

The cost of energizing medium- and heavy-duty truck charging facilities in the United States

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INTRODUCTION AND BACKGROUND

California leads the United States both in terms of policies to promote adoption of zero-emission medium- and heavy-duty vehicles (MHDVs) and in terms of high electricity rates.¹ This creates a dilemma between electrification and affordability for the California Public Utility Commission as well as for investor-owned utilities. On the one hand, these utilities are obligated to support state-wide transportation decarbonization and electrification objectives, facilitate compliance with regulations like the Advanced Clean Trucks rule, and serve the business needs of MHDV charging service providers.² On the other hand, they are instructed to be attentive to ratepayer impacts and are under pressure from consumer advocates to defer or even reject new distribution-grid-infrastructure expenditure for MHDV charging.

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- 1 California Legislative Analyst's Office, *Assessing California's Climate Policies—Residential Electricity Rates in California*, January 7, 2025, <https://lao.ca.gov/Publications/Report/4950>; U.S. Energy Information Administration, "Electric Power Monthly Table 5.6.A. Average Price of Electricity to Ultimate Customers by End-Use Sector, by State, June 2025 and 2024 (Cents per Kilowatthour)," accessed June 5, 2025, https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a; Claire Buysse and Ben Sharpe, *California's Advanced Clean Trucks Regulation: Sales Requirements for Zero-Emission Heavy-Duty Trucks* (International Council on Clean Transportation, 2020), <https://theicct.org/publication/californias-advanced-clean-trucks-regulation-sales-requirements-for-zero-emission-heavy-duty-trucks/>.
- 2 California Public Utilities Code 727-758 (2024), https://leginfo.ca.gov/faces/codes_displayText.xhtml?lawCode=PUC&division=1.&title=&part=1.&chapter=4.&article=2.

This situation is not unique to California; in states where electricity rates are high, distribution-grid-capacity investments by investor-owned utilities are often scrutinized and disputed.³ These competing objectives—maintaining electricity affordability and ensuring that grid capacity is ready for transportation electrification—can slow down decision-making for regulators, utilities, and businesses. Consequently, this risks detrimental delays when it comes to investing in technologies to mitigate climate change, reducing air pollution, making freight transport cheaper, and putting downward pressure on electricity prices.⁴

Drawing from data on the costs of real-world MHDV charging facility projects, this technical brief explores the cost of constructing truck charging facilities, a critical step for filling the information gap between affordability and electrification objectives. Using prototypes of common MHDV charging facility configurations in the market today, we assess the cost components borne by utilities and charging service providers on both sides of the electric meter pertaining to building grid infrastructure as well as the charging facility prototypes. Lastly, we discuss cost-savings options for customers and utilities in both project design and site selection. This work points to potential areas of research to further clarify minimum-cost solutions that meet truck charging needs.

Results of this research can help the diverse stakeholders involved in investing and planning MHDV charging infrastructure—such as fleets and charging facility investors, utility consumer advocates, electric utilities and regulators—to better understand the scale and composition of capital expenditure. This information can reveal common ground for reconciling transportation electrification and affordability imperatives.

METHODS: DATA SOURCES AND CHARGING FACILITY PROTOTYPES

Charging facilities for MHDVs are diverse in their size and layout and are undergoing constant evolution. Factors that determine the design and costs of MHDV charging facilities include the type, duty cycle, and size of the fleet; land cost; availability of distribution grid capacity; and the length of time for interconnection. The myriad conditions of charging facilities and their underlying distribution grids therefore make discussions of infrastructure costs difficult without referencing specific designs.

To overcome this challenge, the ICCT partnered with Black & Veatch (BV) to create three charging facility prototypes. BV is an engineering, procurement, and construction consulting firm with experience designing and building MHDV charging facilities. The prototypes represent general charging facility designs, reflecting layouts and charger compositions that MHDV charging facilities in the United States have adopted by 2025, most of which are located in California. Considering the diverse needs of MHDV fleets and the variety of possible charging solutions, BV developed the prototype parameters and assumptions based on its industry expertise designing, engineering, and constructing MHDV charging projects. These prototypes were reviewed and

³ Selina Shek et al., *Opening Brief of the Public Advocates Office: Application of Southern California Edison Company (U 338-E) For Authority to Increase Its Authorized Revenues for Electric Service In 2025, Among Other Things, and to Reflect That Increase in Rates*, Public Utilities Commission of the State of California, July 15, 2024. <https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M536/K272/536272764.PDF>; Sarah Shenstone-Harris et al., *Electric Vehicles Are Driving Rates Down for All Customers*, Synapse Energy Economics, Inc., January 2024, <https://www.synapse-energy.com/sites/default/files/Electric%20Vehicles%20Are%20Driving%20Rates%20Down%20for%20All%20Customer%20Update%20jan%202024.pdf>.

⁴ Shenstone-Harris et al., *Electric Vehicles*.

validated through interviews with other companies with expertise in MHDV charging infrastructure. To calculate costs for each prototype, BV identified the type, number, and power level of chargers; the utility interconnection upgrades needed; and the costs for each phase of construction. The prototypes can help us understand major cost components in front-of-the-meter (FTM) and behind-the-meter (BTM) infrastructure investments and identify where cost-saving measures can be implemented.

In this analysis, the smallest prototype (measured in terms of nameplate capacity) is a depot charging facility for last-mile delivery vehicles or use cases where the truck fleets have return-to-base operations.⁵ A typical use case for such a facility may include trips from fulfillment centers to retail stores or customers. Because of the predictable operational schedule and energy consumption of these vehicles, we assume that there is a 1:1 ratio between the number of charging ports and the number of vehicles charging at a given time, meaning that a vehicle will have its own designated charging stall. We assume the facility has 14 180 kW dual-port slow chargers—where one charger’s power can be split across two ports to allow for simultaneous charging of at least half power—as well as four 480 kW fast chargers. Table 1 lists the key assumptions about the types of chargers for this analysis. The total nameplate capacity of the facility is around 4 MW.

