Port of Seattle

MOBILITY
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BUILT
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TAXI AND TRANSPORTATION NETWORK COMPANY ELECTRIFICATION RESEARCH – PHASE B

FINAL REPORT

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Executive Summary

The Port of Seattle is advancing its zero-emission transportation goals by supporting the electrification of ground transportation serving port facilities. Phase B of the Taxi and Transportation Network Company (TTNC) Electrification Research project builds on prior policy work by developing site-specific guidance for deploying DC fast charging infrastructure at the Pier 66 parking garage. The objective of Phase B is to inform near-term infrastructure planning while supporting scalable implementation over time.

Phase B consisted of two tasks: Task 2.1 Charging Recommendations and Task 2.2 Cost Estimation. Together, these tasks provide planning-level inputs to support future decision-making without presupposing procurement outcomes.

For Task 2.1, the port identified Level 5 of the Pier 66 parking garage as the target area for potential DC fast charging installation. Through drawing review, site visits, and coordination with port staff, the project team evaluated siting options based on electrical feasibility, constructability, accessibility, operational flow, and future expandability. This process identified the north corner of Level 5—directly above the main electrical room on Level 1—as the most suitable location. The existing electrical service was confirmed to have sufficient capacity to support initial deployment without major upgrades. Two layout scenarios were developed: dual-port chargers vs single-port chargers, each meeting ADA and operational requirements with differing cost and power implications.

The project also evaluated charger performance categories and design attributes based on port specifications and industry standards, including interoperability, footprint, accessibility, and operational suitability for high-turnover rideshare use. This evaluation aims to inform future specification development and procurement by illustrating tradeoffs among charger types available in the market.

Under Task 2.2, the project team developed an interactive EV Charging Infrastructure Cost and Energy Demand Estimation (EVCICE) model. The model integrates electrical infrastructure, civil works, indirect costs, and escalation assumptions to estimate total cost and power demand for alternative configurations. Results demonstrate that cost and energy demand vary significantly by charger configuration, reinforcing the value of scenario-based planning prior to procurement.

Overall, Phase B confirms that the Pier 66 parking garage is well positioned for near-term deployment of DC fast charging to support transportation network company (TNC) electrification, with minimal disruption and strong potential for phased expansion. The findings provide the port with a clear understanding of feasible locations, infrastructure requirements, cost ranges, and planning tradeoffs, while preserving flexibility for future design refinement and competitive procurement.

CHAPTER 1 INTRODUCTION

The Port of Seattle has established ambitious sustainability and decarbonization goals as part of its Century Agenda and related initiatives. A core target is to cut indirect (Scope 3) greenhouse gas emissions from Port-related activities by 50% by 2030 and achieve carbon neutrality by 2050. Reaching these milestones will require significant reductions in emissions from transportation services at Port facilities. Accordingly, the port's strategy emphasizes the transition to electric vehicles (EVs) and other low-carbon solutions for ground transportation, in alignment with policy directives like Port Resolution 3759 and Maritime Climate and Air Action Plan (MCAAP) on sustainable transportation (Port of Seattle, 2019 & 2021).

Transportation Network Companies (TNCs) —such as Uber and Lyft—and taxis play a critical role in passenger mobility at port facilities (including Seattle-Tacoma International Airport and the cruise terminals at Pier 91 and Pier 66) and thus are a key focus for emission reduction efforts. TNC and taxi trips contribute substantially to the port's ground transportation emissions, but they also offer an opportunity for significant emissions reductions through electrification. Port-sponsored previous research indicates that converting all TNC and taxi rides serving the airport to zero-emission vehicles (ZEVs) by 2030 could eliminate nearly 30,000 metric tons of CO_2 annually, equivalent to over 10% of the airport's passenger ground transport emissions. Similar benefits are anticipated for Maritime facilities. Advancing ZEV adoption in the ride-hailing sector not only helps the port meet its climate targets but also aligns with regional clean transportation goals and TNC industry commitments to electrify fleets. However, realizing this transition requires overcoming practical barriers—foremost among them the lack of convenient, affordable charging infrastructure for high-mileage TNC drivers. Insufficient access to charging has been identified as a primary obstacle to TNC and taxi electrification, underscoring the need for targeted infrastructure investments.

In light of these challenges and opportunities, Phase B of the port's Taxi and Transportation Network Company (TTNC) Electrification Research project is focused on translating policy goals into on-the-ground solutions. The specific purpose of Phase B is to develop site-specific EV charging recommendations (Task 2.1) and cost estimation (Task 2.2) to support TNC and taxi electrification. This entails identifying optimal charging station locations and configurations at port facilities and providing quantitative estimates of the total cost and power demand associated with those recommendations. This project aims to deliver a blueprint for deploying charging infrastructure that can effectively serve ride-hail drivers while meeting the port's operational requirements. The recommendations prioritize solutions that balance technical feasibility with cost-effectiveness, energy capacity constraints, and user accessibility, thereby laying the groundwork for pilot implementation at the Pier 66 parking garage.

The rest of the report is organized as follows: Chapter 2 outlines the applicable technical background and design standards. Chapter 3 details the project approach and methodology, including methodology employed in Task 2.1 Charging Recommendations and Task 2.2 Cost Estimation. Chapter 4 reports the findings and results for Task 2.1. Chapter 5 presents the findings and results for Task 2.2. Chapter 6 offers the conclusion and recommendations aligned with the port’s electrification and sustainability goals. Chapter 7 presents the appendix, including supplemental images that support the analyses and findings.

CHAPTER 2 TECHNICAL BACKGROUND AND DESIGN STANDARDS

Modern EV charging design draws from electrical codes, safety standards, accessibility guidance, and practical infrastructure considerations. The literature review of this report is drawn from national and international frameworks such NEC, NFPA, UL, ADA, Access Board, Section 508, FHWA, MUTCD, NREL, DOE, EPRI, NIST, PCI DSS, ISO 15118, OCPP, IEC 61851, IEC 62196, SAE J1772, SAE J3400, IEEE 519. The review confirms that EV charging is not a single technical discipline—it is an integrated design problem requiring coordinated attention to power systems, human factors, structural stability, and network reliability. The following sections and tables (Tables 2-1 through 2-10) synthesize the most relevant standards and research shaping the design of the Level 3 charging layout for the Port of Seattle facility.

2.1 Electric Vehicle Supply Equipment

Electric Vehicle Supply Equipment (EVSE) is defined not merely as a charger, but as a *system* of interoperating components responsible for delivering safe, reliable power to an electric vehicle (EV). The National Electrical Code (NEC) Article 625 and UL standards emphasize that EVSE must integrate conductors, connectors, control circuitry, grounding mechanisms, and user interfaces into a single, cohesive assembly. This systems-based nature is what makes EVSE engineering uniquely interdisciplinary.

Table 2-1: Core Components of EVSE Systems

Component Category	Description	Governing Standards
Power Electronics	Converts AC input to a controlled DC output	UL 2202; NEC 625
Conductors & Connectors	Cable assemblies, plugs, couplers	SAE J1772; UL 2251
Protection Systems	Ground fault, overcurrent & isolation monitoring	UL 2231
User Interfaces	Displays, controls, indicators	ADA / Section 508
Network Systems	OCPP communications, diagnostics	OCPP 2.0.1; ISO 15118

2.2 Level 3 DC Fast Charger Requirements

Charging levels differ not only in power but in fundamental design intent. Industry studies from NREL and FHWA consistently identify Level 3 fast charging as the only feasible option for time-critical fleets, such as port and airport rideshare vehicles, due to its ability to deliver rapid energy replenishment. Level 3 charging bypasses the vehicle's onboard charger, supplying power directly to the battery. This design supports rapid operational cycles—precisely the pattern observed in airport-based rideshare fleets, making Level 3 the industry-appropriate choice for the port facility. This charger type introduces electrical, mechanical, and communication requirements far more stringent than other charging levels. It is consistently framed as an infrastructure of high-power electrical equipment requiring industrial-grade protection by all standards.

2.2.1 Equipment & Enclosures

Table 2-2: Mechanical and Environmental Requirements for Level 3 Chargers

Requirement	Value / Description	Relevant Standard
Enclosure Rating	NEMA 4X (weather + corrosion protection)	UL 50E
Cable Length	≥ 20 ft, automated cable management	Access Board
Mounting Design	Pedestal, tamper-resistant, impact-protected	Port Specification
Protection Devices	Bollards/wheel stops, without blocking clear space	ADA; Access Board

The shift toward NEMA 4X enclosures in the literature signals a recognition that charging stations in public garages must withstand corrosion, moisture, vandalism, and constant use. Cable length and automated management are highlighted not only as convenience features but as safety measures, improving accessibility and reducing operational downtime.

2.2.2 Electrical Performance

Table 2-3: Electrical Standards for High-Power DC Fast Charging

Electrical Parameter	Required Value	Standard
Input Source	480 V AC, 3-phase	NEC 625
DC Output Range	200–1000 V	UL 2202
Continuous Load Sizing	125% of load	NEC 210/215
Total Harmonic Distortion	< 5%	IEEE 519
Power Factor	≥ 0.98	Industry Practice
Efficiency	≥ 96%	UL 2202 / NREL

High-power chargers must be placed close to their electrical source to limit conductor size, reduce losses, and maintain voltage quality. Therefore, placing chargers directly above the electrical room at the Pier 66 parking garage is fully aligned with best-practice siting principles and significantly reduces both capital costs and electrical risks.

