renters, and individuals living in multifamily buildings have less access to dedicated home chargers.[49] Additionally, public EV chargers are currently concentrated in higher-income areas, following early EV sales.[50] This limits both the visibility and availability of the charging infrastructure necessary to make EV ownership more accessible. EV price notwithstanding, without reliable chargers it's difficult to imagine an equitable adoption of EVs. Therefore, targeted and low-cost workplace charging could be an important solution to addressing equity issues related to charger access by providing an opportunity for those without home charging infrastructure to charge during the day.

Workplace charging increases the likelihood of employees purchasing an EV by six times.[51] However, just as early adopters of EVs tend to be from higher-income households, early adopters of workplace charging tend to be high-income employees at tech companies, hospitals, universities, and government workplaces.[52] To ensure that workplace charging is

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[47] EV Safe Charge. "EV Safe Charge Warranty." Accessed May 14, 2023. https://evsafecharge.com/ev-safe-charge-warranty/#:~:text=The%20warranty%20on%20electric%20vehicle,years%20depending%20on%20the%20brand.

[48] Lee, Henry, Grant Lovellette, and John D. Graham. "Electric vehicle charging infrastructure deployment guidelines for municipalities." Harvard Kennedy School, July 2018. https://projects.iq.harvard.edu/files/energyconsortium/files/rwp18-026_lee_1.pdf.

[49] National Renewable Energy Laboratory. "Electric Vehicle Charging Infrastructure Analysis: Site Selection and Resiliency Planning." NREL Technical Report, 2021. https://www.nrel.gov/docs/fy22osti/81065.pdf.

[50] Kennedy, Ryan, Paul Alstone, and Debbie Brackeen. "Building the electric-vehicle-charging infrastructure America needs." McKinsey & Company, September 2020. https://www.mckinsey.com/industries/public-and-social-sector/our-insights/building-the-electric-vehicle-charging-infrastructure-america-needs.

[51] National Renewable Energy Laboratory. "U.S. Department of Energy Workplace Charging Challenge: Mid-Program Review." NREL Technical Report, 2016. https://afdc.energy.gov/files/u/publication/wpc_2016_progress_report.pdf.

[52] Forth. "Centering Equity in EV Charging: A Field Scan of Equity Needs, Best Practices, and Emerging Solutions." Forth Mobility, 2021. https://forthmobility.org/storage/app/media/Reports/Centering%20Equity%20in%20Charging%20Report%20EVS.pdf.

accessible to lower-income groups, workplace charging programs will need to consider how they can better serve low-wage workers. This may include proactive outreach to employers that depend on low-wage workers and subsidies, such as in the retail and hospitality industries.[53]

The ICCT estimates that one-sixth of EV owners were low income in 2020 and predicts that their share will increase to a quarter of new EV owners by 2030, with many relying on workplace charging access.[54] In a different study on quantifying the economic equity implications of electric vehicle adoption, ICCT identified an especially great potential for EV ownership across low-income groups in the used EV market. Based on their analysis, in the 2025 to 2030 period, used EVs will see reduced costs and achieve cost parity for low-income households. [55] Used EVs, however, have lower battery ranges, amplifying range anxiety concerns. Workplace charging could potentially support adoption of used EVs to better equity outcomes over time.

3.7 Planning for Workplace Charging

Implementing workplace charging requires many decisions. Businesses must evaluate the number, level (L1, L2, DCFC), and type (networked or stand-alone) of chargers they want. They must also budget appropriately, evaluate incentives, and assess their facility's electrical service for potential needed upgrades. They must also determine their charging policy and who will oversee charging management. Based on our interviews, the process can take anywhere from six months to more than two years. Other studies have confirmed that it can take up to 24 months to get workplace charging up and running. [56]

3.7.1 Typical Stakeholders

Planning for workplace charging can be a complex process involving multiple external and internal participants. Externally, the employer will need to interact with suppliers of EVSE, installers of EVSE, or turnkey installer/operators, network providers, utilities, permitting departments, and building owners in the case that parking space is leased. Internally, bringing employees, upper management, and facilities staff into the planning process is essential for

[53] Ibid
[54] International Council on Clean Transportation. "Charging up America: Assessing the growing need for U.S. charging infrastructure through 2030." The ICCT, 2017. https://theicct.org/publication/charging-up-america-assessing-the-growing-need-for-u-s-charging-infrastructure-through-2030/.
[55] International Council on Clean Transportation. "Equity in the EV revolution: Charging infrastructure deployment to benefit low-income communities." The ICCT, February 2021. https://theicct.org/sites/default/files/publications/EV-equity-feb2021.pdf.
[56] Kennedy, Ryan, Paul Alstone, and Debbie Brackeen. "Building the electric-vehicle-charging infrastructure America needs." McKinsey & Company, September 2020. https://www.mckinsey.com/industries/public-and-social-sector/our-insights/building-the-electric-vehicle-charging-infrastructure-america-needs.

ensuring a successful workplace charging setup.[57] Technical, financial, and organizational aspects of the project should be carefully evaluated prior to committing to a workplace charging plan.

3.7.1.1 Employee Education and Engagement

The City of Boston *How-To Guide: Starting an EV workplace charging program* points out that the first step in the planning stage is to gauge future demand and estimate employee needs, as this will determine the extent and type of charging appropriate for the workplace.[58] They recommend starting by conducting employee engagement surveys and workshops. Surveys are designed to collect comprehensive information, including:

- Workplace commuting habits
- Types of vehicles driven by employees (ICE, EV, or hybrid) and their make
- Length of commute
- Typical travel patterns during workday
- Future car purchasing plans
- Ability to install an at-home charger
- Thoughts on installing a charger in the workplace
- Interest to participate in an employee EV task force or becoming an EV ambassador

This stage of the process also presents an opportunity to educate employees about the benefits of EVs (i.e., environmental, lower maintenance cost over the lifetime of the vehicle, etc.) and how workplace charging could support the decision to make the switch if employees currently do not own EVs. The Clean Cities Coalition Network recommends the use of presentation or webinar on EVs and workplace charging and provides materials to support employers to develop these resources on their website.[59]

Engaging employees at the outset of the planning process is important for a few reasons. For one, they will be the primary beneficiary of workplace charging and solutions must meet their needs. Results of our interviews with subject matter experts indicate that workplace charging projects are often initiated at the request of employees. Feedback and early input means that businesses have a better understanding of the overall demand for charging and provides an opportunity to educate employees about EV ownership and how workplace charging can support it.[60]

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[57] Alternative Fuels Data Center. "Electric Vehicle Charging for the Workplace." U.S. Department of Energy. Accessed May 14, 2023. https://afdc.energy.gov/fuels/electricity_charging_workplace.html.
[58] City of Boston. "1527-03 - Workplace Charging." March 2020. https://www.boston.gov/sites/default/files/file/2020/03/1527-03%20-%20Workplace%20Charging.pdf.
[59] Clean Cities. "Workplace Charging." Accessed May 14, 2023. https://cleancities.energy.gov/technical-assistance/workplace-charging/
[60] City of Boston. "Workplace Charging." March 2020. https://www.boston.gov/sites/default/files/file/2020/03/1527-03%20-%20Workplace%20Charging.pdf.