Table 1
Key assumptions about chargers in this brief

	Power rating	Number of ports per charger	Charging session length
Slow charger	180–240 kW	2 (dual port)	8 hours
Fast charger	480 kW	1	30 minutes
Ultra-fast charger	MW	1	30 minutes

The next prototype is a hybrid facility that accommodates the charging needs of a larger depot in addition to public charging. The facility would support various types of fleet operations, including freight logistic firms serving distribution hubs, delivery operations to e-commerce local fulfillment centers, and regional-haul freight transport between distribution centers. Given the duty cycles, the time of use of the charging infrastructure will be variable, so we assume a mix of first-come, first-served availability as well as a reservation system that assigns trucks to chargers. We assume the facility has 36 180 kW dual-port slow chargers and four 480 kW fast chargers at each site. This second prototype has a total nameplate capacity of around 8 MW.

The largest prototype in terms of load size represents a public charging facility on a freight corridor for trucks with more demanding duty cycles, such as long-haul tractor trucks carrying freight from ports and factories to distribution hubs farther away. Long-haul vehicles can have unpredictable operating schedules and charging needs. Therefore, for this public charging facility we assume a one-to-many ratio between the number of charging ports and the number of vehicles charging at a given time, meaning some trucks will wait for an available port. For this prototype, we assume there are 20 240 kW dual-port slow chargers, 10 480 kW fast chargers, and five ultra-fast chargers with 1,200 kW of power for vehicles with the most demanding charging needs. The final prototype has a total nameplate capacity of around 16 MW.

⁵ Nameplate capacity refers to the combined nominal power from all connected charger loads in a charging facility at any given time.

The physical layout of parking stalls is designed to suit each fleet’s needs, minimize land requirements, and improve operational efficiency. Here, we distinguish between pull-in and pull-through stalls. A pull-in stall requires trucks to back in or out, often after disconnecting from their trailers. Pull-in stalls require less space, but trucks take time to maneuver before and after using the charger. A pull-through stall allows trucks to enter and exit the site in a single direction and to retain their trailers. This design maximizes time savings at the expense of greater land area. Table 2 summarizes the design of the three prototypes in this brief.

Table 2
Summary of truck charging prototype design

Prototype size	Expected use case	Number of chargers	Number of charging stalls	Total nameplate capacity (MW)	Expected land requirement (acres)
Small	Depot charging	14 dual-port slow, 4 fast	28 pull-in stalls 4 pull-through stalls	4	1
Medium	Hub charging	36 dual-port slow, 4 fast	60 pull-in stalls 16 pull-through stalls	8	6
Large	Corridor charging	20 dual-port slow, 10 fast, 5 ultra-fast	5 pull-in stalls 50 pull-through stalls	16	8

Figure 1 illustrates the layout of the small 4 MW prototype. It has 28 pull-in stalls that require trailers to be removed before use, with 14 dual-port slow chargers and four pull-through stalls with 480 kW fast chargers.