2.2.3 Safety & Protection

Table 2-4: Required Electrical Protection Features

Ground Fault	20 mA DC protection	UL 2231
Isolation Monitoring	Mandatory	UL 2202
Overcurrent Protection	NEC-compliant	NEC 240
Auto-Fault Reset	Allowed where safe	Port Specification
Cold-Load Pickup	Sequential restart logic	IEEE 1547

DC faults behave differently than AC faults and require specialized detection methods. Automated protective functions reduce reliance on human intervention, which is critical in unattended public charging environments like port garages.

2.2.4 Network Connectivity

Table 2-5: Communication and Cybersecurity Requirements

Requirement Type	Description	Standard
Communication Protocol	OCPP 2.0.1+	Open Charge Alliance
Data Security	Encrypted communication, signed firmware	NIST
Authentication	RFID, app, or ISO 15118 plug-and-charge	ISO 15118
Remote Control	Diagnostics, alerts, load management	OCPP 2.0.1

Network connectivity is not a convenience—it is the operational backbone of DC fast charging. Liu et al. (2023) showed that networked chargers achieve significantly higher uptime due to remote diagnostics and automated reporting. In a commercial port-airport ecosystem, this reliability is non-negotiable.

2.2.5 User Interface & Communication Accessibility

Table 2-6: User Interface & Accessibility Requirements

UI Feature	Requirement	Guideline
Display	High-contrast, daylight-readable	ADA / ABA
Tactile Features	Braille + raised text	Section 508
Audio	Speech-enabled	Access Board
Operable Height	≤ 48" reach	ADA
Feedback Modes	Visual + audible signals	Section 508

User interface (UI) accessibility is one of the most empirically documented pain points in public charging (Touker et al., 2025). The Consumer Report (2025) found that UI failures are often more common than hardware faults. Thus, incorporating multisensory, reach-compliant interfaces, the design reduces user error and expands accessibility.

2.2.6 Payment & Customer Support

Table 2-7: Payment Requirements for Public Charging

Requirement	Description	Framework
Payment Security	PCI DSS / PA-DSS compliance	PCI
Multi-Modal Payment	App, RFID, plug-and-charge	ISO 15118
Pricing Transparency	Clear on-screen display	ADA/508
Customer Support	24/7 assistance requirement	Best Practice

Payment accessibility is directly tied to user trust (Liu et al., 2023). Airport drivers—often working on tight schedules—require reliable, frictionless payment options. Payment Card Industry (PC) compliance and multi-modal payments are repeatedly recognized as drivers of charging reliability and user satisfaction.

2.3 Accessibility Requirements

Table 2-8: Key Accessibility Standards for EV Charging

Feature	Requirement	Standard
Accessible Stall	11 ft × 20 ft	Access Board
Access Aisle	5 ft wide	ADA
Max Slope	1:48	ADA
Clear Floor Space	30" × 48"	Access Board
UI Reach Range	≤ 48"	ADA

Accessible charging requires more than wider parking stalls (Mastoi et al., 2023), it requires circulation space, unobstructed routes, and accessible interfaces. The ADA/ABA standards highlights a core distinction—charging involves *physical engagement* (lifting, positioning cables), not simply parking. This distinction justifies the expanded stall geometry and clear floor space integrated into the project layout.

2.4 Civil & Structural Requirements

Table 2-9: Civil & Structural EVSE Requirements

Element	Requirement	Reference
Equipment Pad	8" reinforced concrete slab	Port Spec
Concrete Strength	4000 psi	ACI
Pad Elevation	4" above finished grade	Port Spec
Accessible Slope	≤ 1:48	ADA
Bollards	Protection without blocking access	Access Board/Port Spec

Civil design literature stresses durability and accessibility (Lin et al., 2024). Reinforced pads prevent equipment settlement, while ADA-compliant grades ensure maneuverability. Placing chargers directly above electrical room also avoids unnecessary slab penetration and reduces structural risk.

2.5 Layout Design Considerations

Table 2-10: Drivers Influencing Charger Location

Driver	Practical Importance	Literature Source
Electrical Proximity	Reduces feeder length & cost	NEC; NREL
Accessible Geometry	Aligns aisle with charger face	ADA; Access Board
Circulation Efficiency	Minimizes turning conflicts	FHWA
Structural Feasibility	Avoids PT tendon zones	ACI
Operational Safety	Maintains sightlines & lighting	IES
Maintenance Access	Consolidates equipment zones	EPRI

Siting the chargers directly above the electrical room satisfies all major criteria recognized in the literature: low electrical cost, accessible layout, safe circulation, minimal structural disruption, and simplified maintenance. In fleet-based environments, such as airport rideshare staging, this alignment between design standards and operational logic is a hallmark of best-practice infrastructure planning.

CHAPTER 3 PROJECT APPROACH AND METHODOLOGY

The methodological approach for this project followed a structured, evidence-driven process designed to ensure that Task 2.1 Charging Recommendations and Task 2.2 Cost Estimation were grounded in both the Port of Seattle's operational needs and the technical requirements of EVSE installation. The process combined drawing review, field screening, technical analysis, and iterative consultation with the port to progressively refine the proposed solutions. The methodology described below reflects a sequence of deliberate steps that aligned with professional practice and project objectives.

3.1 Data Collection and Preliminary Assessment

3.1.1 Architectural and Electrical Drawing Review

Following initial coordination with Port representative (Jessica Brown), the project team collected data on the potential sites for charger location. The port stated their interest in having DC fast dual-port chargers at Level 5 of the Pier 66 parking garage. The team thus requested and received architectural and partial electrical drawings for the Pier 66 parking garage. These drawings were reviewed to understand structural constraints, the electrical distribution system, available conduit pathways, and the spatial characteristics of Level 5. This early technical review formed the basis for identifying plausible charger locations before any field investigation occurred.

3.1.2 Site Visits and Field Screening

After reviewing the drawings, the team conducted five site visits—including a site walk with the port personnel on November 4—to validate and refine their understanding of site conditions. Field screening focused on:

- Confirming the proximity between Level 5 and the electrical room on Level 1
- Confirming the services capacities
- Understanding ADA pathways, slopes, and existing stall geometry
- Identifying obstacles such as structural elements, drainage, posts, and overhead obstructions
- Observing natural vehicle circulation patterns
- Verifying panel and disconnect access

These observations were used to validate drawing information and ensure that the proposed design would reflect real-world conditions.

3.1.3 Benchmarking and Industry Context

To contextualize design decisions, the team visited other parking facilities with existing EVSE installations. These visits helped the team understand practical design considerations such as stall layout, cable management, visibility, accessibility features, and equipment protection measures. Benchmarking ensured the target charger installation would reflect current industry's best practices.

3.2 Task 2.1 Charging Recommendations

3.2.1 Charger Siting and Location Evaluation

The process of selecting a preferred charging location followed a criteria-driven evaluation framework.

Based on the review and site visit findings and industry guidelines, the team applied a consistent set of screening criteria to evaluate sites on Level 5:

- Electrical feasibility: available panel capacity, transformer and switchgear support, and the ability to minimize conduit runs
- Structural feasibility: avoiding major slab penetrations or post-tensioned areas
- Accessibility compliance: ADA routes, path-of-travel clarity, and operable-part reach
- Operational flow: intuitive driver approach, safe turning radius, and garage circulation patterns
- Expansion potential: opportunities to scale from initial chargers to future deployments
- Visibility and user convenience

3.2.2 Charger Type Recommendation

The evaluation of suitable Level 3 DC fast chargers followed a structured, criteria-based methodology inspired by industry selection frameworks such as the multi-factor evaluation matrix shown in the *EV Charger Selection Guide*. Using the same structured logic, the project team developed a screening matrix tailored to the Port of Seattle’s operational environment, site constraints, and procurement requirements.

This evaluation matrix (Table 3-1) allowed the team to move beyond purely technical comparisons and instead evaluate how well each charger type would perform within the specific operational environment of the Pier 66 parking garage. Importantly, the port’s specification identifying Autel, EVCS, EV Gateway, EVBox, and Kempower as acceptable manufacturers also served as a filtering boundary. Only chargers offered by these manufacturers—or equivalents meeting all technical requirements—were advanced through the full evaluation matrix.

Table 3-1: Charger Type Screening and Evaluation Matrix

Category	Evaluation Criteria	Rationale for Methodological Use
1. Electrical Performance	Output power range (kW) Number of ports (single vs dual) Connector type (CCS / NACS) Input power requirements (480V, 3Ø) Power sharing / load management capability	Ensures compatibility with existing electrical infrastructure, minimizes service upgrades, and aligns with Port-approved design specifications. Electrical performance also affects charging speed, queue management, and operational efficiency.
2. Mechanical Design & Footprint	Charger mounting configuration Physical footprint & clearance needs Cable length and management Enclosure rating (NEMA 3R/4X) Structural compatibility with Level 5 deck	Ensures chargers physically fit within Level 5 constraints, maintain ADA compliance, and withstand environmental conditions. Also evaluates installability without major structural modifications (e.g., avoiding post-tensioned areas).
3. Software & Network Capabilities	OCPP 2.0.1 compliance Remote diagnostics Firmware updates Energy monitoring/reporting Integration with Port backend systems	Reflects the port's need for remotely monitored, maintainable, and data-driven charging infrastructure. Software capability is a key determinant of operational reliability and customer service.
4. User Interface, Accessibility & Payment	ADA-compliant interface height & reach Clarity of display NFC/app/credit card payment options Plug-and-Charge readiness Multilingual support (optional)	Ensures chargers meet ADA and U.S. Access Board guidelines. Payment flexibility and usability affect customer satisfaction and reduce transaction frictions.
5. Vendor Compliance & Port Alignment	Whether vendor is on Port-approved list (Autel, EVCS, EV Gateway, EVBox, Kempower) Availability of service/warranty support Expected longevity	Ensures compliance with procurement requirements and reduces vendor-related delays or warranty risks.
6. Operational Suitability for Rideshare Electrification	Charger uptime and reliability ratings Queueing and throughput performance Dual-charging efficiency	Reflects the unique operational demands of Uber/Lyft fleets, where high turnover and minimal downtime are mission-critical.