3.7.1.2 Utility Outreach

Additionally, interview results show that contacting local utility to discuss workplace charging often happens in tandem or closely follows employee engagement. Utilities ultimately help make the assessment of the charging solution in terms of technical feasibility (i.e., additional load that can go on the grid, infrastructure upgrades). Having this conversation early ensures that the charging plan is realistic and avoids potentially costly and time-consuming changes later in the process.[61]

3.7.1.3 Contractor Outreach

Early engagement with a contractor will help determine the needs of the facility. Together with the utility, the contractor can discern what type of upgrades are required, if any. Additionally, the contractor can assist with permitting requirements, should they apply.[62]

3.7.2 Fee Charging or Free Charging

A big decision when planning for workplace charging is whether to charge employees a fee for charging privileges. Free charging provides a huge incentive, especially for those EV owners who lack dedicated at-home charging. In fact, the majority (75%) of partners in the Workplace Charging Challenge survey indicated that they provide free EV charging—although the percentage of employers who charge their employees a fee increased from 20% to 25% in 2016.[63] However, there are drawbacks to no-fee workplace charging. For example, employees with at-home charging might choose to charge exclusively at work, reducing charging opportunities for EV owners with no access to at-home charging. In this case, charging a fee that is a little over prevailing market rate for electricity will discourage the incentive to abuse the privilege to charge exclusively at work if at-home charging is available. Drivers with no access to home charging can still take advantage of at-work charging at reasonable prices. Moreover, charging a fee for EVSE usage can also help offset the installation, upfront costs, and maintenance costs.[64,65]

3.7.3 Financing

Based on our literature review and stakeholder interviews, there is not a typical financing mechanism for workplace charging. Some projects are funded through internal capital budgets

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[61] U.S. Department of Transportation. "EV Infrastructure Planning Project Planning Checklist." Accessed May 14, 2023. https://www.transportation.gov/rural/ev/toolkit/ev-infrastructure-planning/project-planning-checklist.
[62] Plug-in NC. "Updated Workplace Charging Guide." Accessed May 14, 2023. https://pluginnc.com/wp-content/uploads/2016/06/Updated-Workplace-Charging-Workplace-Guide.pdf.
[63] U.S. Department of Energy. "2016 Workplace Charging Challenge Annual Progress Report." 2017. https://www.energy.gov/sites/prod/files/2017/01/f34/WPCC_2016%20Annual%20Progress%20Report.pdf.
[64] City of Boston. "1527-03 - Workplace Charging." March 2020. https://www.boston.gov/sites/default/files/file/2020/03/1527-03%20-%20Workplace%20Charging.pdf.
[65] Plug-in NC. "Updated Workplace Charging Guide." Accessed May 14, 2023. https://pluginnc.com/wp-content/uploads/2016/06/Updated-Workplace-Charging-Workplace-Guide.pdf.

and a blend of other funding, such as state, federal, and utility incentives, while other projects are financed entirely by capital budgets.

Section 4 Workplace Charging Enablers and Market Opportunities

Utilities, cities, states, and the federal government have all increased their efforts to promote EV charging infrastructure as a means of supporting widespread transportation electrification. While interviewees signaled the existence of a breadth of incentives for EVSEs, they highlighted that very few target workplace charging specifically. Nevertheless, incentives targeting transport electrification will have an impact on workplace charging. This section provides an overview of the type of drivers and incentives available in the current market.

4.1 Federal Enablers

4.1.1 Zero-Emission Vehicle Goal

The Biden Administration has set a goal that half the vehicles sold in United States will be zero-emissions by 2030.[66] To lead by example, President Biden signed an Executive Order requiring all new federal vehicles to be zero-emission vehicles by 2035, with light duty vehicles acquisitions achieving this target by 2027.[67]

4.1.2 The Infrastructure Investment and Jobs Act

IIJA sets aside about $7.5 billion for EV charging infrastructure. The bill allocates $5 billion to carry out the National Electric Vehicle Infrastructure Formula Program, which provides funding to states that deploy EV infrastructure under an interconnected network to facilitate data collection, access, and reliability. Additionally, the IIJA provides $2.5 billion in grants for charging and fueling infrastructure, aiming to deploy electric, hydrogen, propane, and natural gas fueling infrastructure.[68] Half of this funding is directed toward community grants, with priority given to projects in rural areas, low- and moderate-income neighborhoods, and communities with less private parking space than households.[69] According to the IIJA, these funds are directed at promoting publicly accessible charging infrastructure. Companies deploying workplace charging

[66] The White House. "Executive Order on Strengthening American Leadership in Clean Cars and Trucks." August 5, 2021. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/08/05/executive-order-on-strengthening-american-leadership-in-clean-cars-and-trucks/.
[67] The White House. "Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability." December 8, 2021. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability/.
[68] United States Congress. Consolidated Appropriations Act, 2021. Public Law 116-260, 116th Cong., 2nd sess. (December 27, 2020).
[69] Ibid

could benefit from these funds if the charging infrastructure is located in publicly accessible parking facilities.

4.1.3 Inflation Reduction Act

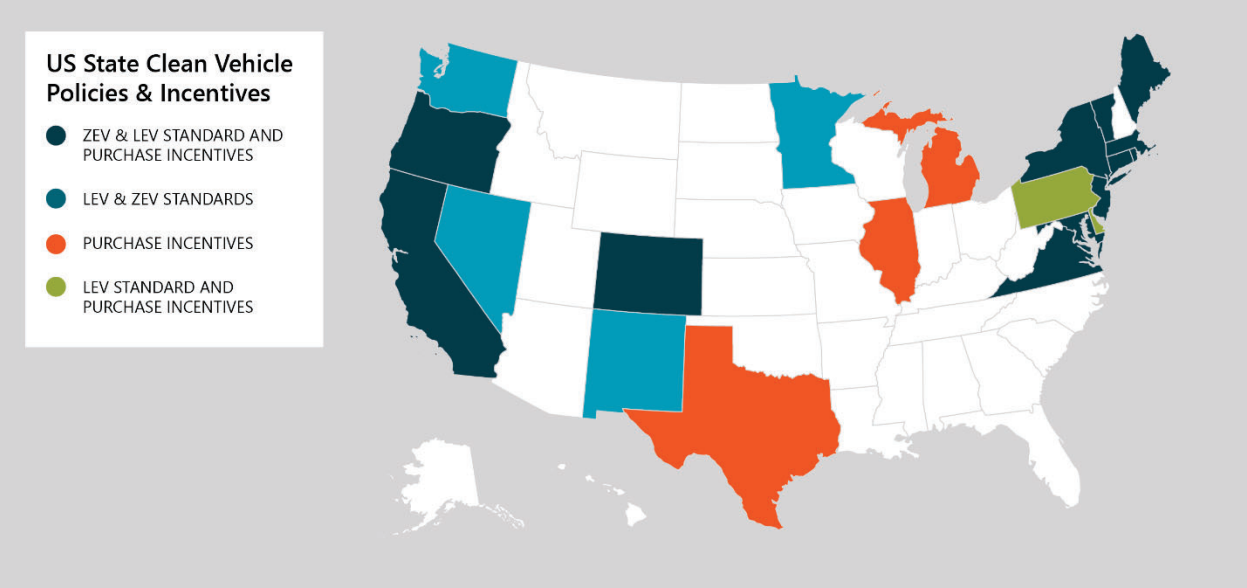
The IRA offers two main funding sources in the transportation electrification sector: one directed toward the purchase of EVs and the other oriented to charging infrastructure.[70] For the former, the IRA offers tax credits for the purchase of new and used EVs, which can increase the need for workplace charging if low- to moderate-income consumers and renters who lack access to at-home chargers start taking advantage of these tax credits. The other funding is based on the Neighborhood Access and Equity Grant Program, which offers access to charging infrastructure for underserved communities. This program was implemented through the extension of the Alternative-Fuel Vehicle Refueling Property Credit, which originally expired on December 31, 2021. For business properties, the credit is 6%, with a ceiling of $100,000. Business properties meeting prevailing wage and registered apprenticeship requirements may be eligible for a credit amount of 30%.[71] However, starting in 2023, qualifying property is limited to low-income or nonurban census tracts.[72]

4.2 State Enablers

Figure 1 shows states that have adopted clean vehicles policies and/or offer EV purchase incentives.