Figure 1
Layout of the small charging facility prototype

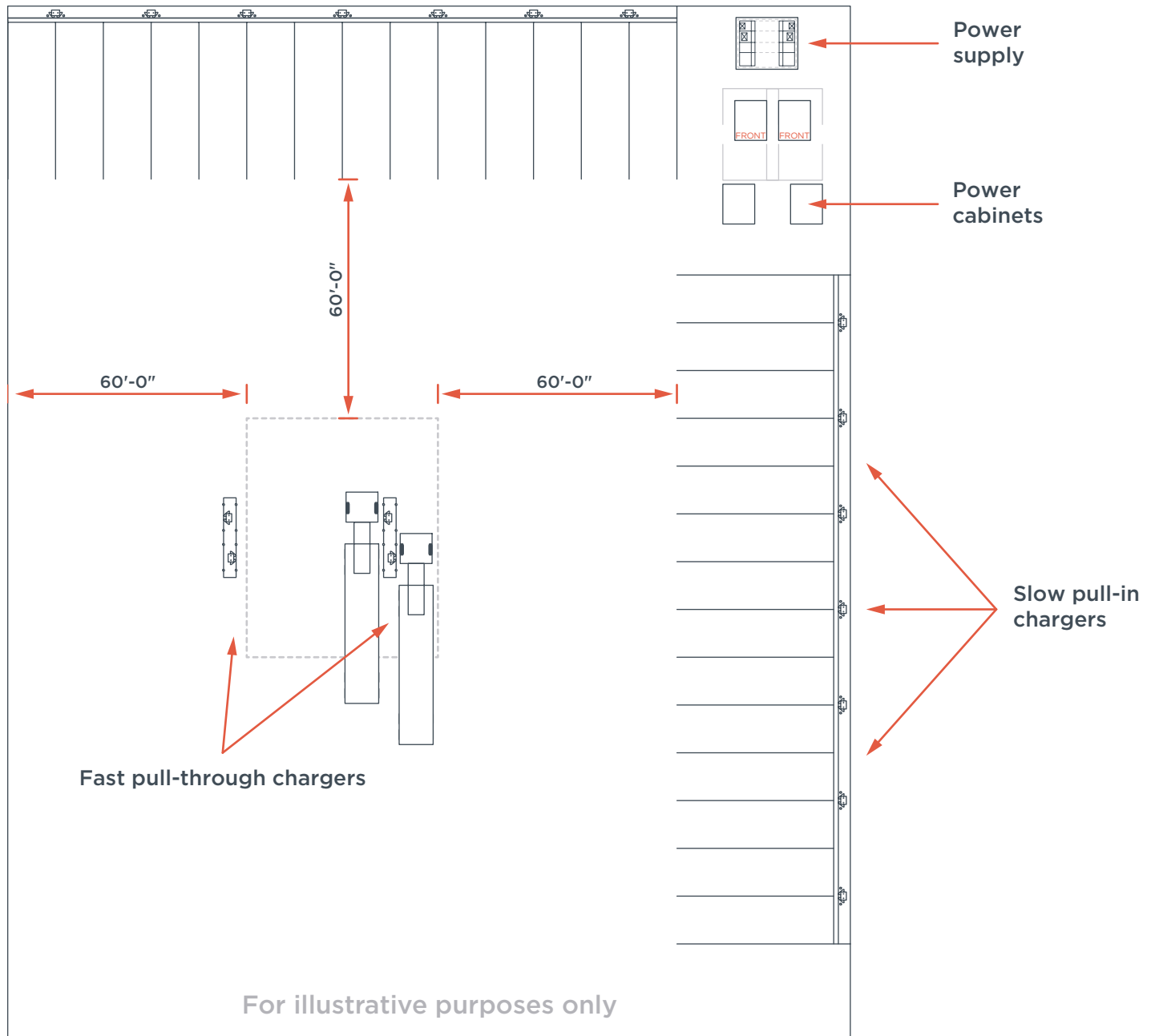


Figure 2 shows the layout of the medium 8 MW hybrid charging facility prototype. It has 60 pull-in stalls and 16 pull-through stalls, with some dual-port 180 kW chargers in a pull-through configuration for more convenient maneuverability.

Figure 2
Layout of the medium charging facility prototype

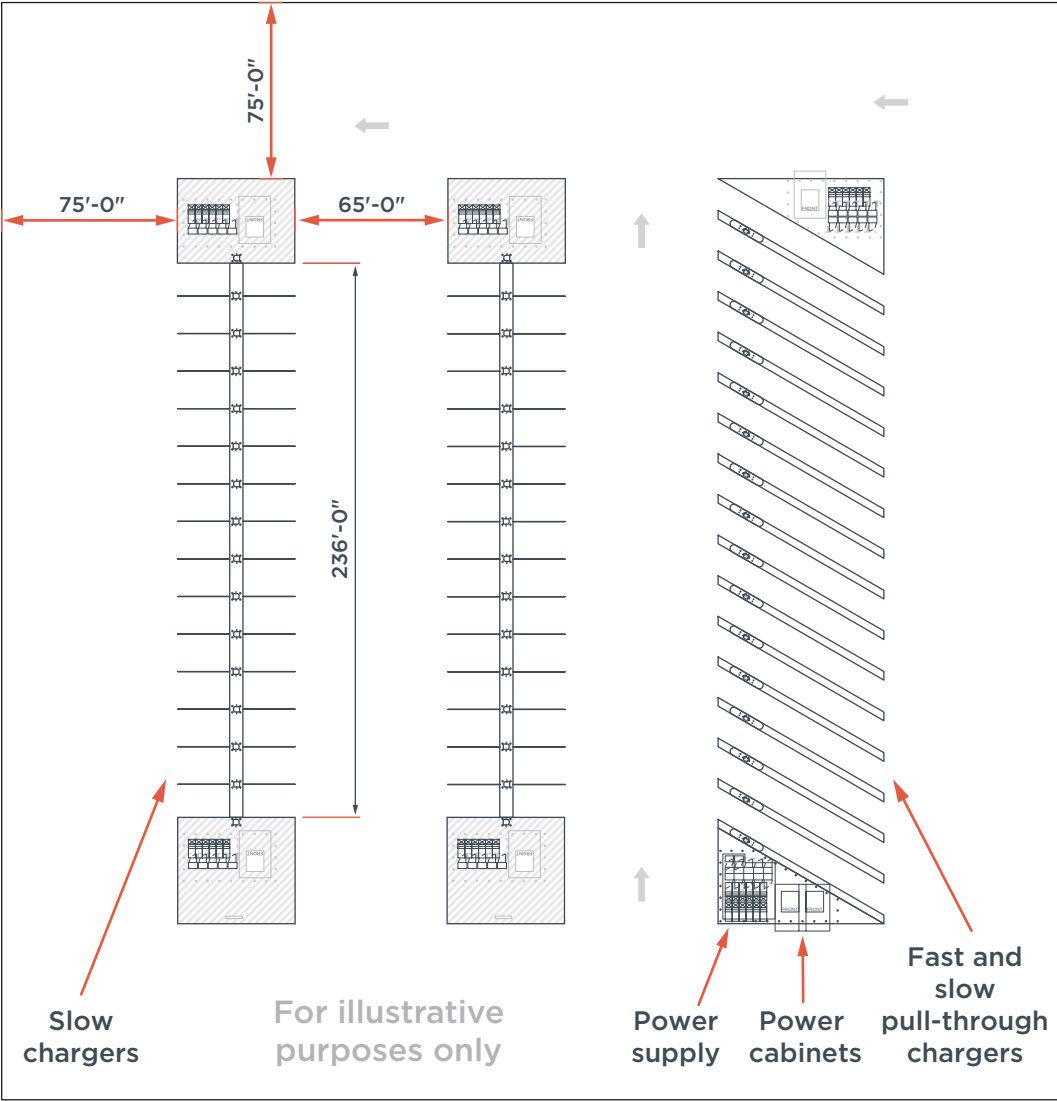
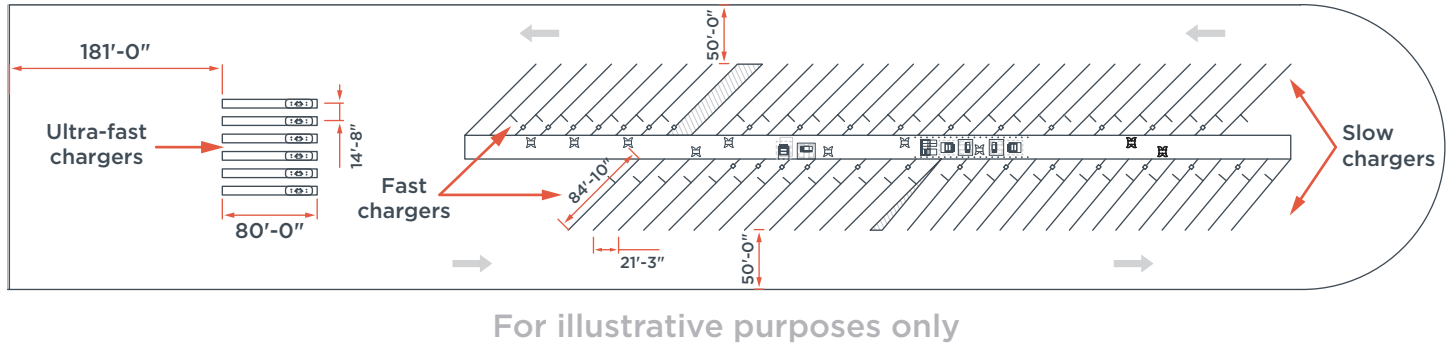