3.3 Tasks 2.2 Cost Estimation

The cost estimation process for this project followed a structured methodology designed to produce a reliable, user-friendly, and adaptable conceptual cost and energy demand tool for EV charging infrastructure. Central to the approach was the development of a model (EVCICE) that could support scenario-based planning and decision-making.

3.3.1 Model Development Framework

The project team began by establishing the conceptual structure for the EVCICE model. The initial model framework identified all major cost components associated with all kinds of charging infrastructure, including hardware, electrical service equipment, installation labor, and civil works. The purpose was to ensure the tool calculated both total capital cost and corresponding electrical power demand for various design configurations for varying options of charging infrastructures.

3.3.2 Cost Component Identification

The cost estimation methodology categorized all relevant elements of the EVSE installation into three major groups, as summarized in Table 3-2.

Table 3-2: Cost Components for Level 3 EVSE Installation

Cost Category	Subcomponents / Elements Included
1. Electrical Infrastructure	Level 2 chargers (single-port or dual-port) Level 3 DC fast chargers (single-port or dual-port) Transformers (new, upgraded, or existing capacity confirmation) Switchgear Circuit breakers and protective devices
2. Civil and Structural Works	Trenching and backfill X-ray and core drilling (for slab penetrations) Housekeeping pads for equipment Bollards and wheel stops Pavement striping and ADA signage Optional canopy structures
3. Indirect Cost Components	General Conditions WA State B&O Tax City B&O Tax Permitting and Plan Review Design Services Design Contingency Construction Contingency Insurance & Bond Contractor Fee

3.3.3 Data Sources and Cost Inputs

To ensure that the model reflects realistic construction conditions and market pricing, the project team used a combination of regional contractor inputs and nationally recognized cost databases. This blended approach strengthens both the accuracy and applicability of the model's output.

- *Valley Electric* – A major electrical contractor operating throughout the Western United States, with extensive experience in commercial, industrial, transportation, heavy civil, and marine electrical systems.
- *EV Support (aka, Puget Sound Solar)* – A Washington State–based general electrical contractor specializing in EV charging infrastructure.
- *JOBS EVSE 2.0 (Argonne National Laboratory, 2023)* – An Excel-based analytical tool developed to estimate capital costs and economic impacts associated with EVSE.
- Gordian, *Building Construction Costs Book* (2025) – A leading U.S. construction cost reference widely used by industry professionals.
- *Tyler, National Electrical Estimator (2023)* – A comprehensive cost guide published by the Craftsman Book Company, providing detailed labor, material, and equipment costs for electrical installations.

3.4 Data Validation

The team had a series of meetings with Valley Electric to validate the model's structure, assumptions, and outputs. Valley Electric reviewed material quantities, cost drivers, installation methods, iterations used, and their feedback directly informed adjustments to construction assumptions. The cost data was further validated with inputs from EV Support. The team thereafter presented the findings to the Port of Seattle for feedback.

CHAPTER 4 TASK 2.1 CHARGING RECOMMENDATIONS

4.1 Rationale for the Preferred Charger Location

4.1.1 Summary of Site Screening

The Port of Seattle identified Level 5 of the Pier 66 parking garage as the viable site for the target DC fast charger installation. Initial discussions called for two dual-port chargers, but later meetings opened the option to use four single-port units. The team evaluated both configurations based on proximity to power, accessibility, vehicle circulation, and constructability. As detailed in Chapter 3, these criteria led to the selection of a cluster of stalls on the north corner of Level 5, directly above the main electrical room on Level 1, as the preferred location for the charger (Figure 4.1).

Figure 4-1: *Location on Level 5 north corner of Pier 66 garage identified for DC fast charger installation, directly above the electrical room to minimize conduit length and installation cost.*

4.1.2 Proximity to Electrical Infrastructure

The chosen site aligns vertically with the electrical room on Level 1, allowing a short, direct conduit run that minimizes installation cost, energy loss, and structural impacts. The electrical room services—switchgear and transformer capacities—can support the proposed chargers without major electrical upgrades, making this the most efficient and least disruptive location.

4.1.3 Constructability and Future Expansion

The alignment with the electrical room on Level 1 eases the core drilling operation through the post-tensioned deck and avoids long horizontal conduit routes. Also, installation can occur without closing large sections of the garage. The clustered layout also provides future scalability—additional chargers can be installed along the same line using existing electrical provisions. This approach meets current needs for up to four charging ports while preparing the site for phased expansion as demand grows.

4.2 Preferred Charger Layout Configuration

Two layout scenarios were developed for the Level 5 charger installation to meet the port's needs and maintain flexibility for equipment procurement. The first scenario includes two dual-port DC fast chargers (to serve up to four vehicles simultaneously), while the second provides four single-port chargers in the same area. Both layouts are shown in Figures 4-2 & 7-4 (dual-port) and Figures 4-3 & 7-3 (single-port).

Each scenario was designed to illustrate vehicle flow to and from the charging area, the configuration of stalls, and the integration of ADA accessibility requirements. Both layouts were reviewed against the design standards summarized in Chapters 2 and 3, including those from the U.S. Access Board's 2023 EV Charging Guidelines, 2010 ADA Standards for Accessible Design, and Port of Seattle EVSE Specifications

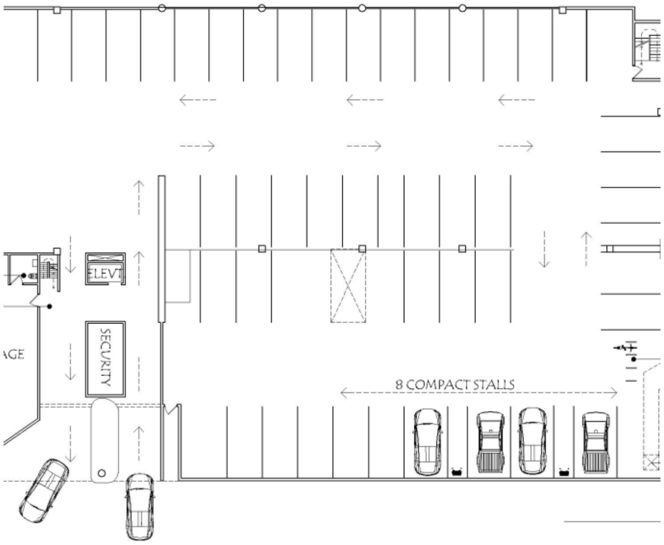


Figure 4-2: *Layout showing two dual-port DC fast chargers serving four parking stalls, arranged along the outer lane of Level 5 to align with one-way vehicle circulation and minimize maneuvering conflicts.*

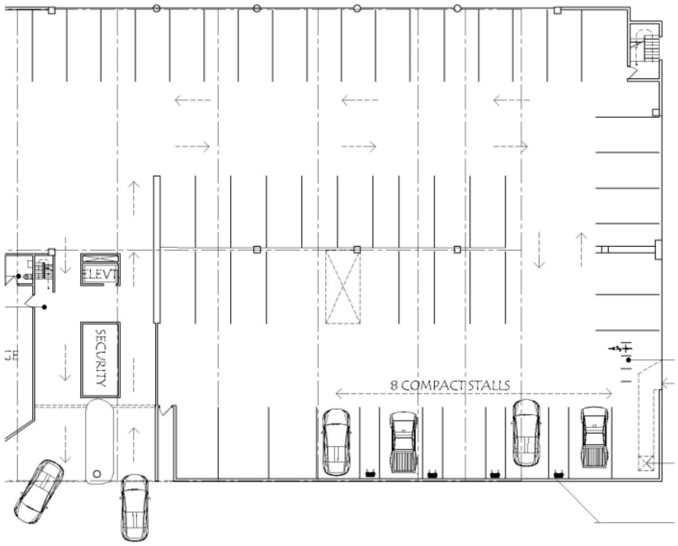


Figure 4-3: *Layout showing four single-port DC fast chargers distributed across adjacent stalls, allowing individual vehicle access while maintaining circulation flow on Level 5.*

4.2.1 Accessibility and ADA-Compliant Stall Design

The plan layouts (Figures 4-2, 4-3, 7-3, & 7-4) show vehicles entering Level 5 through the existing circulation route from Elliott Avenue, then turning into the charging area along the outer lane. The chargers are placed between parking bays, allowing drivers to pull in forward with cables reaching either side. This arrangement minimizes reverse maneuvers and keeps vehicles aligned with the flow of traffic. Clear directional arrows and pavement markings guide approach and exit paths to maintain smooth circulation for rideshare operations (See Figures 4-4, 4-5, 7-8, 7-9, & 7-10).

Figure 4-4: *Conceptual ADA-compliant EV charging layout showing accessible stall dimensions, access aisle, and compliant reach ranges for charger interface and cable access (AI generated)*

Each scenario is ADA-accessible, in accordance with the U.S. Access Board's Technical Assistance Document (2023). The accessible stall includes:

- Minimum stall width of 11 ft and an adjacent 5 ft access aisle, and 20 ft length, striped with contrasting color for visibility.
- Vertical clearance of at least 98 inches (8 ft-2 in) to accommodate vehicles with roof-mounted equipment.
- No wheel stops in front of the stall to ensure full maneuvering clearance for personal mobility assistance device users.
- Reachable interface heights, ensuring operable parts (e.g., screen, plug holster, payment system) are mounted between 15 inches and 48 inches above the ground.
- The accessible stall is marked with the International Symbol of Accessibility (ISA) and labeled "Accessible EV Charging Only."
- Other stalls are painted "EV Charging Only" with green demarcation lines to distinguish them from general parking.
- Directional arrows guide vehicles into the stalls in accordance with the garage one-way traffic pattern.
- Overhead or wall-mounted signs reinforce stall use restrictions and identify charging bay numbers for driver clarity.