[70] United States Congress. American Rescue Plan Act of 2021. Public Law 117-2, 117th Cong., 1st sess. (March 11, 2021).
[71] Yacobucci, Brent D. "The Biden Administration's Proposed Advanced Technology Vehicle Purchase Incentives: Overview and Analysis." Congressional Research Service, April 19, 2021. https://crsreports.congress.gov/product/pdf/IN/IN12003.
[72] A population census tract where the poverty rate is at least 20%; or Metropolitan and non-metropolitan area census tract where the median family income is less than 80% of the state medium family income level. https://crsreports.congress.gov/product/pdf/IN/IN12003

Figure 1: State Clean Vehicle Policies and Incentives



Source: Modified from https://www.c2es.org/document/us-state-clean-vehicle-policies-and-incentives/

4.2.1 Zero-Emission Vehicle Standards

As of August 2022, 16 states have adopted California's zero-emissions vehicle standards,[73] which require car manufacturers to produce and sell a given number of zero-emission vehicles per year based on a percentage of total sales in the state.[74]

In 2022, California, Vermont, Oregon, Washington, and New York all adopted the Advanced Clean Cars II Program, and other states have started rulemaking or suggested the interest in doing so.[75] This program requires that all new passenger cars, trucks, and sport utility vehicles sold in those states be zero-emission by 2035, starting with 35% in 2026 models and gradually increasing to reach the 100% target in 2035.[76] With states adopting stringent standards on zero-emission vehicles, additional charging infrastructure, including workplace charging, will be needed to power transportation.

[73] Center for Climate and Energy Solutions. "U.S. State Clean Vehicle Policies and Incentives." Accessed May 14, 2023. https://www.c2es.org/document/us-state-clean-vehicle-policies-and-incentives/.
[74] Clean Energy Transition. "Zero Emission Vehicle Mandates Accelerate EVs." Accessed May 14, 2023. https://www.cleanenergytransition.org/post/zero-emission-vehicle-mandates-accelerate-evs.
[75] National Caucus of Environmental Legislators. "What California's New Advanced Clean Car Rule Means for Other States." Accessed May 14, 2023. https://www.ncelenviro.org/articles/what-californias-new-advanced-clean-car-rule-means-for-other-states/.
[76] California Air Resources Board. "Advanced Clean Cars II." Accessed May 14, 2023. https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii.

4.2.2 State Incentives

The range of incentives for the deployment of alternative-fuel vehicles, including EVs, and charging infrastructure varies widely across states. The National Conference of State Legislatures describes different types of existing incentives to promote adoption of EV and deployment of EV infrastructure:[77]

- Legislative incentives, which include:
    - High occupancy vehicle lane exemptions
    - Vehicle inspection or emissions test exemptions
    - Parking incentives
- Financial incentives, which account for the following:
    - Vehicle and EVSE rebates
    - Vehicle and EVSE tax credits
    - Registration fee reduction
    - Grant programs

A growing number of states have also awarded money for transportation electrification through the Volkswagen Settlement, with 40% of funds dedicated to EV charging across all vehicle types.[78] States have discretion when it comes to spending these funds, but there could be an opportunity for workplace charging incentives.

While there are states across the country offering incentives for electric vehicles, few focus specifically on funding workplace charging. As more federal funds reach states, this may change. Cadeo reviewed incentive data from Enel and the U.S. Department of Energy Alternative Fuels Data Center and found that there are currently three states that provide incentives or rebates for workplace charging. This includes Delaware, New York, and Pennsylvania.[79,80] As more states continue to adopt zero-emission vehicle mandates, we expect that state funding for charging infrastructure, including workplace chargers, will continue to increase.

[77] National Conference of State Legislatures. "State Policies Promoting Hybrid and Electric Vehicles." Accessed May 14, 2023. https://www.ncsl.org/energy/state-policies-promoting-hybrid-and-electric-vehicles.
[78] Drive Electric Northern Colorado. "Colorado Legislature Unanimously Passes Bills to Accelerate EV Adoption." Accessed May 14, 2023. https://us13.campaign-archive.com/?u=26abb7b630884ef648822201c&id=f452ed1321.
[79] "State Laws and Incentives." Alternative Fuels Data Center, U.S. Department of Energy, accessed May 14, 2023, https://afdc.energy.gov/laws/state. Note – there were 4 utilities offering incentives of $250 per charger that were excluded from this count.
[80] "Federal and State Electric Vehicle Incentives." Enel X, accessed May 14, 2023, https://evcharging.enelx.com/resources/federal-and-state-electric-vehicle-incentives.

4.2.3 Building Codes

State building codes are also changing to encourage EVSE installations. While charger requirements for multifamily buildings are more common, some states are adopting minimum requirements for commercial buildings as well. For example:

- Oregon requires that all new commercial and mixed-use buildings with more than five units have electric car charging in at least 20% of parking spaces (House Bill 2180).[81]
- Massachusetts requires one EV-ready parking space for any new commercial construction with more than 15 parking spaces.[82]

In other states, cities are taking the lead (see Section 4.3 below).

4.2.4 Employee Commute Options

In 1990, the Clean Air Act mandated the implementation of programs to reduce air pollution. Following this Act, the Environmental Protection Agency established the Employee Commute Option, which required states and employers to work together to reduce pollution from employees' miles traveled while commuting to work.[83] Many states have developed the Employee Commute Option throughout the years, focusing on public transit, biking, walking, and carpooling. However, with the deployment of EVs in the past year, including EV commuting in this program while offering workplace charging can help further reduce emissions. For instance, in Southern California, workplaces with over 250 employees are required to meet designated emission reduction targets by the Southern California Air Quality Management District (SCAQMD). SCAQMD Rule 2202 provides a menu of emission reduction strategies to meet these targets, including installing charging stations to mitigate vehicle emissions from employee vehicles and any company fleets.[84]

4.3 City Enablers

4.3.1 Building Codes

Cities across the United States are adopting commercial building codes that require EV-ready parking. The Southwest Energy Efficiency Project has compiled a list of all EV parking

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[81] "Building Codes Division Releases Guidance on Electric Vehicle Charging in Condos and Apartments." State of Oregon: Department of Consumer and Business Services, accessed May 14, 2023, https://www.oregon.gov/bcd/laws-rules/Documents/20220701-hb2180-evcharging-pr.pdf.
[82] "Massachusetts State Building Code, 780 CMR." Mass.gov, accessed May 14, 2023, https://www.mass.gov/massachusetts-state-building-code-780-cmr.
[83] Zachary L. Olmsted, "Parking Space for Change: Resolving Electric Vehicle Charging Station Conflicts in Condominiums and Homeowners Associations." William & Mary Environmental Law and Policy Review 37, no. 2 (2013): 509-542, https://scholarship.law.wm.edu/cgi/viewcontent.cgi?article=1355&context=wmelpr.
[84] J.R. DeShazo, Nicholas J. Chaset, and Sanderling D. Goble, "Getting Connected: A Guide to EV Charging at Work." UCLA Luskin Center for Innovation, March 2019, https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/EV_Charging_at_Work.pdf.

requirements from different cities across the nation. The list includes Washington D.C. and 44 cities or counties in 12 states: Colorado, Georgia, California, Illinois, Arizona, Hawaii, Wisconsin, Massachusetts, New York, Washington, Utah, and Missouri.[85]