Figure 3 shows the layout of the large 16 MW corridor facility prototype. It has a total of 50 pull-in stalls and five pull-through stalls, all for trucks with trailers attached, making the site well-equipped for quick turnarounds. The increase in power level of the dual-port slow chargers from 180 kW to 240 kW also reflects this use case.

Figure 3
Layout of the large charging facility prototype



To simplify the analysis, we make the following assumptions about the distribution grid and site conditions for these prototypes:

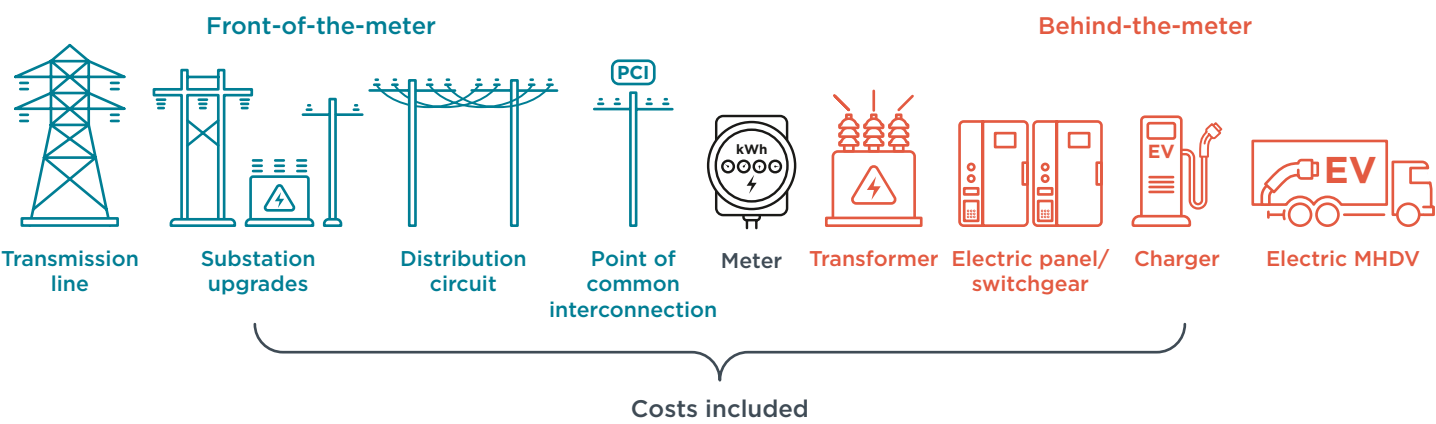
- » The prototype site is in a greenfield location where substantial demolition or repurposing of a large existing structure is not required.
- » The cost of land acquisition is not included in project costs given the high degree of variability in land pricing.
- » There are no special permitting requirements for site construction.
- » The prototype cost estimates assume that each site will be served by a new distribution circuit path. For the large prototype, this path assumes two distribution circuits on a single circuit path will be used to deliver the energy required for the site.
- » The assumptions for the prototypes include the costs for additional substation banks to serve the sites. They do not include the siting and construction of a full, new substation.
- » The distribution circuits serving the prototype site are overhead and not buried underground. The distance between poles is 200 feet.
- » For the small and medium prototypes, the distribution system operating voltage is assumed to be 12.47 kV. The large prototype requires 34.5 kV to serve the heightened load.
- » The charging equipment uses conventional AC power input converted to DC power at the power cabinets and dispensers.
- » The prototype sites do not use managed charging to reduce the peak electricity load.

In a later section, we also consider how changing these assumptions would affect grid-upgrade and charging-equipment costs.

COST OF MHDV CHARGING FACILITY PROTOTYPES

To deliver power to a new MHDV charging facility, both FTM and BTM grid hardware are needed. FTM hardware refers to the grid components owned and controlled by electric utilities, such as substations, transformers, and feeder lines that run to the point of common interconnection and to the electricity meter. BTM hardware refers to the utility customer's side of the electricity meter, which typically starts at the electric panel and extends to the charging ports that plug into vehicles. FTM costs are investments that utilities typically make, while BTM costs are typically the customer's responsibility. Figure 4 illustrates the demarcation of FTM and BTM charging infrastructure components. In cases of extremely large loads, costs of dedicated electricity circuits can be passed on to customers requesting such interconnections for their projects.

Figure 4
Key components in a battery electric medium- and heavy-duty vehicle charging infrastructure prototype



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Table 3 summarizes the FTM costs included in this analysis, and Table 4 summarizes BTM costs. Both FTM and BTM costs are divided into pre-construction and construction costs. Some costs are scalable (by distance between the facility and distribution substation and the power level, for example), while other costs are fixed per project. Costs vary by architectural design and size of the prototype and are based on historical industry information that may not reflect recent impacts of tariffs, inflation, labor costs, and other market forces. These costs are described in detail in the next section. All cost data reflect 2025 price levels.