- Each charger is set on a housekeeping pad (approx. 4 ft × 4 ft, 12 in deep)
- All cable lengths of minimum 20 ft and swing radii comply with the reach envelopes specified in IEC 61851-1 and ADA Section 309.

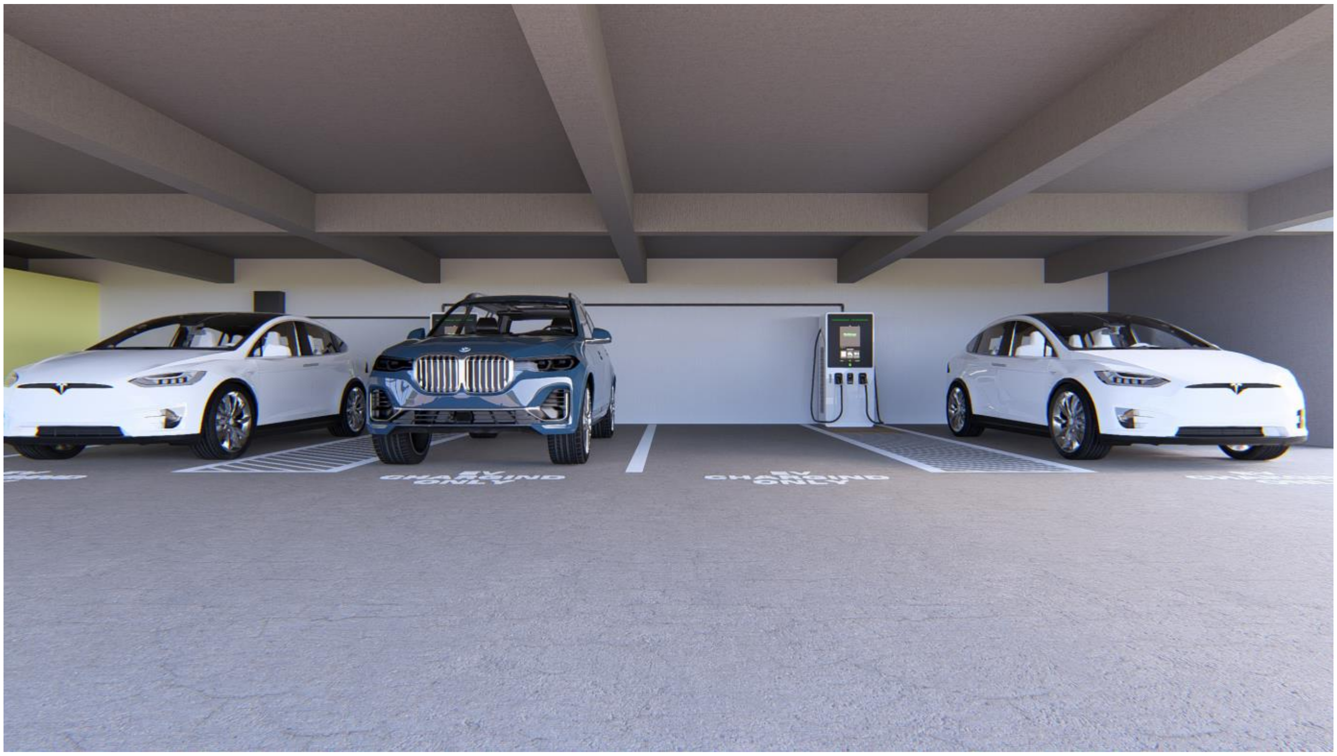


Figure 4-5: *Dual-port charger layout with ADA-compliant stall configuration, including access aisle, directional markings, and charger placement optimized for forward entry and exit.*

4.3 Charger Type Recommendation

4.3.1 Application of Screening Criteria

As detailed in Chapter 3, the project team evaluated DC fast charger options from the manufacturers specified in the Port of Seattle's *EVSE Technical Specification*, including Autel, EVCS, EV Gateway, EVBox, and Kempower, or an approved equal. Each candidate was assessed using the screening criteria outlined in the methodology (Table 3-1). This analysis utilized publicly available technical data and manufacturer specifications. Only models with verified OCPP compliance, UL certification, and NEMA 3R or higher enclosure rating was considered suitable for the port's application.

4.3.2 Recommended Charger Type / Model Category

Table 4-1 summarizes the performance characteristics of chargers from each port-approved manufacturer, as evaluated against the agency's requirements. Data reflects verified public specifications as of 2025.

4.3.3 Advantages and Trade-offs

The evaluation indicates that charger solutions offered by manufacturers currently included in the Port of Seattle's specifications—such as Autel, Kempower, and EVBox—are capable of meeting the port's requirements for power delivery, software interoperability, and physical compatibility within the Level 5 parking garage environment. Solutions similar to Autel's MaxiCharger demonstrate modular scalability (60–240 kW), OCPP 2.0.1 compliance, and North American market support within a compact cabinet—ideal for constrained spaces and phased expansion. Charger systems comparable to Kempower's Station Charger provide a higher-end solution, offering shared output up to 400 kW, intuitive cable management, and a strong user interface, but with greater space and power demands. Solutions comparable to EVBox's Troniq Modular emphasize compact design and ADA compliance but appear to have limited domestic support and longer part replacement lead times.

EV Gateway and EVCS, while included in the port's approved list, operate primarily as network management platforms rather than hardware suppliers and are better suited as integration partners.

The evaluation results indicate that charger solutions with characteristics similar to those offered by Autel and Kempower align well with the port's technical requirements and operational constraints. This evaluation is intended to inform future specification development and procurement planning by illustrating comparative strengths and constraints across charger types, rather than to recommend or endorse specific products.

4.4 Electrical Feasibility Findings

4.4.1 Panel Capacity

A review of the port's electrical drawings and a joint site visit with the port personnel confirmed that the existing electrical service on Level 1 as shown in Figure 7.1 provides sufficient spare capacity to support the proposed installation of two dual-port or four single-port DC fast chargers. The available panel and switchgear ratings can accommodate the required load without major service upgrades. Only standard over-current protection and feeder connections will be needed during installation.

4.4.2 Feeder Routing Feasibility

Because the preferred charger location on Level 5 sits directly above the electrical room, the feeder routing is short, direct, and technically feasible, as shown in Figure 7.2. The design proposes a vertical conduit run through the garage structure, minimizing bends, slab penetrations, and cable lengths. This approach reduces voltage drop, installation cost, and potential interference with post-tension cables. Additional layout designs could be assessed at Chapter 7—the Appendix of this report.