Cities are leading the charge on EV infrastructure. Denver recently announced that, by 2030, 30% of all registered vehicles should be electric.[86] To support this, Denver implemented one of the most ambitious EV infrastructure requirements: 100% of all new parking spaces in multiunit dwellings must include EV infrastructure, distributed as follows: 80% EV capable,[87] 15% EV ready, and 5% EV installed. For the commercial sector, the requirement is 10% EV capable, 10% EV ready and 5% EV installed.[88] Other cities like Palo Alto and Atlanta have large requirements for EV-capable parking spaces in the commercial sector: 20% of parking spaces. While Chicago and Honolulu have at least 20% requirement for EV ready in 30+ and 12+ parking areas.[89]

4.4 Utility Enablers

Utilities across the nation have been investing heavily in the deployment of EVs and charging infrastructure. Utility-offered incentives typically include time-of-use rates, rebates, grants, loans, and support services for plug-in electric vehicles and EVSE.[90] In 2020, $760 million in EV utility investment was approved by state regulators, mainly for EVSE utility assets and make-ready programs.[91] Policy and regulation supporting zero-emission vehicle deployment, EVSE infrastructure, or GHG emissions reductions have also increased utility programmatic funding for developing EV charging infrastructure, with some programs designed specifically for workplace charging. Based on incentive data from Enel there are currently 14 utilities in 12 states offering

[85] "Electric Vehicle Charging Station Codes and Standards." Alternative Fuels Data Center, U.S. Department of Energy, accessed May 14, 2023, https://docs.google.com/spreadsheets/d/1lgppSv7HvU4ExH8TJarE23o8-Y-q9oLV0TaBPBMKaiE/edit#gid=27292754.

[86] "Denver's Electric Vehicle and Charging Infrastructure Action Plan." City and County of Denver, accessed May 14, 2023, https://denvergov.org/files/assets/public/climate-action/documents/renewable-energy/denvervehicleelectrificationactionplan.pdf.

[87] "EV-Capable, EV-Ready, and EV-Installed: How to Future-Proof Your Parking Lot." Charged Future, accessed May 14, 2023, https://www.chargedfuture.com/ev-capable-ev-ready-and-ev-installed/. EV-capable includes sufficient panel capacity with dedicated branch circuit and a continuous raceway from the panel to the parking spot.

[88] "Building Codes and EV Charging Infrastructure." Southwest Energy Efficiency Project, accessed May 14, 2023, https://www.swenergy.org/transportation/electric-vehicles/building-codes.

[89] Ibid

[90] "Utility Examples." Alternative Fuels Data Center, U.S. Department of Energy, accessed May 14, 2023, https://afdc.energy.gov/laws/utility-examples.

[91] "Electric Utilities." EV Toolkit for Rural Communities, U.S. Department of Transportation, accessed May 14, 2023, https://www.transportation.gov/rural/ev/toolkit/ev-partnership-opportunities/electric-utilities.

rebates specifically targeting workplace charging EVSE deployment.[92] Additionally, Puget Sound Energy in Washington[93] and AES Ohio[94] are launching dedicated rebates for workplace charging. Other utilities offer L2 rebates for their commercial customers, which could tentatively be used to install chargers at the workplace. Based on the Alternative Fuels Data Center database, 45 different utilities offer rebates in 29 states ranging from $1,000 to$6,000 per L2 port.[95]

4.5 Private Company Drivers

Increasingly, corporate sustainability goals are strategically important in attracting and retaining top talent and branding products in the private sector. Half of Fortune 500 companies have already invested in EV charging.[96] Installing workplace charging can support certification by green building certification programs, including Leadership in Energy and Environmental Design (LEED), Green Globes, ENERGY STAR® for Buildings and Plants, and Sustainability Tracking, Assessment, and Rating Systems.[97] Based on the Amping Up California Workplaces study, promoting a green and sustainable image was the most common reason for installing charging stations.[98]

[92] "Federal and State Electric Vehicle Incentives." Enel X, accessed May 14, 2023, https://evcharging.enelx.com/resources/federal-and-state-electric-vehicle-incentives.
[93] "Workplace Charging." Puget Sound Energy, accessed May 14, 2023, https://www.pse.com/en/pages/electric-cars/Workplace-charging.
[94] "EVSE Rebate Program." AES Ohio, accessed May 14, 2023, https://www.aes-ohio.com/evse-rebate-program.
[95] "State Laws and Incentives." Alternative Fuels Data Center, U.S. Department of Energy, accessed May 14, 2023, https://afdc.energy.gov/laws/state; note – there were 4 utilities offering incentives of $250 per charger that were excluded from this count.
[96] "Top 4 Reasons for Offering EV Charging in the Workplace." ChargePoint, accessed May 14, 2023, https://www.chargepoint.com/en-gb/blog/top-4-reasons-offering-ev-charging-workplace.
[97] Workplace Charging." Alternative Fuels Data Center, U.S. Department of Energy, accessed May 14, 2023, https://afdc.energy.gov/fuels/electricity_charging_workplace.html.
[98] "EV Charging at Work: A Guide for Employers." UCLA Luskin Center for Innovation, accessed May 14, 2023, https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/EV_Charging_at_Work.pdf.

Section 5 Barriers to Workplace Charging Adoption

Cadeo organized barriers for workplace charging adoption into three main categories:

- **Technical:** Barriers related to technical aspects of workplace charging deployment.
- **Economic:** Barriers associated with costs incurred to adopt, install, operate, or maintain electric chargers in the workplace.
- **Achievable:** Regulatory, behavioral, or programmatic market barriers that prevent or slow down workplace charging adoption.

Each category includes a summary table of the underling barriers as well as a more comprehensive discussion of each of them, including the rational for its existence.

5.1 Technical Barriers

Key technical barriers are listed in Table 4:

Table 4: Technical Barriers

Barrier	Significance/Impact
Lack of building/parking facility ownership	High
Supply Chain Issues	Medium
Shortage of Skilled Workforce	Medium
Unclear and Long Permitting Process	Low
Complex Process	Medium

5.1.1 Lack of Building/Parking Facility Ownership

Some businesses own the buildings and parking lots used for operations, but many lease their facilities, including parking garages. Leased facilities represents a barrier for workplace charging because employers are not the decision makers for deploying workplace charging.[99] The landlord of the facility or parking garage have the final say. While it is possible to try and negotiate the installation and retrofitting of parking facilities for the purposes of installing EVSEs, as tenants, businesses may not have much leverage in persuading the property owner to undertake the project, which can be substantial in terms of time and financial requirements.

[99] "Workplace Charging Challenge: 2016 Progress Update." U.S. Department of Energy, accessed May 14, 2023, https://www.energy.gov/eere/vehicles/articles/workplace-charging-challenge-2016-progress-update.

There are incentives to both parties for installing chargers on site—for instance, the business will provide benefits for employees and achieve sustainability goals while the building or parking owner can improve their offering for future tenants and secure a higher lease in the future—altering the status quo is not attractive. The landlord already has a lease in place with the current tenant; thus, there is no incentive to invest time and money into this. The tenant could consider incurring the capital expenditure of installing chargers, upon approval of building owner, but is discouraged from doing so because there is no certainty that they will continue to lease the property. These conditions make this barrier hard to overcome.

One of the installers interviewed for this study pointed out that overcoming this barrier will likely depend on the relationship between the landlord and tenant. He discussed instances where workplace charging in leased facilities did indeed happen, with property owners keen on justifying higher lease rates because of EVSE. However, he also pointed out that such investment has likely lost some of its attractiveness for property owners post-pandemic. In the above cited case, for instance, chargers were installed to accommodate pre-pandemic levels of office attendance. The subsequent increase in work-from-home policies and lower utilization of parking spaces made such an investment harder to justify as there was less demand for EV charging. Another installer commented that it could be less of a barrier in the manufacturing and industrial sectors as the employer typically has to make substantial investment in the leased facility. Coupled with long-term lease agreements (e.g., 10 years or more), installing EVSE would still result in substantive benefits.