Table 3**Front-of-the-meter costs for medium- and heavy-duty vehicle charging facilities considered in this brief**

Stage	Cost item	Description	Variable/ fixed cost
Pre-construction	Substation planning analysis	Planning study to determine required substation transformer bank size, necessary feeder and breaker additions, and any additional bank and breaker protection schemes	Variable by site
	Planning analysis	Planning study to ensure adequate feeder capacity to serve required demand (wire size and operating voltage)	Fixed
	Distribution routing and preliminary design	Preliminary design of distribution routing to serve the load	Variable by distance
	Coordination review and settings development	Reviewing protection scheme and development of settings for new protection elements (e.g., breakers, reclosers, automated devices)	Fixed
	Permitting	Acquiring necessary permits from different government entities for distribution routing	Variable
	Real estate easement acquisition	Easement acquisition for distribution routing	Variable
Construction	Construction and installation – substation bank	Constructing and energizing substation upgrades and/or additions, including replacing or installing transformer banks, bus work, breaker additions, reinforcing or replacing transformer pads, and completing civil work to expand substation footprint	Fixed
	Construction and installation – distribution feeder	Constructing and energizing distribution feeder components, such as setting poles, installing pole hardware, pulling wires, and completing civil work for structural foundations	Variable by distance
	Construction and installation – point of interconnection	Constructing and energizing the framework and device demarcating the point of interconnection; completing civil work for structural foundations ^a	Fixed
	Testing and commissioning	Testing and setting of installed components, component protections, and automated devices	Fixed

^a The point of interconnection is where the charging facility connects to the existing distribution line in the local electrical system of the utility.

Table 4

Behind-the-meter costs for medium- and heavy-duty vehicle charging facilities considered in this brief

Stage	Cost item	Description
Pre-construction	Project management	Planning, organizing, and overseeing the project to meet goals, timeline, and budget
	Design and engineering	Creating detailed plans and specifications, including technical drawings and calculations
	Switchboard coordination	Managing the design, integration, scheduling, logistics, and operations of switchboards and determining necessary electrical parts
	Utility coordination	Working with utility companies to ensure smooth integration with existing utility grid infrastructure
	Permitting	Obtaining necessary permits and approvals from local authorities for land use and construction
	Land survey	Measuring and mapping land to determine topography, boundaries, and other features
Construction	Construction management	Overseeing the construction process to ensure work is completed according to plan, on time, and within budget
	Demolition	Removing existing structures to make way for new construction; laying down conduits; installing concrete pads for the electrical and charging equipment
	Trenching and backfill	Excavating trenches for underground utilities or foundations and filling them back in after installation
	Hardscape	Installing hardscape (asphalt and concrete) structures, such as parking lots, driveways, walkways, and patios
	Site improvements	Installing charging site structures, including bollards and fences
	Electrical work	Materials and installation of electrical wiring and conduits
	Electrical equipment procurement and installation	Acquiring necessary electrical equipment, including switchgears, transformers, and switchboards; installation by trained electricians to ensure safe operations
	Charging equipment procurement and installation	Acquiring chargers and installation per manufacturer specifications
	Commissioning support	Assisting with final testing and verification of charging and electrical equipment to ensure compliance with specifications and safety guidance