Table 4-1: Comparison of Candidate DC Fast Chargers

Manufacturer	Example Model / Family & Power Class	Verified DC Power Range (kW)	Connector Options (DC)	OCPP / Cross-Vendor Software Compatibility	Notable Mechanical / Site Fit Notes	Typical Use / Comments
Autel	MaxiCharger DC Fast – Mid-Range Config	Modular 60–240 kW, configurable in 20 kW steps (Autel Energy)	Dual CCS1, or CCS1 + CHAdeMO (some configs also CCS1 + NACS) (BEQ Technology)	OCPP-compliant; Smart Cloud Portal. Can manage any OCPP-compatible chargers using Autel's cloud portal (Autel Energy)	Outdoor-rated (NEMA 3R), UL/CSA listed; pedestal cabinet with integrated 27" touchscreen; suitable for structured parking environments (Autel Energy)	Good "workhorse" mid-to-high power DCFC with flexible modular power; attractive where you may start around 120 kW and scale up later without full hardware replacement.
Autel	MaxiCharger DC Fast – High-Power Config	Same family, configured near upper range 180–240 kW (BEQ Technology)	Same as above (Dual CCS1 or CCS1 + CHAdeMO / NACS) (BEQ Technology)	Same OCPP-compliant platform; cloud portal can interoperate with other OCPP chargers on the same backend (Autel Energy)	Higher input current (up to ~365 A at 240 kW) so requires stronger upstream electrical capacity and careful panel/feeder sizing (BEQ Technology)	Suitable for sites where very fast turnaround is critical and electrical infrastructure can support higher continuous loads.
Kempower	Station Charger – Mid-Range Config	50–200 kW from modular 50 kW power blocks (Kempower)	1–2 DC outlets; CCS1, CHAdeMO, NACS options (Kempower)	OCPP backend integration supported; chargers can be connected directly to a customer's OCPP backend (operator defines OCPP endpoints) (Kempower TIP)	Compact cabinet with 1–2 outlets; advanced spring-supported cable management (≈4–6 m reach); modular cabinet count allows tuning footprint vs. power (Kempower)	Very flexible for constrained garage environments where modular scaling and good cable management are important.
Kempower	Station Charger – High-Power Config	Up to 400 kW total system power; up to 240 kW per port, dynamic power sharing (Storyblok)	Up to 4 DC outputs in some multi-cabinet builds (Kempower)	Same OCPP support; Kempower's ChargEye platform offers APIs and integrations, and can also connect to third-party OCPP backends (Kempower)	Multi-cabinet layouts can support multiple satellites; more floor area but high throughput. Good fit where multiple vehicles are expected to fast charge concurrently (Kempower)	Strong candidate for a future "high-throughput" scenario if the port later wants more power and multiple simultaneous fast charges in the same footprint.
EVBox	Troniq Modular – Mid-Range Config	Starts at 90 kW, upgradable in 30 kW steps up to 240 kW (Hagenum)	Up to 3 connectors (e.g., CCS2, CHAdeMO, AC Type 2 in EU markets; NA variants focus on CCS1) (Hagenum)	OCPP-compliant, can connect to *any* OCPP backend. OCPP 1.6J with roadmap to 2.0.1; ISO 15118 / Plug-and-Charge ready (Hagenum)	Modular design (≈40 kW modules); compact footprint (Troniq Compact ~0.3 m²) simplifies layout in tight garages; modules are field-replaceable for easier maintenance (EVBox)	Very attractive where space is tight but the port still wants scalable power and full OCPP interoperability with its chosen backend.
EVBox	Troniq High Power – High-Power Config	200–400 kW total output (high-power DC family) (EVBox)	High-power CCS configuration for rapid DCFC; supports multi-vehicle simultaneous charging with dynamic load sharing (EVBox)	OCPP 1.6J, ready for 2.0.1; can integrate into any OCPP-compliant backend, providing true cross-vendor backend flexibility (EVBox)	Requires more electrical capacity and careful thermal/space planning; best suited where the port prioritizes maximum power over number of ports.	Candidate for a "premium" fast-throughput airport scenario where vehicle dwell time is very short and high-power charging is mission-critical.
EvGateway	EvGateway Network + Hardware-Agnostic DCFC	Power depends on the paired charger (EvGateway does not manufacture its own DCFC hardware; it integrates hardware from multiple vendors) (Siemens Assets)	Connector type depends on underlying hardware (CCS / CHAdeMO / NACS possible)	Hardware-agnostic OCPP network: any charger that complies with OCPP 1.6 or above can be integrated (Siemens Assets)	No single standard footprint—EvGateway pairs its software/network platform with third-party hardware selected per site (Siemens Assets)	EvGateway is best thought of as the network and management layer, not as a specific charger. For Port purposes, this is relevant to backend/CMS selection and cross-vendor compatibility, not to physical model choice.
EVCS	EVCS DC Fast Charger Deployments (Vendor Mix)	Power varies by installation; EVCS operates sites with DC fast chargers, some retrofitted with NACS connectors in CA, but does not publicly market a single standard DCFC model line under "EVCS" branding (EVCS)	Sites typically support CCS and NACS; mix of Level 2 and DCFC equipment (EVCS)	Public sources describe EVCS primarily as a network/CPO; detailed OCPP documentation for a specific "EVCS"-branded DCFC is not clearly published. Likely uses OCPP-compliant third-party hardware but not explicitly specified.	Hardware and footprint depend on deployed vendor (e.g., Tritium or others); no single "reference" cabinet to design around.	For this project, EVCS is most relevant as a potential operating partner, not as a distinct hardware product family. If the port wants hard specs, it will need to identify the underlying hardware vendor used in an EVCS deployment.

CHAPTER 5 TASK 2.2 COST ESTIMATION

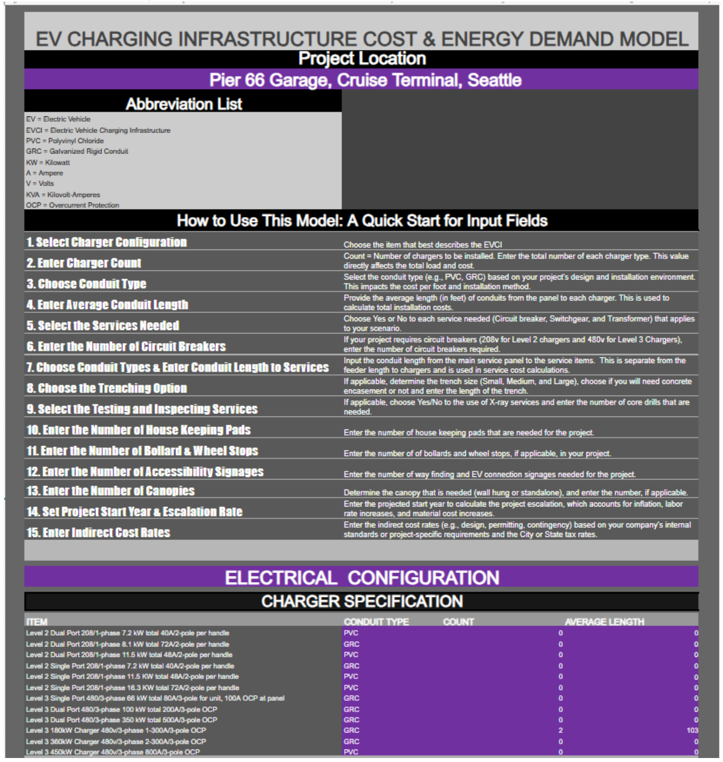
5.1 Cost Estimation Results

5.1.1 Total Estimated Cost and Energy Demand

An interactive user-friendly cost and energy demand model was developed, called EV Charging Infrastructure Cost and Energy demand model (EVCICE) tool to estimate the total cost and the total energy (kW) demand for the proposed EV charging infrastructure on Level 5 of the Pier 66 parking garage. The tool is adaptable and thus could be used in different projects and planning scenarios. It integrates both electrical and civil components and produces scenario-based cost outputs to support planning and decision-making.

The tool is organized into three functional sections:

- *Input Section (Figures 5-1 & 5-2):* Users select the charger configuration and specify site-specific electrical needs, civil works required, annual escalation rate, and indirect costs applicable. The interface includes toggles that let the user define whether the installation will require a new circuit breaker, switchgear, transformer, or any combination thereof — or rely entirely on existing service capacity. These conditional inputs determine how the model allocates electrical equipment and installation costs.
- *Calculation Section:* It is the hidden section of the model that support iterative and interactive calculations. This section automatically computes cost subtotals for electrical infrastructure, and civil works based on the selected configuration. All material and labor unit rates are sourced from *Valley Electric* cost data, as well as industry-standard references, including *Gordian Building Construction Cost Data (2023)*, *National Electrical Estimator (Tyler, 2023)*, and *JOBS EVSE 2.0 (Argonne National Laboratory, 2023)*. And later validated by inputs from EV Support (aka, Puget Sound Solar)
- *Output Section (Figure 5-3)***:** *Generates* the total estimated cost and aggregate energy demand (kW) for the selected scenario, displaying both as summary table for quick interpretation.



EV CHARGING INFRASTRUCTURE COST & ENERGY DEMAND MODEL

Project Location

Pier 66 Garage, Cruise Terminal, Seattle

Abbreviation List

EV = Electric Vehicle
EVCI = Electric Vehicle Charging Infrastructure
PVC = Polyvinyl Chloride
GRC = Galvanized Rigid Conduit
KW = Kilowatt
A = Ampere
V = Volts
KVA = Kilovolt-Amperes
OCP = Overcurrent Protection

How to Use This Model: A Quick Start for Input Fields

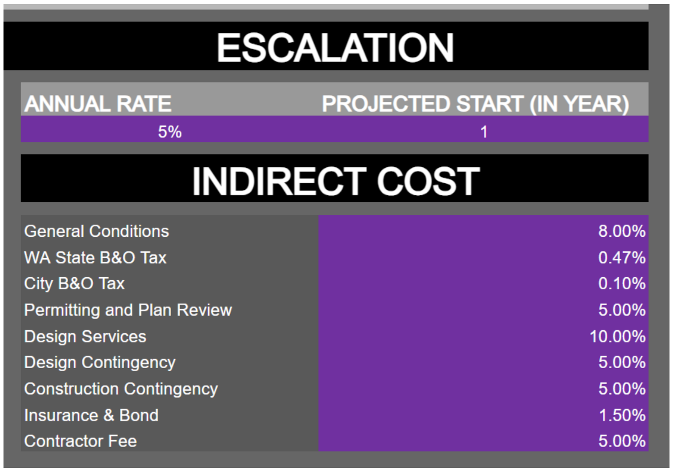
1. Select Charger Configuration	Choose the item that best describes the EVCI
2. Enter Charger Count	Count = Number of chargers to be installed. Enter the total number of each charger type. This value directly affects the total load and cost.
3. Choose Conduit Type	Select the conduit type (e.g., PVC, GRC) based on your project's design and installation environment. This impacts the cost per foot and installation method.
4. Enter Average Conduit Length	Provide the average length (in feet) of conduits from the panel to each charger. This is used to calculate total installation costs.
5. Select the Services Needed	Choose Yes or No to each service needed (Circuit breaker, Switchgear, and Transformer) that applies to your scenario.
6. Enter the Number of Circuit Breakers	If your project requires circuit breakers (208v for Level 2 chargers and 480v for Level 3 Chargers), enter the number of circuit breakers required.
7. Choose Conduit Types & Enter Conduit Length to Services	Input the conduit length from the main service panel to the service items. This is separate from the feeder length to chargers and is used in service cost calculations.
8. Choose the Trenching Option	If applicable, determine the trench size (Small, Medium, and Large), choose if you will need concrete encasement or not and enter the length of the trench.
9. Select the Testing and Inspecting Services	If applicable, choose Yes/No to the use of X-ray services and enter the number of core drills that are needed.
10. Enter the Number of House Keeping Pads	Enter the number of house keeping pads that are needed for the project.
11. Enter the Number of Bollard & Wheel Stops	Enter the number of of bollards and wheel stops, if applicable, in your project.
12. Enter the Number of Accessibility Signages	Enter the number of way finding and EV connection signages needed for the project.
13. Enter the Number of Canopies	Determine the canopy that is needed (wall hung or standalone), and enter the number, if applicable.
14. Set Project Start Year & Escalation Rate	Enter the projected start year to calculate the project escalation, which accounts for inflation, labor rate increases, and material cost increases.
15. Enter Indirect Cost Rates	Enter the indirect cost rates (e.g., design, permitting, contingency) based on your company's internal standards or project-specific requirements and the City or State tax rates.