5.1.2 Supply Chain Issues

Lack of preexisting electrical infrastructure needs for EV charging, such as electrical panel capacity, raceways, and pre-wiring, could make workplace charging a complicated and expensive venture. Infrastructure upgrades might stall the project due to additional cost requirements (see Section 5.2), but they also create a technical barrier stemming from a shortage of components and skilled workforce (see 5.1.3).

Large worksites installing many chargers or even smaller facilities installing DCFC chargers might find that they need a transformer upgrade on top of the infrastructure upgrades highlighted above. For instance, one of our interviewees indicated that a transformer upgrade was needed for one of their sites deploying 16 L2 charging station ports. Another interviewee that deployed workplace charging mentioned the delays in equipment availability due to supply chain shortages. Currently, there is a shortage in transformers throughout the United States, which has increased the procurement time from 16 to 20 months in 2021 to 20 to 39 months today. This shortage has resulted in the cancellation of some electrification projects.[100] Although the need for transformer upgrades is site specific and depends on the capacity of existing transformers in

[100] "Distribution Transformer Shortage Threatens Grid Modernization Plans, Casten Warns." Utility Dive, April 6, 2021. https://www.utilitydive.com/news/distribution-transformer-shortage-appa-casten/639059/.

the area, this supply chain constraint could become more significant as other electrification projects enter the grid.

Several interviewees mentioned supply chain issues impacting their workplace charging projects. One employer with workplace charging interviewee encountered a year-long wait list for their first-choice brand of chargers. As a result, they selected the second-best option, which had a shorter wait time, because the funding they were awarded had a 1-year project completion condition—supply chain issues can affect more than project length but also jeopardize funding. Additionally, interviewees also pointed out the long wait times for things like conduit and other building materials needed to install workplace charging. As demand for chargers increases, we can expect supply chain issues to remain in the near future, especially as the economy recovers from the effects of the pandemic.

5.1.3 Lack of Skilled Workforce

On the workforce front, developing a domestic workforce to support electrification projects is needed. A recent research study shed light on the difficulty of finding electricians to install distributed energy resources (DER) in houses.[101] A shortage of electricians could hit the market as more DERs (such as solar, heat pumps, and EV chargers) are pursued by homeowners looking for resiliency, bill savings, and GHG emission reduction. One interviewee pointed out that in Washington, there is a palpable lack of electricians available to work on workplace charging installations. According to him, the boom in the construction industry in the state over the past decade offered highly attractive wages for electricians, making them less available for jobs in other sectors, including EV infrastructure. Moreover, until recently, state rules on obtaining electrician's license precluded out-of-state electricians from using their hours working on jobs outside of the state toward obtaining Washington electrical license. This meant experienced out-of-state electricians willing to move to Washington were disincentivized from doing so, further depressing the supply of qualified electricians in the state. Despite this recent change in certification rules, the interviewee anticipates substantial difficulty in finding qualified electricians for EVSE installations in the short and medium term.

An interviewee who is employer with workplace charging noted that the company had trouble finding local installers who were trained and certified in EVSE installation. Working with a certified EVSE installer was one of the requirements for the program funding they obtained. To meet this requirement, the employer had to expand their search to the nearest large city, which meant not working with someone in their local community, which they had a preference for, given that their business is located in a disadvantaged community.

An employer interviewee who considered workplace charging but did not pursue it also noted that the requirements for a licensed contractor with EVSE training certification for workplace

[101] Sheppard, Julian Spector and Molly. "We Need a Lot More Electricians If We're Going to Electrify Everything." Canary Media, March 18, 2021. https://www.canarymedia.com/articles/clean-energy-jobs/we-need-a-lot-more-electricians-if-were-going-to-electrify-everything.

charging installations in California posed an issue for them in soliciting bids from installers in 2019. At the time, there were only two companies in California that offered in-person EVSE certification training, which restricted the number of available certified installers.

5.1.4 Unclear and Long Permitting Process

The permitting process for installing EV chargers can be cumbersome and delay the project. Permitting might require approval from different local officials. A zoning permit might be required for EV charging, although EV charging commonly falls under "accessory use" to an existing facility, such as an office building or a parking lot, which means a zoning review is not necessary.[102] Nevertheless, not all municipalities have ordinances in place to clarify that this is the case, which can lead to inconsistent interpretation at the local level and negatively impact installation of charging projects. For example, California implemented best practices with regulation Assembly Bill 1236, but lack of implementation of regulation and enforcement in cities and counties can lead to zoning conflicts, where larger charging installations are considered fueling stations and therefore are limited to certain locations.[103]

Additionally, acquiring building and electrical permits can be time-consuming under the best conditions but can be lengthier if the local officials are unfamiliar with EVSE systems. The paperwork required must include a diagram showing that the planned EVSE installation will be in accordance with the building code, the electrical code, the Americans with Disabilities Act (ADA), and other relevant regulations, resulting in an extensive documentation and paperwork.[104] After the installation is complete, an inspection is necessary to ensure compliance with code and the requested permit, which again could be a lengthy process if the inspector is not familiar with EVSE systems.[105]

5.1.5 Complex Process

As found throughout the literature review, pursuing workplace charging requires coordination with different internal and external stakeholders. This could be an extensive and time-consuming process that might deter some employers from deploying chargers at their facilities. One of our employer interviewees with workplace charging mentioned that just the process of hiring a vendor took 27 months. He believes this is a combination of using a public procurement

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[102] "Permitting Fact Sheet for Workplace Charging." Plug In America, March 2021. http://pluginamerica.org/wp-content/uploads/2021/03/Permitting-Fact-Sheet-for-Workplace-Charging_March-2021.pdf.

[103] "EV Streamlined Permitting (AB 1236) Info & Best Practices." Gateway Cities Council of Governments, 2018. http://www.gatewaycog.org/media/userfiles/subsite_9/files/rl/Planning/EV%20Streamlined%20Permitting%20(AB%201236)%20%20Info%20%26%20Best%20Practices.pdf.

[104] "Permitting Fact Sheet for Workplace Charging." Plug In America, March 2021. http://pluginamerica.org/wp-content/uploads/2021/03/Permitting-Fact-Sheet-for-Workplace-Charging_March-2021.pdf

[105] Ibid

process and that this was their first time acquiring chargers. Therefore, he expects that this task to be less time-consuming in the future. One of the subject matter experts (SMEs) interviewed emphasized the complexity of the process, as all stakeholders need to align on strategy before the project moves forward. An SME interviewee confirmed that there is a lot of inertia at this stage and many projects die down.

There is also the complexity of navigating EVSE options in a quickly evolving space, where interests of EVSE suppliers and employers often compete. One of the interviewed employers with workplace charging pointed out that the research needed to make an informed decision when purchasing charging equipment was especially time-consuming. With a vast array of options in charging equipment, along with different price points, they found it challenging to assess and quickly decide between options. They also pointed out that soliciting quotes from EVSE vendors and installers can be tricky, as both are profit motivated and might suggest less than optimal charging solutions for the company needs.

Installers interviews confirmed the existence of this problem. One noted that customers often solicit multiple quotes and receive wildly different offerings at significantly different price points. This can confuse customers, who do not have the technical knowledge to make an educated distinction among the quotes. In his experience, faced with such options, customers tend to go with the cheapest alternative, which does not always offer the best value for the customer in the long term. He has also encountered customers buying their own EVSE and hiring electricians without an EVSE training certification to install them. Although this route could potentially offer upfront cost savings, it often results in a suboptimal charging solution. For instance, future proofing the facility might be important if the employer is expecting employees to adopt EVs in the future—installing a few extra ports or ensuring that the underlying infrastructure can handle the addition of charging stations in the future is an important consideration to make at the outset. Similarly, deciding whether to get stand-alone or network-capable chargers should occur prior to the installation, since network-capable stations offer more options for the employer in the future in terms of managing charging behavior and charging a fee for charging the vehicles.