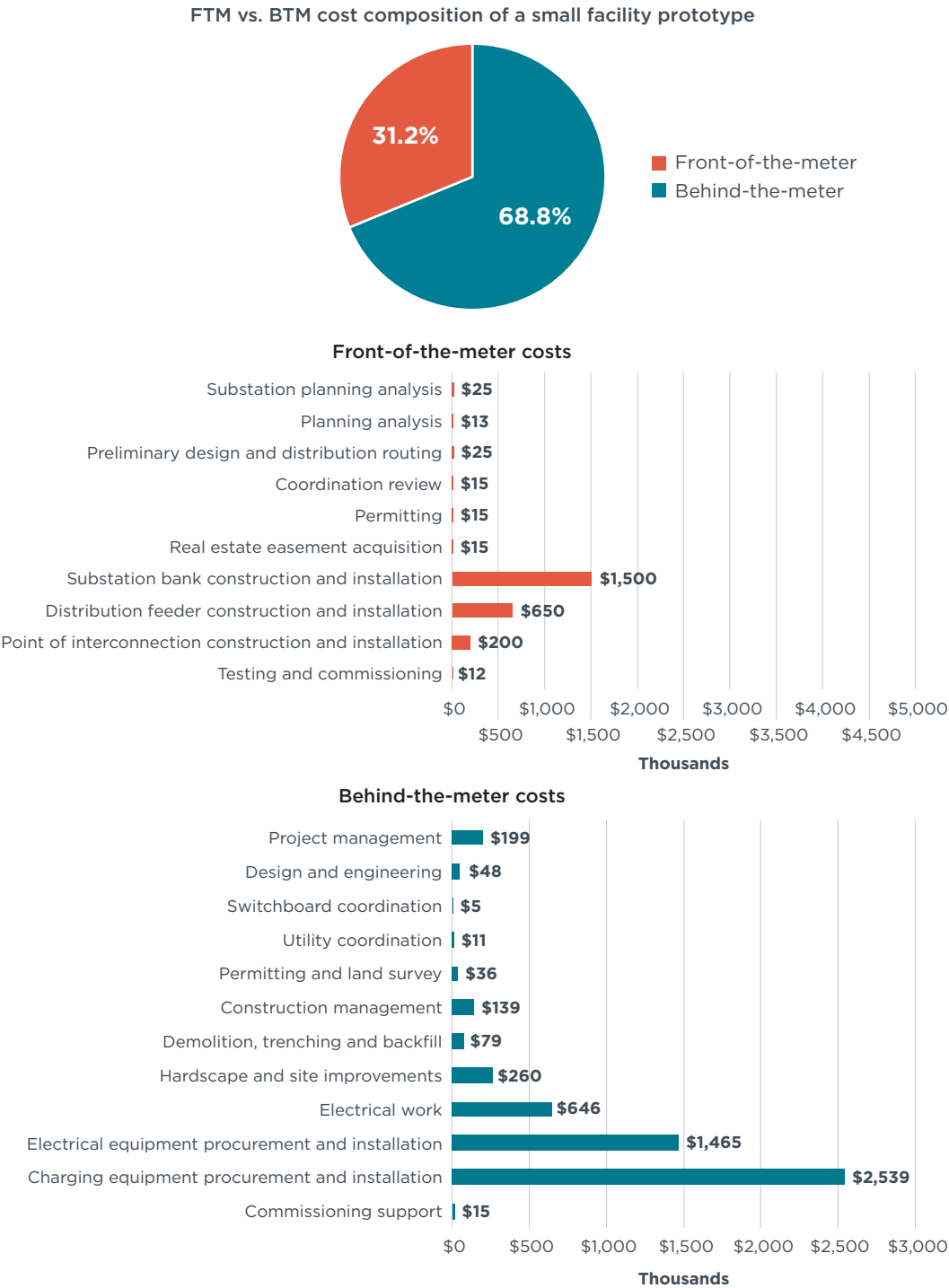
COST OF SMALL PROTOTYPE

The estimated total cost of a small depot charging facility prototype is \$7.9 million. As shown in Figure 5, FTM investments account for 31.2% of total costs, and BTM investments represent the remaining 68.8%. High FTM cost items include labor and materials for the construction and installation of three-phase transformer banks at distribution substations (60.7% of total FTM costs), followed by the construction and installation of distribution feeders (26.3% of total FTM costs) and construction and installation at the point of interconnection (8.1% of total FTM costs). The pre-construction planning, analysis, and review steps are estimated to account for less than 5% of the total FTM costs.

With regard to BTM investments, 46.7% of costs are from the procurement and installation of charging equipment, such as power cabinets and charging dispensers, which can cost \$170,000 per 480 kW power cabinet and \$90,000–\$100,000 per charging dispenser. The procurement and installation of electrical equipment is the second highest BTM cost (26.9% of total BTM costs). The estimated unit cost is \$540,000 for a medium-voltage switchgear, \$240,000 for a switchboard, and

\$160,000 for a transformer. Other BTM costs consist of electrical labor at the charging facility (11.9%), asphalt and concrete hardscaping of the project site plus other site improvements (4.8%), project management during the pre-construction stage (3.7%), and construction management once construction has begun (2.6%).

Figure 5
Breakdown of cost components of a small charging facility prototype



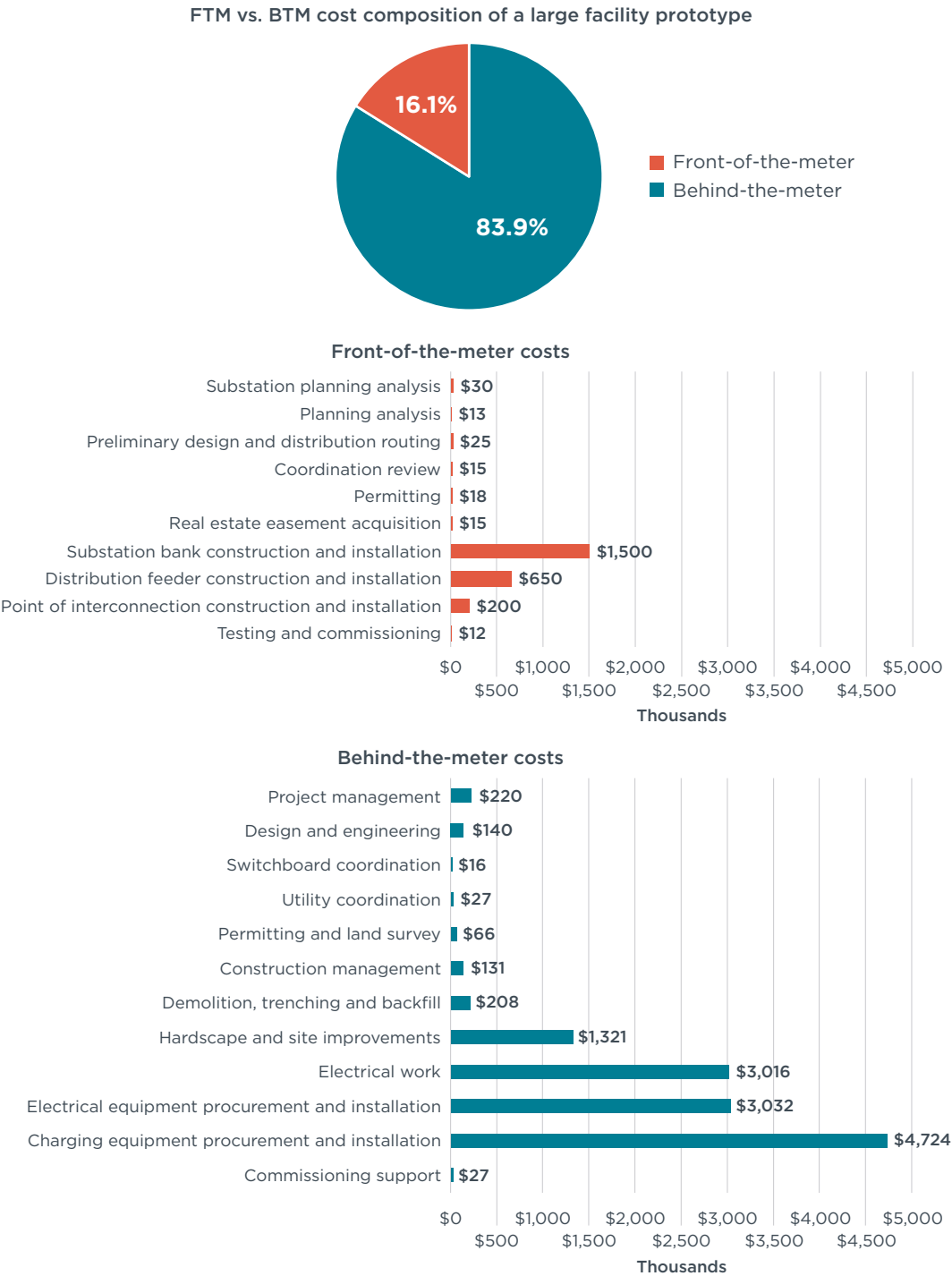
COST OF MEDIUM PROTOTYPE

Moving from a small prototype to a medium prototype increases the project cost to \$15.4 million. The increase primarily comes from BTM costs, which amount to \$12.9 million. BTM costs account for 83.9% of total project costs, while FTM costs remain largely unchanged at \$2.5 million. Given the higher BTM costs, the FTM cost share falls to 16.1% of total costs (Figure 6).