ELECTRICAL CONFIGURATION

CHARGER SPECIFICATION

ITEM	CONDUIT TYPE	COUNT	AVERAGE LENGTH
Level 2 Dual Port 208/1-phase 7.2 kW total 40A/2-pole per handle	PVC	0	0
Level 2 Dual Port 208/1-phase 8.1 kW total 72A/2-pole per handle	GRC	0	0
Level 2 Dual Port 208/1-phase 11.5 kW total 48A/2-pole per handle	PVC	0	0
Level 2 Single Port 208/1-phase 7.2 kW total 40A/2-pole per handle	GRC	0	0
Level 2 Single Port 208/1-phase 11.5 KW total 48A/2-pole per handle	PVC	0	0
Level 2 Single Port 208/1-phase 16.3 KW total 72A/2-pole per handle	PVC	0	0
Level 3 Single Port 480/3-phase 66 kW total 80A/3-pole for unit, 100A OCP at panel	GRC	0	0
Level 3 Dual Port 480/3-phase 100 kW total 200A/3-pole OCP	GRC	0	0
Level 3 Dual Port 480/3-phase 350 kW total 500A/3-pole OCP	GRC	0	0
Level 3 180kW Charger 480v/3-phase 1-300A/3-pole OCP	GRC	2	103
Level 3 360kW Charger 480v/3-phase 2-300A/3-pole OCP	GRC	0	0
Level 3 450kW Charger 480v/3-phase 800A/3-pole OCP	PVC	0	0

Figure 5-1: *Screenshot of the input interface of the EVCICE model, showing user-defined parameters such as charger configuration, electrical infrastructure options, civil works, and project assumptions.*



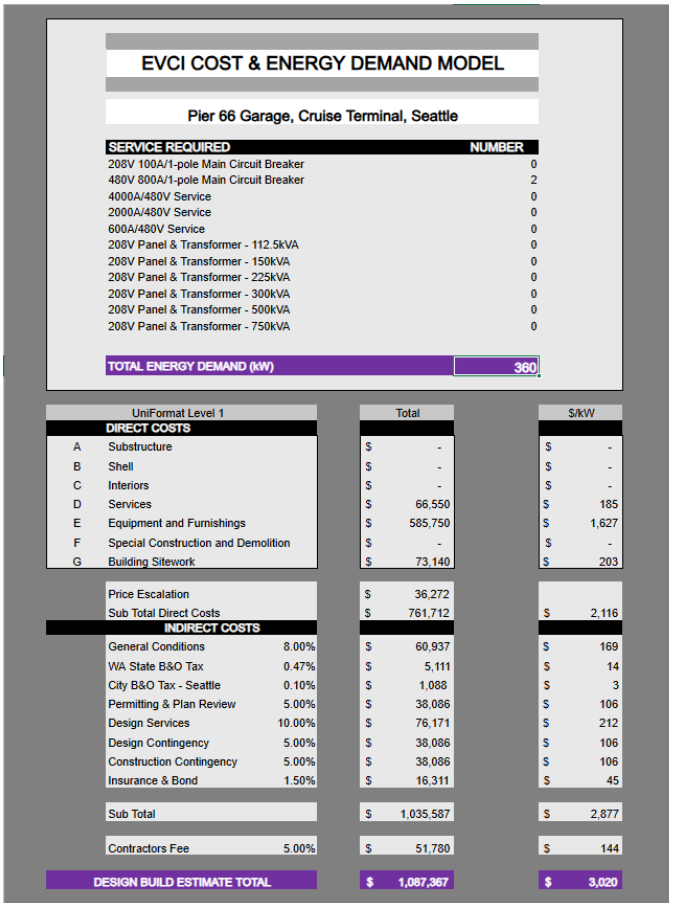
ESCALATION

ANNUAL RATE	PROJECTED START (IN YEAR)
5%	1

INDIRECT COST

General Conditions	8.00%
WA State B&O Tax	0.47%
City B&O Tax	0.10%
Permitting and Plan Review	5.00%
Design Services	10.00%
Design Contingency	5.00%
Construction Contingency	5.00%
Insurance & Bond	1.50%
Contractor Fee	5.00%

Figure 5-2: *Input interface showing escalation rate and indirect cost parameters within the EVCICE model, allowing adjustment of project year, inflation assumptions, and additional cost factors.*



EVCI COST & ENERGY DEMAND MODEL

Pier 66 Garage, Cruise Terminal, Seattle

SERVICE REQUIRED	NUMBER
208V 100A/1-pole Main Circuit Breaker	0
480V 800A/1-pole Main Circuit Breaker	2
4000A/480V Service	0
2000A/480V Service	0
600A/480V Service	0
208V Panel & Transformer - 112.5kVA	0
208V Panel & Transformer - 150kVA	0
208V Panel & Transformer - 225kVA	0
208V Panel & Transformer - 300kVA	0
208V Panel & Transformer - 500kVA	0
208V Panel & Transformer - 750kVA	0
TOTAL ENERGY DEMAND (kW)	360

UniFormat Level 1			Total	$/kW
	DIRECT COSTS			
A	Substructure		$ -	$ -
B	Shell		$ -	$ -
C	Interiors		$ -	$ -
D	Services		$ 66,550	$ 185
E	Equipment and Furnishings		$ 585,750	$ 1,627
F	Special Construction and Demolition		$ -	$ -
G	Building Sitework		$ 73,140	$ 203
	Price Escalation		$ 36,272	
	Sub Total Direct Costs		$ 761,712	$ 2,116
	INDIRECT COSTS			
	General Conditions	8.00%	$ 60,937	$ 169
	WA State B&O Tax	0.47%	$ 5,111	$ 14
	City B&O Tax - Seattle	0.10%	$ 1,088	$ 3
	Permitting & Plan Review	5.00%	$ 38,086	$ 106
	Design Services	10.00%	$ 76,171	$ 212
	Design Contingency	5.00%	$ 38,086	$ 106
	Construction Contingency	5.00%	$ 38,086	$ 106
	Insurance & Bond	1.50%	$ 16,311	$ 45
	Sub Total		$ 1,035,587	$ 2,877
	Contractors Fee	5.00%	$ 51,780	$ 144
	DESIGN BUILD ESTIMATE TOTAL		$ 1,087,367	$ 3,020

Figure 5-3: *Output interface of the EVCICE model displaying calculated total installed cost and estimated energy demand based on selected configuration inputs.*

5.1.2 Major Cost Drivers

Project costs in the EVCICE Model are primarily influenced by the following components:

- *Charger Hardware:* The single largest contributor to total installed cost. Unit price varies with power output and manufacturer but typically accounts for more than half of the project total.
- *Electrical Infrastructure*: Includes feeders/conduits, circuit breakers, and, where selected, switchgear and transformer costs. The model's toggle function isolates these components, allowing users to quantify cost impacts of each electrical element.
- *Civil and Architectural Works:* Covers core drilling, housekeeping pads, ADA-compliant striping, pavement markings, and signage. Costs are proportional to the number of chargers and stalls.
- *Escalation (Figure 5.2):* Users select the intended year of project execution (from the 2025 baseline) and apply a customizable annual escalation rate. This enables dynamic adjustment of projected costs to reflect inflation or market trends, enhancing the model's long-term planning utility.
- *Indirect Costs (Figure 5.2):* Includes taxes, insurance, permitting, and contingency allowances (typically 5–15%), applied as a percentage of direct construction costs.

5.1.3 Scenario Comparisons

The model evaluates two primary charger configurations under identical site conditions:

- *Scenario 1:* Dual-port DC fast charger configuration (serving four vehicles simultaneously).
- *Scenario 2:* Single-port DC fast charger configuration (four chargers total).

For this analysis, the model assumes a project start year of 2026 with a 5% annual escalation rate applied to cost components. Both the dual-port and single-port scenarios are embedded as selectable options within the model's Charger Configuration input menu. When users choose either "Dual L3" or "Single L3" and specify the required electrical components, civil works required and the indirect cost, the model automatically recalculates total cost, energy demand, and associated infrastructure needs. These outputs are summarized in Table 5.1 below.

Table 5-1: Summary of Cost Model Outputs by Scenario

Scenario	Charger Configuration	Electrical Upgrade Components Selected	Civil Work Components Selected	Total Installed Cost (USD)	Estimated Energy Demand (kW)
1	Dual-Port DC Fast Chargers (Level 3) 180kW Charger 480v/3-phase 1-300A/3-pole OCP (2 units / 4 ports)	Two Circuit Breaker Zero Switchgear Zero Transformer, 103 ft average length of Feeder	X-ray concrete Slab, Four core drill, Two Housekeeping pads, Four Bollards, Four Way Finding signages, and Two EV connection signages	$1,087,367	360kW
2	Single-Port DC Fast Chargers (Level 3) 480v/3-phase 66 kW total 80A/3-pole for unit, 100A OCP at panel	Four Circuit Breaker, Zero Switchgear, Zero Transformer, 114 ft average length of Feeder	X-ray concrete Slab, Four core drill, Four Housekeeping pads, Eight Bollards, Four Way Finding signages, and Four EV connection signages	$818,374	266kW

The cost model estimates a total installed cost of $1,087,367 and an energy demand of 360 kW for the dual-port configuration, compared to $818,374 and 266 kW for the single-port configuration. These variations are primarily driven by the power ratings of the selected charger units, with higher-capacity chargers significantly increasing both cost and energy requirements. Importantly, if lower-power dual-port chargers are selected, the dual-port configuration could become more cost-effective than the single-port option. The model's modular structure will enable the port to adjust critical inputs—such as charger type, quantity, and supporting equipment—and immediately assess the impact on total estimate and electrical load. This flexibility ensures the tool remains responsive to evolving procurement options and infrastructure constraints.