5.2 Economic Barriers

Key economic barriers are listed in Table 5:

Table 5: Economic Barriers

Barrier	Significance/Impact
Upfront Cost	High
Low Return on Investment	Low
Ongoing Costs	Medium
Funding Conditions	Low

5.2.1 Upfront Costs

According to the Amping Up California Workplaces study, installation costs are one of the main barriers to workplace charging.[106] Upgrading infrastructure is not only a technical barrier but also an economic one. Studies have found that retrofitting scenarios for charger installations are far more expensive than installations in new construction.[107] For instance, the cost of retrofitting can be 91% higher than outfitting garages during the construction phase.[108] Retrofits costs are higher due to demolition and repair of parking, breaking and repairing walls, longer conduit runs, upgrading electric service panels, and soft costs, which includes permits, plans, inspections and project management.[109]

An installer interviewed pointed out that additional factors, like state or federal parking requirements, could make installation of EVSE more expensive. In Washington, there is a requirement for handicap parking to be within the shortest distance to a building entrance,[110] which often means front of the building. When applying this requirement to an EV parking spot, getting power in front of the building could be an expensive endeavor.

Another installer mentioned that trenching 100 feet could easily cost $15,000 in the Midwest. This would be in addition to permitting and electrical infrastructure costs. He referenced a project for the installation of only two L2 chargers with an overall estimated cost of $40,000 because of the long distance from the available parking to the main service panel. The client did not proceed with the project.

One of the employers interviewed had considered workplace charging but decided against it because of the upfront cost associated with parking retrofits. He was looking to install two 2-port L2 chargers, which would require trenching from the parking lot to the main service panel. On top of that, the parking spots would need to be ADA accessible, which required an extension of the existing sidewalk. The estimated cost for this structural work was $15,000, but the company could not justify this expenditure at the time given the low number of employees with EVs.

In addition, a utility worker pointed out that in their service territory, 90% of the time, the installation of chargers in parking lots requires running a conduit, as well as demolition and

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[106] "EV Charging at Work: A Guide for Employers." UCLA Luskin Center for Innovation, March 2019. https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/EV_Charging_at_Work.pdf.
[107] "EV Charging at Work: A Guide for Employers." UCLA Luskin Center for Innovation, March 2019. https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/EV_Charging_at_Work.pdf.
[108] "EV-Ready Ordinances: A Summary of Local Policies for Electric Vehicle Supply Equipment (EVSE) Readiness." Great Plains Institute, June 2019. https://www.betterenergy.org/wp-content/uploads/2019/06/GPI_EV_Ordinance_Summary_web.pdf.
[109] "Building Codes for EVs." Southwest Energy Efficiency Project, n.d. https://www.swenergy.org/transportation/electric-vehicles/building-codes.
[110] "Parking for People with Disabilities in Washington State." Northwest ADA Center, n.d. https://nwadacenter.org/factsheet/parking-people-disabilities-washington-statesu.

repair of the parking surface. This type of work can easily cost $20,000, which constitutes a prohibitive sum for many smaller businesses.

5.2.2 Low Return on Investment

Workplace EVSEs are investments that don't follow the typical return on investment (ROI) rationale. Chargers are considered amenities, and the decision to offer this amenity means that employers must make an investment that does not guarantee significant payoff. How much of the initial investment is recouped depends on several factors, including whether or not charging is free to employees, the level of incentives and tax credits obtained to cover the initial investment, applicable utility rates, and whether chargers are made available to the general public for a fee.

An SME interviewee pointed out workplace charging as an amenity and that "there is no ROI so to speak." An installer from the Midwest region pointed out that often human resource departments do not see benefit in installing workplace charging since it is expensive, provides an amenity only to EV-owning employees, and has very little ROI, even when employees are charged for usage.

5.2.3 Ongoing Costs

An SME interviewee indicated that even if chargers were completely free, there are many ongoing costs, such as operation, maintenance, and management, that can discourage a company from deploying chargers. She emphasized that these decisions need to be made upfront. Moreover, she stressed that electricity and service costs can be expensive. For example, one employer with workplace charging installed four networked commercial L2 chargers and made them available to employees for free and to the public for a fee. The annual network fee is $1,400, but the revenue from public charging events was not enough to cover this amount. This cost is in addition to the $700 for each charging station. In contrast, their L1 chargers cost $350 a piece, presenting an inexpensive option that works.

SMEs mentioned that often employers tend to not think about ongoing costs at the outset of an EV charger installation project. One employer mentioned that their charger requires troubleshooting on a regular basis, which often falls on employees to deal with. They expressed being unprepared for how time-consuming this process would become despite their charging solution consisting of one L2 charger (open to the public). Another employer, who bought a maintenance plan from their network service provider, mentioned that although the maintenance does not fall on employees, the maintenance plan fees add up over time, making their L2 chargers more expensive than initially thought. Several other interviewees, including installers and utility representatives, pointed out that employers often do not know what questions to ask when it comes to ensuring successful operation of their charging solution. The focus at the outset of the project is typically on the equipment, not how that equipment will be

used and maintained and its costs. Unless the installer discusses such expenses upfront, which might not happen if the company hires a general electrician, employers often can find themselves surprised by these costs.

5.2.4 Funding Conditions

While external funding can encourage adoption of workplace charging, sometimes it comes with counterproductive requirements. For example, some utilities might require that all chargers that receive rebates are networked. If the employer wants to pursue this funding, their choice of EVSE might be restricted to networked chargers only. Because networked chargers tend to be more expensive both up front and over a lifetime, employers might be discouraged to pursuing such funding, thus discouraging workplace charging adoption.

Additionally, two interviewees, a network service provider, and an employer who did not deploy workplace charging, mentioned that some state funding requires chargers to be made available to the public to receive any funding. Public charging at private companies can be impractical in cases where parking is secured or where employees have to compete with the public for charging spaces.

5.3 Achievable Barriers

Achievable barriers are listed in Table 6.

Table 6: Achievable Barriers

Barrier	Significance/Impact
Remote Working	High
Equity Considerations	Medium
Lack of awareness about incentives	High
Lack of Knowledge	High
Vandalism	Low

5.3.1 Remote Working

One of the results of the COVID-19 pandemic was remote working. Employees showed employers that performance and productivity can be maintained while working from home. The repercussions of this are large: throughout the country, office areas sit empty. Some companies are encouraging their employees to return to the office, but the success has been low, with many companies still operating in remote mode or offering hybrid schedules. One interviewee pointed out that after COVID-19, employers are looking to downsize physical workspaces or not renewing leases, resulting in decreased demand and interest in deploying workplace charging. One utility employee interviewed mentioned that while there are many projects in their

transport electrification program portfolio, none are for workplace charging, indicating that there is not much demand among employers for installing workplace charging currently.

5.3.2 Equity Considerations

Based on the literature review, some firms have chosen not to provide workplace charging because of equity concerns. They worry that dedicated parking spaces for EVs would only benefit a small number of employees.[111] Other equity concerns have to do with overuse of EVSEs by some employees,[112] specifically those who have access to home charging but prefer to charge at work because charging is readily available and free, for example. This would be especially problematic if there are employees with no access to workplace charging at home, as their usage of workplace chargers would be reduced. In one particular case noted by an SME interviewee, an employer received a quote for public charging solution at one of the workplace locations. However, upper management thought it would be inequitable to offer charging at only one location and expanded the project to all company locations. The adjusted quote, which included networked chargers with advanced features, quickly became prohibitively expensive to implement. Instead of seeking out a quote for a simpler charging setup, the firm scrapped the project entirely.