A greater number of chargers at higher power levels account for the increase in BTM costs of the medium prototype. Charging equipment procurement and installation costs are \$4.7 million (36.5% of total BTM costs). Costs of electrical equipment procurement and costs for installation and electrical work are both \$3 million, each accounting for around 23.3% of total BTM costs. Hardscaping and site-improvement costs also increase to \$1,321,000, together representing 10% of total BTM costs, because of the larger acreage required and greater number of pull-through charging stalls.

Figure 6

Breakdown of cost components of a medium charging facility prototype



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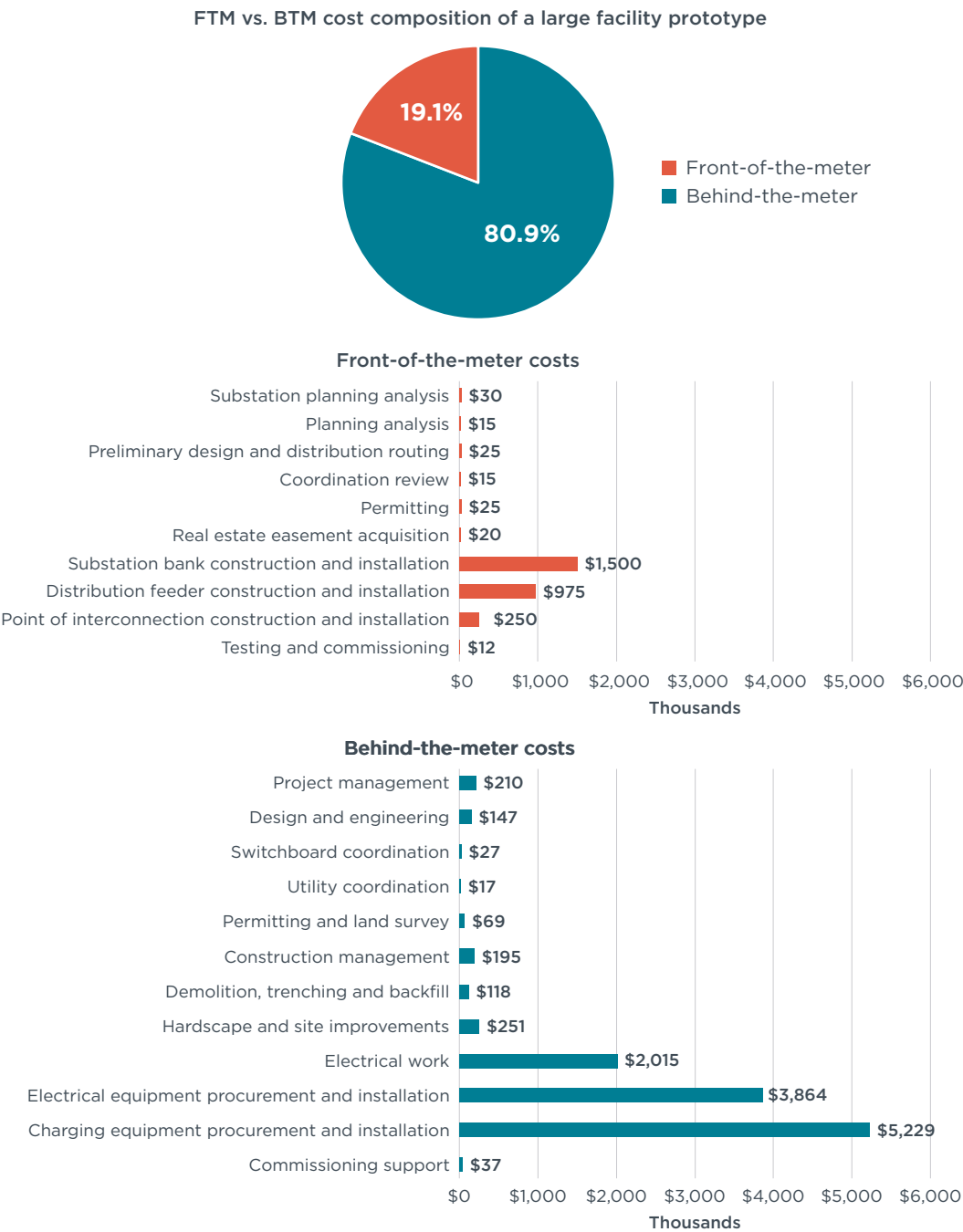
COST OF LARGE PROTOTYPE

The large prototype has a total cost of \$15 million, which is close to the total cost of the medium prototype. While the nameplate capacity of the large prototype jumps to 16 MW and the site acreage increases slightly to around 8 acres, the number of charging stalls decreases because the site has fewer dual-port slow chargers.

FTM costs are 19.1% of the combined costs of this prototype (Figure 7). Substation bank construction and installation costs are assumed to be the same as the two smaller prototypes because we make the same conservative assumption about substation and transformer-bank capacities in all prototypes. The inclusion of greenfield substations would raise the FTM costs substantially, but this analysis did not quantify those costs. Nevertheless, substation bank construction and installation costs still represent the greatest percentage of total FTM costs (52.3%). Additional costs for this prototype include an added circuit, which is associated with elevated construction and installation costs for a distribution feeder and point of interconnection; these items are the second and third largest components (34.0% and 8.8%, respectively) of FTM costs.