CHAPTER 6 RECOMMENDATIONS AND CONCLUSION

The analysis presented in this report supports a strategic, cost-efficient deployment of EV charging infrastructure to accelerate TNC and taxi electrification at the Port of Seattle's Pier 66 parking garage. Based on the evaluation of candidate sites, electrical feasibility, charger hardware options, and cost scenarios, we provide the following recommendations:

6.1 Recommendations

1. *Preferred Location – Level 5 North Corner*: Select the north corner of Level 5 in the Pier 66 parking garage for initial deployment. This location offers a direct vertical conduit path to the electrical room on Level 1, minimizing installation cost, and reduces voltage drop, potential interference with post-tension cables and construction disruption while preserving future scalability.
2. *Charger Configuration – Flexible Scenario-Based Implementation*: Adopt a modular deployment approach that allows for either dual-port or single-port DC fast chargers, depending on availability and procurement cost. Both configurations have been evaluated for ADA compliance, traffic circulation, and energy demand. The dual-port configuration is preferred for space efficiency if compatible units are readily available.
3. *Hardware Selection – Charger Type Evaluation*: Evaluate charger solutions representative of those offered by manufacturers—for example, Autel and Kempower—to assess how different design approaches align with the port's technical requirements and operational goals. Charger systems comparable to Autel's MaxiCharger illustrate OCPP 2.0.1 interoperability and characteristics that may support cost-effective, phased deployment. Charger systems comparable to Kempower's Station Charger demonstrate advanced modular systems suitable for higher-throughput applications and future fleet-scale needs. These examples are presented to illustrate performance tradeoffs and integration considerations and are intended to inform future specification development and procurement planning.
4. *Cost Planning – Use of Interactive Model (EVCICE):* Utilize the EVCICE model to support procurement and capital planning. This tool enables estimation of total cost and energy demand based on user-defined configurations, escalation rates, and infrastructure requirements. It should serve as a living tool for ongoing project refinement and decision-making.
5. *Scalable Infrastructure Design*: Design civil and electrical infrastructure with expansion in mind. The

selected Level 5 at the north corner alignment enables phased installation of additional chargers in line with anticipated demand growth, helping the port meet its ZEV targets while managing capital exposure.

6.2 Conclusion

The Phase B evaluation demonstrates that the Port of Seattle can deploy high-capacity EV charging infrastructure at the Pier 66 parking garage in a manner that is technically feasible, cost-efficient, and aligned with TNC electrification goals. The analysis identified the Level 5 north corner as the optimal installation site, offering a direct electrical path to existing infrastructure and sufficient capacity to support up to four DC fast charging ports without major service upgrades.

Both dual-port and single-port charger configurations were assessed in detail using a set of defined criteria and the EVCICE cost and energy demand model. While both scenarios meet ADA and operational requirements, dual-port chargers offer greater space efficiency and reduced unit cost per kW when power availability and equipment lead time allow.

The evaluation also examined charger performance characteristics within the port’s approved list of manufacturers, illustrating how different solutions align with the port’s interoperability, performance, and serviceability requirements. These findings aim to inform future specification development and procurement planning.

By integrating site-specific electrical review, industry-informed cost inputs, and quantitative scenario analysis, this project provides a structured framework to support informed EVSE planning and investment decisions. The results offer the port a clear technical and economic basis for near-term TNC electrification at Pier 66, while preserving flexibility for future expansion and application to other port facilities.

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CHAPTER 7 APPENDIX

Figure 7-1: *Photograph of the electrical room on Level 1 of the Pier 66 parking garage, showing existing switchgear and electrical infrastructure supporting the proposed EV charger installation.*

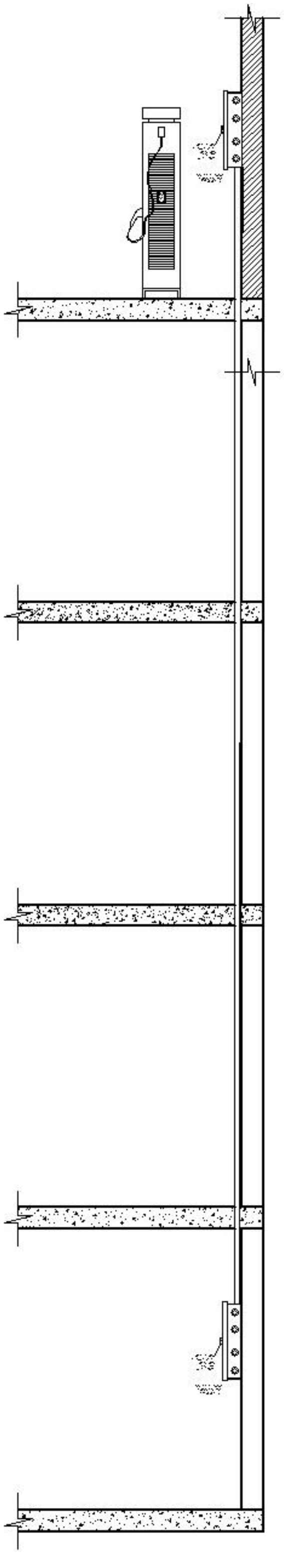

Figure 7-2: *Sectional diagram showing vertical alignment between Level 5 charger location and Level 1 electrical room, illustrating proposed conduit routing path.*

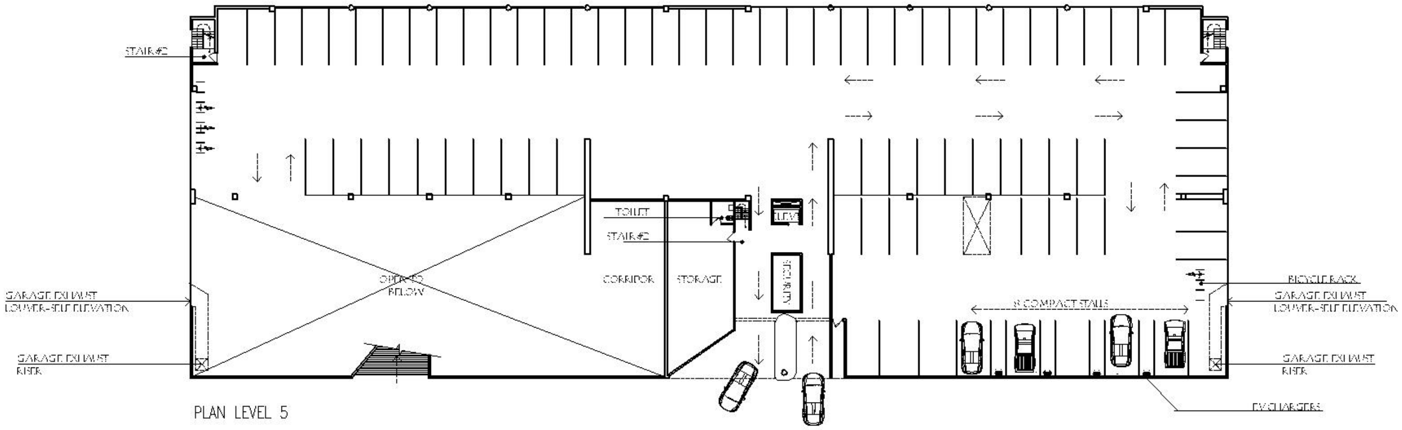

Figure 7-3: *Detailed plan view of single-port DC fast charger configuration showing stall arrangement, cable reach, and circulation paths.*

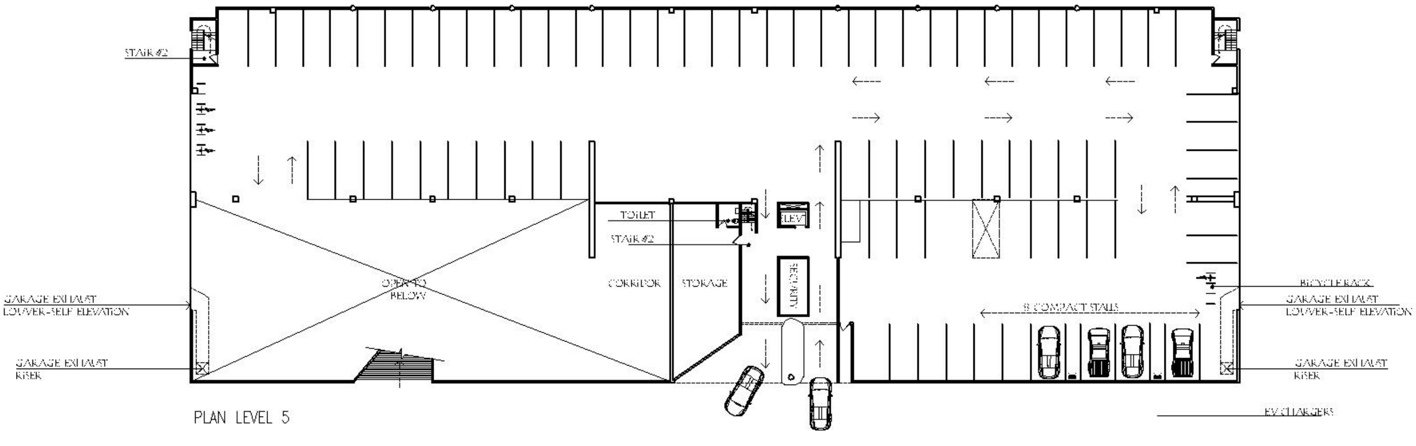

Figure 7-4: *Detailed plan view of dual-port DC fast charger configuration showing shared charger placement between stalls and vehicle access paths*.