5.3.3 Lack of Awareness of Incentives

Results from our interviews showed a lack of awareness about incentives as a main barrier. Interviewees repeatedly mentioned that incentives are scattered and there is no one centralized place where this information can be found in aggregate. One interviewee mentioned that some companies might reach out to the Clean Cities Coalition for support and guidance, but many are unaware of these resources. The result is that they drop the idea of installing workplace charging due to high cost or proceed without incentives but may limit the type of chargers or the amount deployed at the facility.

One of the installers interviewed in the Midwest region mentioned that there is a widespread perception amongst employers that EVSE funding available for workplace charging is quite small (10% or less), but in fact some programs offer generous rebates, such as the AES Ohio's EVSE Rebate Program that provided 50% of eligible project costs up to $10,000 per station.[113]

5.3.4 Lack of Knowledge

There are many decisions to make when pursuing workplace charging. Making those decisions requires a considerable amount of knowledge of charging solutions, technology availability, infrastructure upgrades, and management throughout the lifetime of the chargers. Not only are

[111] UCLA Luskin Center for Innovation. "EV Charging at Work: A Guide for Employers." Los Angeles, CA, March 2019. https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/EV_Charging_at_Work.pdf.
[112] Ibid
[113] AES Ohio. "EVSE Rebate Program." Accessed May 14, 2023. https://www.aes-ohio.com/evse-rebate-program.

employers lacking such knowledge, but they are also left to make decisions without fully comprehending the different possibilities and opportunities, which is conducive to bad investment and less-than-optimal charging solutions.

One of the interviewed installers highlighted the plethora of questions that employers should ask at the initial stages of considering a workplace charging project. Typically, though, employers are not even aware of those questions. One employer with workplace charging mentioned the lack of knowledge of EVs and EVSEs was a barrier to adoption. The interviewee spent long hours researching online what type of EVSE was the best option for the facility. This interviewee was overwhelmed by the different options and lacked guidance. Finally, this employer found support in the local electric utility provider, but this situation could end differently for many other employers interested in workplace charging.

Another employer with workplace charging also commented on the difficulty of knowing what to ask during the EVSE selection process. Specifically, this person mentioned that after selecting and installing chargers, they were surprised to learn that the chargers selected didn't support tiered charging fees due to network software. This prevented the employer from implementing an idle fee for its chargers to encourage people to move their cars when charging was complete. In retrospect, this feature held a considerable degree of importance, so much so that had the employer known to ask this question ahead of time, they probably would have explored their EVSE options more.

5.3.5 Vandalism

Although not as widely spread, vandalism could also present a barrier to workplace charging. One of the installers interviewed cited an instance where a business with charging equipment installed in a publicly accessible parking facility was vandalized on more than one occasion. He cited damaged screens and cut cords to all 20 chargers in the parking lot. Vandalism occurs more often in non-secured locations and might deter certain employers from pursuing workplace charging.

Section 6 Recommendations

Our recommendations are based on solutions to overcome the key barrier listed in Section 5. Recommendations are not one to one with barriers because there are different activities and interventions that tackle more than one barrier simultaneously. Recommendations and barriers are listed in Table 7.

Table 7: Recommendations for Workplace Charging

Recommendation	Barrier Addressed
Options for employers leasing facilities	Lack of building/parking facility ownership
Streamline the permitting process	Unclear and long permitting process
Workforce training and development	Lack of skilled workforce
One-stop shop for information	Complex process Lack of awareness about incentives Upfront cost Ongoing costs Low ROI Lack of knowledge Funding requirements restrictions
Dedicated technical assistance to oversee the project	Complex process Unclear and long permitting process Equity considerations Lack of knowledge
EV provisions in building codes	Supply chain issues Upfront cost
New business models for downsized office spaces	Remote working
Private Partnerships	Upfront cost Ongoing costs Equity considerations
Charging a fee for charging	Low ROI Equity considerations
Raise awareness of the equity impacts of workplace charging	Equity considerations

6.1.1 Options for Employers Leasing Facilities

As discussed earlier, several businesses, especially in urban cores, do not own their own buildings or parking facilities and need buy-in from the property landlords to set up charging infrastructure. Best practices suggest setting up an advisory committee together with other tenants in the building, negotiate the installation of EVs as part of the lease extension, or partner with another parking lot or business in the proximity to develop a cooperative charging program.[114] Employers need practical examples of how to navigate this process and what approaches have proven successful. To this end, a collection of case studies on how businesses leasing office space were able to successfully deploy workplace charging would be a great resource for other employers renting space to review different strategies and choose an approach that works best for them and adapt it to their needs.

6.1.2 Streamline the Permitting Process

The current trend indicates that permitting departments will see an increase in the number of permits for installations of EV charging infrastructure. If rapid deployment of EV charging infrastructure is required to meet energy transition and state policy goals, permitting departments should prepare to reduce the chances of becoming the bottle neck in this process. Therefore, recommendations are directed to permitting departments to:

1 | Provide clear information on their website regarding the permitting process for installing EV charging infrastructure by sector type, whether residential or commercial, or charger type of applicable.
2 | Provide a list of all the paperwork and forms (in downloadable format) required for each case.
3 | Allow electronic registration, submission, and tracking of permit progress, including electronic signatures in forms.
4 | Develop department staff skills in this area to reduce delays and provide support to contractors and applicants.
5 | Train department staff inspectors for on-site inspections.
6 | Charge an application fee to encourage only serious applicants.

6.1.3 Workforce Training and Development

To be prepared for an electrified future, the market needs a greater number of skilled electricians. Three recommendations fall under this category:

1 | Include installation trainings on different DERs, including EV charging, in existing curricula in electrician technical school and centers.

[114] Joint Venture Silicon Valley. "Best Practices for Workplace Charging." Accessed May 14, 2023. https://jointventure.org/images/stories/pdf/Best_Practices_for_Workplace_Charging.sflb.pdf.

2 | Create specific market sector training courses or workshops (EV infrastructure, solar, storage, etc.) to increase the skillset of existing workforce.

3 | Develop an outreach program to make younger generations aware of the market opportunities for electricians and promote the development of areas of expertise among existing electricians.

A well-prepared workforce will be crucial to accelerate the deployment of electrification measures, including EV charging infrastructure. State and local governments can work with technical institutions to include specific curricula topics that cover the needs discussed above. They can also set up specific market sector training workshops, like EV charging infrastructure and other distributed generation installation, for improving the skills of the existing workforce. Ideally, these training courses could be free or offered at discounted prices for income eligible or disadvantage communities.

State and local governments can also collaborate with nonprofits, advocates, and community-based organizations to develop and implement outreach programs for younger generations and the existing workforce to partake in the new available educational opportunities (trainings and workshops mentioned above) in the market.

As of now, the Electric Vehicle Infrastructure Training Program (EVITP) offers 20 hours of online training for the installation of EVSEs for qualified electricians. EVITP it is a volunteer-based nonprofit organization that collaborates with other industry partner organizations to develop curriculum to train and certify electricians in all 50 states.[115] In fact, the program has already certified 20,000 electricians through the White House Talent Pipeline Challenge.[116]

6.1.4 One-stop Shop for Information

While the underlying complexity of the process might not change given the number of stakeholders involved when deciding to deploy workplace charging, the process can be simplified with a one-stop shop to guide employers through each step. There are already many resources out there offering guidance about installation of workplace charging. Resources addressing planning stage, funding, type of chargers, and networked chargers among others can be found with a quick search, but the information might be overwhelming, is not aggregated in a single place, and is often outdated.