For BTM costs, three project components alone account for more than 90% of the total. Procurement and installation of charging equipment and electrical equipment rank the highest at \$5.2 million and \$3.7 million, respectively (42.9% and 31.7% of total BTM costs), followed by the cost of electrical work at about \$2 million (16.5% of total BTM costs). The costs of hardscaping and site improvement are lower than for the medium-sized facility, because the large public facility has fewer charging stalls and therefore requires less trenching, conduits, and civil engineering tasks, such as installing charger foundations and concrete pads for electrical equipment. Compared with the medium prototype, the higher BTM costs of charging and electrical-equipment procurement and installation are offset by the lower costs of electrical work, hardscaping, and demolition. This results in similar project costs for the medium and large prototypes, despite the large prototype having almost twice the electrical load size of the medium prototype.

Figure 7
Breakdown of cost components of a large charging facility prototype



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OPPORTUNITIES FOR LOWERING MHDV CHARGING FACILITY COSTS

In all three prototypes, cost variations primarily come from BTM investments. FTM costs range between \$2.5 million and \$2.9 million and at most account for 31.2% of the total project budget. The relatively constant FTM costs are a result of assumptions we make about the local distribution grid capacity at the prototype sites: we assume that the three prototypes require the utility to add a new transformer bank to the substation, and the large corridor prototype requires the utility to build a secondary circuit to connect to the distribution grid. We also assumed that it is not necessary to construct any new substations and that the distance between the substation and the charging facility site was assumed to be no farther than one mile. In cases where these assumptions are not true, FTM costs will be higher: a substation to transform the transmission voltage of 115 kV to the distribution voltage of 12.47 kV can range between a few million dollars to close to \$15 million, according to data from California.⁶ Increasing the distance between the substation and project site will also raise the cost of conductors and wires by around \$25,000 per mile. Avoiding these FTM costs could reduce the burden on ratepayers.

To achieve these FTM cost savings, utilities would need to partner with charging facility developers in the site-planning process. Analysis maps with up-to-date and accurate hosting capacity or integration capacity could help customers pick locations that have sufficient distribution grid capacity, thereby circumventing expensive and lengthy distribution grid upgrades.⁷

Demand for truck charging is also projected to increase over the next decade.⁸ So, in addition to these screening tools for near-term investments, utilities could also consult with developers and fleets that are potential truck-charging customers regarding the distribution network's capacity, interconnection timeline, and grid expansion costs over longer timeframes. Aligning distribution grid upgrades of electric utilities with the charging facility plans of targeted customers helps improve the cost-effectiveness of BTM and FTM investments.

Siting decisions can also have an impact on BTM costs. The prototypes assume that the developer owns the land of the charging facility, that it is zoned for commercial or industrial use, and that it is ready for construction. Therefore, land costs and permitting costs are minimal for the prototypes. In reality, these costs will depend on the location and conditions of the site. The costs of permitting, land acquisition and survey, construction management, demolition, trenching and backfill, hardscaping, and site improvements—identified in Table 3 and Table 4—may be much higher.

The highest BTM costs in all three prototypes are for charging-equipment procurement and installation. These costs will likely decline as the technology matures and the market scales. Modular design and the use of prefabricated charging equipment can also reduce the time and cost of on-site installation. However, the cost of electrical

6 California Independent System Operator, "Participating Transmission Owner per Unit Costs - 2023," February 13, 2023, <https://stakeholdercenter.caiso.com/RecurringStakeholderProcesses/Participating-transmission-owner-per-unit-costs-2023>.

7 U.S. Department of Energy, "U.S. Atlas of Electric Distribution System Hosting Capacity Maps," May 2024, <https://www.energy.gov/eere/us-atlas-electric-distribution-system-hosting-capacity-maps>.

8 Hamilton Steimer et al., *Mind the Gap: An Assessment of 2030 and 2035 Charging Infrastructure Needs for Zero-Emission Medium- and Heavy-Duty Vehicles in the United States* (International Council on Clean Transportation, 2025), <https://theicct.org/publication/assessment-of-2030-and-2035-charging-infrastructure-needs-for-ze-mhdv-us-jul25/>.

equipment such as transformers and switchgear (the second highest BTM cost) is less likely to decrease, because the technology and production are relatively mature and may even increase due to demands for electrification from other economic sectors.

To understand how charging-service providers can minimize BTM costs, Table 5 compares the unit costs of the three prototypes measured against MW of nameplate capacity and charger count. When we measure cost-effectiveness in terms of cost per charging port, the cost is \$170,000 per port for both the small and medium prototypes. In terms of cost per MW, the large prototype—the facility with the highest nameplate capacity—is the most cost-effective at \$0.8 million per MW. Recall that the large prototype has five ultra-fast 1,200 kW chargers, whereas the small and medium prototypes have none. This metric suggests that to reduce costs on a per-MW basis, charging-facility developers may opt for fewer and faster chargers over a larger number of slower chargers. The caveat is that more higher-power chargers also create a bigger load that may exceed the distribution grid’s capacity, thus triggering the need for more extensive FTM investments.

Table 5
Behind-the-meter unit costs for prototypes in this brief

Prototype	Nameplate capacity	Number of charging ports	Behind-the-meter costs	Behind-the-meter cost per MW	Behind-the-meter cost per port
Small	4 MW	32	\$5.4 million	\$1.4 million	\$170,000
Medium	8 MW	76	\$12.9 million	\$1.6 million	\$170,000
Large	16 MW	55	\$12.1 million	\$0.8 million	\$222,000

Finally, the adoption of alternative technologies can potentially reduce both BTM and FTM costs. Managed charging at facilities that serve vehicles with longer dwell times—that is, those with primarily slow chargers—can reduce the total peak load of the site, thereby reducing costs related to electrical and charging equipment procurement, BTM infrastructure installation, and FTM substation or distribution-feeder upgrades. Other solutions like on-site solar photovoltaic and battery-energy storage systems are more capital intensive. However, these may suit facilities that have room for expansion or sites that face grid-capacity limitations or delays associated with connecting to local distribution grids. The cost and timeline of these technologies are also affected by whether the on-site generation and battery-storage system solutions are connected to the distribution grid or if they only serve the load from the charging facility.



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