Understanding the benefits of future-proofing charging solutions (i.e., planning for greater demand in the future) is another consideration that needs to be addressed in the planning stage of the project. Employers would benefit from a specific website for workplace charging. This site

[115] Electric Vehicle Infrastructure Training Program. "EVITP." Accessed May 14, 2023. https://evitp.org/.
[116] The White House. "Fact Sheet: Biden-Harris Administration Announces New Standards and Major Progress for a Made in America National Network of Electric Vehicle Chargers." Washington, D.C., February 15, 2023. https://www.whitehouse.gov/briefing-room/statements-releases/2023/02/15/fact-sheet-biden-harris-administration-announces-new-standards-and-major-progress-for-a-made-in-america-national-network-of-electric-vehicle-chargers/.

could contain best practices and up-to-date information for the deployment of workplace charging in each state or even municipality. Additionally, the website could include ongoing costs after charger installations, such as maintenance and operations, so that employers could make informed decisions and know what to expect moving forward. Ways to reduce electricity costs such as time-of-use rates or managed charging could be included to provide options for employers concerned about these future costs. Finally, the website could contain a list of partners in each state that the employer could contact to receive guidance from a trusted local source.

6.1.5 Dedicated Technical Assistance to Oversee the Project

One SME highlighted that even if chargers were completely free, the complexity of the process requires technical assistance staff that can guide the employer through the process and even oversee the project from start to finish. This is especially true for businesses in disadvantaged communities that may not have the resources to dedicate their own staff to this endeavor. This technical assistance can be provided by state and local governments through nonprofits or other organizations working in the EV space.

One of the interviewed employers with workplace charging noted that working with a neutral third party who is knowledgeable about workplace charging was especially helpful in navigating installer quotes and determining the right charging solution for their business.

During a conversation with a utility representative, he reiterated the importance of technical assistance when it comes to decisions of workplace charging. He shared the experience and results of technical assistance provided to 60 small businesses in 2019 and 2020. Nearly two-thirds of these businesses ended up installing chargers, and when surveyed by an independent evaluator, over half stated that the technical assistance received was highly influential in their decision to pursue workplace charging.

The availability of technical assistance from an objective party is crucial for increasing adoption of workplace charging among employers. Technical assistance can be promoted through the one-stop shop website for workplace charging and marketing campaigns, as well as utilities, EVSE providers, business associations, and other actors working in the space.

6.1.6 Electric Vehicle Provisions in Building Codes

Adopting EV provisions in building codes can help avoid expensive electrical retrofits later. This also reduces other retrofit-related costs such as inspection fees and permitting costs. As of today, many states and local governments have already added EV provisions to their building codes, local ordinances and zoning requirements,[117] but as a minimum we recommend adopting the EV infrastructure requirements proposed by Pacific Northwest National Laboratory and

[117] U.S. Department of Energy. "Technical Brief: Electric Vehicle Charging Infrastructure Requirements in Energy Codes." Washington, D.C., July 2021. https://www.energycodes.gov/sites/default/files/2021-07/TechBrief_EV_Charging_July2021.pdf.

International Code Council staff in 2021 that was built upon the language considered for the 2021 International Energy Conservation Code (IECC), and includes the following considerations for new commercial buildings (see Figure 2):

- Minimum number for installed EVSE spaces
- Minimum number for EV-capable spaces - panel capacity and conduit that is not less than 208/240 V and 40 amp to accommodate future EV charging infrastructure.
- Minimum number of EV-ready spaces – EV-capable plus wiring, receptacles and overprotection devices

Figure 2: EVSE Installed, EV-Ready Space, and EV-Capable Space Requirements for New Commercial Buildings

Total Number of Parking Spaces	Minimum number of Spaces with EVSE Installed[a]	Minimum Number of EV-Ready Spaces	Minimum Number of EV-Capable Spaces
1	1	1	-
2 – 10	1	2	-
11 – 15	1	2	1
16 – 19	1	2	2
21 – 25	2	3	2
26+	5% of total parking spaces	10% of total parking spaces	10% of total parking spaces

(a). Spaces that terminate with a Level 2 EVSE are considered *EV-Ready Spaces* and count towards the minimum number of *EV-Ready Spaces*.

Source: https://www.energycodes.gov/sites/default/files/2021-07/TechBrief_EV_Charging_July2021.pdf

6.1.7 New Business Models for Downsized Office Spaces

While the impacts of remote working after COVID-19 are still playing out, many companies have return to office policies and others have set flexible schedules for attendance. Some companies might be thinking of downsizing their offices, but only a minority has decided to go fully remote. Employees still need a space to meet and work at least a few times a week. However, the expected increase adoption of EVs throughout the coming years will put more pressure on deploying workplace charging as more employees will own EVs and will want this benefit when in the office. A downsize in office space will lead to a downsize in parking spaces, thus reducing upfront costs if fewer chargers are needed. Additionally, companies that own large spaces might want to rent part of their office space to other companies and this could open the door to different business models for the financing and use of chargers at the worksite.

6.1.8 Private Partnerships

For employers facing high upfront costs of workplace charging installation, one potential solution is to form private partnerships with EVSE providers. These partnerships are ones in which the employer serves as a site host for charging equipment that is owned and operated by an EVSE provider. We have interviewed one employer who is pursuing this model. The employer

is a city and owns 400 parking lots across a large territory that need to be electrified to meet both state mandates and its own employees' EV charging needs. Given that this is an expensive venture, the city will pick a vendor(s) who will be responsible for the entire workplace charging procurement process, and who will own and operate the stations, which will be made available to both city employees and the public. The vendor will collect all charging fees, and at the end of the 10-year contract will sell the infrastructure improvements to the city at a predetermined discount rate. This innovative solution meets the needs of the city as an employer to provide charging infrastructure without having to finance the electrification of its parking lots. They will also lean on the expertise of the vendor to procure and install all equipment, with the city providing input and expectations regarding the charging solution at the outset of the project. For this example, the city wants the chargers to be placed in disadvantaged areas and has specifically asked bidders to present pathways for meeting this specific goal.

6.1.9 Implementing Charging Fees

As mentioned previously, many workplaces offer EV charging as an amenity and the ROI is low. Higher ROIs can be achieved by including a fee for charger use by employees. Although this might be counterintuitive from the perspective of equity, fees can support investments moving forward. Fees can also limit the time that employees with at-home charging capabilities are connected at work, as charging is not free anymore, which gives more room for employees without dedicated residential chargers to charge their vehicles.

Another opportunity to recoup investment is to open the chargers to the public. If the chargers are networked, there is an opportunity to charge a higher rate for nonemployees that are still competitive relative to the market.

Overall, a workplace charging investment can be recouped within years if these strategies are paired with grants and rebates. It certainly will depend on the type of charger being deployed, the power output, the number of chargers, and utilization rates.

6.1.10 Raise Awareness About Charging Infrastructure Equity Impacts

Based on interviewees responses, some employers feel that providing dedicated parking spaces will benefit the few employees that own EVs, who tend to be early adopters; therefore, the ones on the higher end of the income scale. However, while this may seem true at the outset of deploying workplace chargers, by installing chargers the company is providing employees without dedicated at-home chargers (as mentioned before renters, low-income individuals, and multifamily housing occupants) access to charging infrastructure in a place that they frequent regularly. This recurrent and reliable access to EV charging, combined with available federal, state, and local funding for EV adoption provides a real opportunity to bring equity to the sector. To this end, raising awareness about the equity impact of workplace charging is an excellent way to increase charging infrastructure at these sites. A specific marketing campaign focused on the equity impacts of workplace charging can help employers realize the benefits they bring to employees from disadvantage communities and others with no dedicated at-home

charging. It is not only good from an environmental perspective but also from a societal one. This marketing campaign can be led by federal or state governments and promoted at the municipality and city level through local advocates, utilities, government agencies, and business associations, among others.