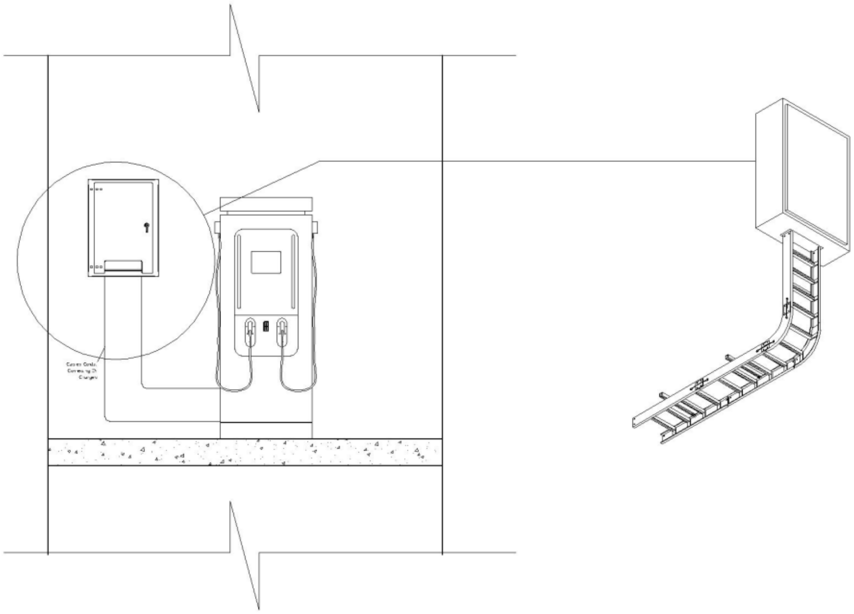

Figure 7-5: *Illustration of a dual-port DC fast charger installation including associated circuit breaker and electrical protection components.*

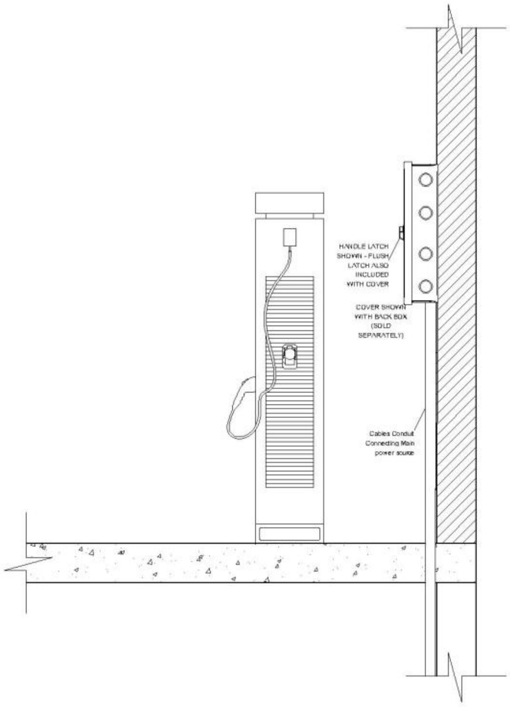

Figure 7-6: *Sectional drawing of charger installation showing equipment mounting, conduit routing, and connection to electrical infrastructure.*

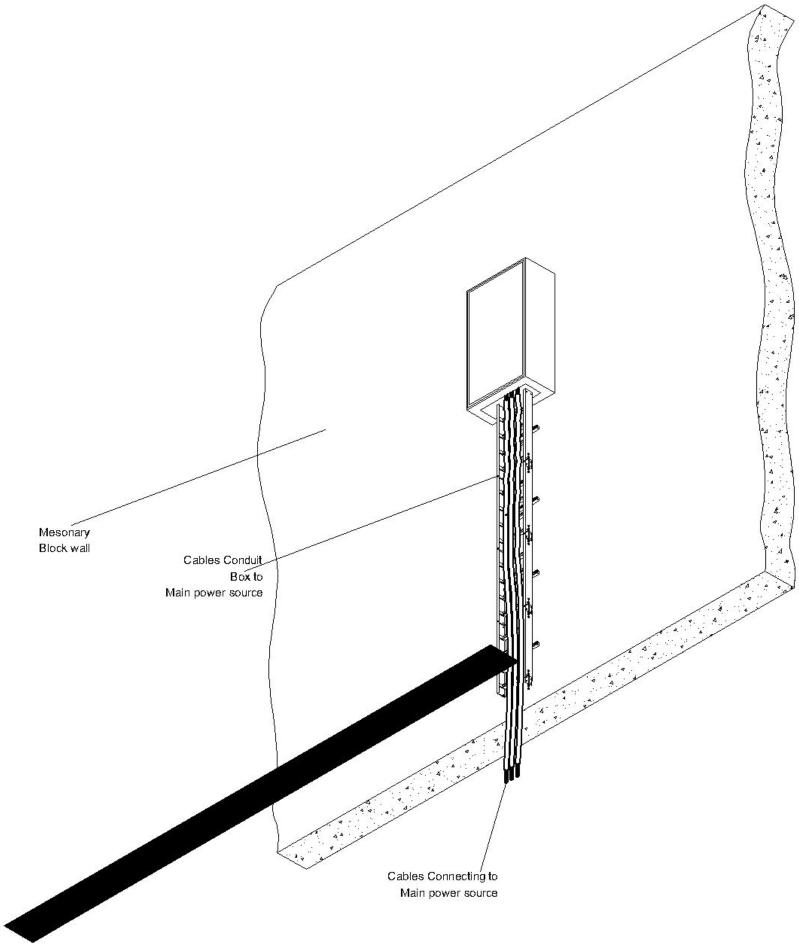

Figure 7-7: *Diagram illustrating electrical cable routing from charging units to the electrical room, including conduit path and connection points.*

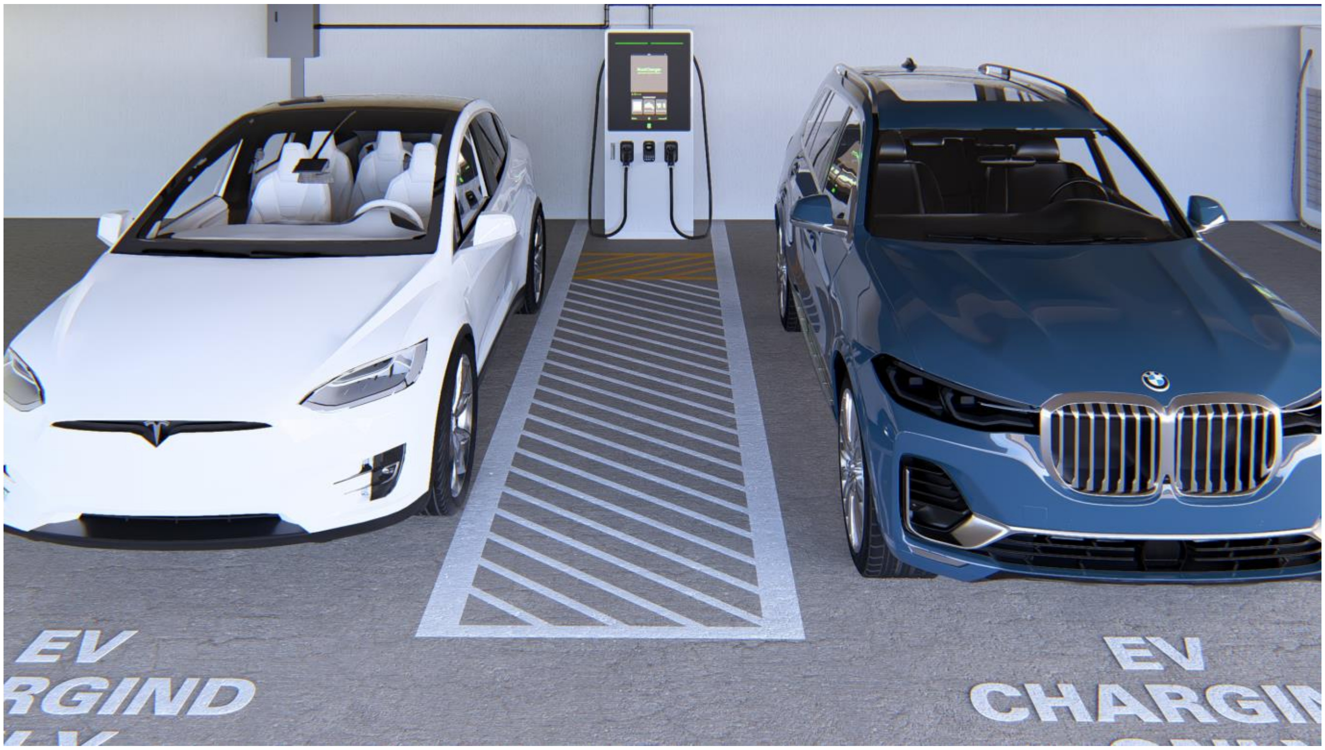

Figure 7-8: *Illustration of a dual-port DC fast charger setup showing a centrally located unit serving two adjacent vehicles with cables extending to both sides.*

Figure 7-9: *Illustration of a dual-port DC fast charger configuration showing charger placement between parking stalls and simultaneous charging of two vehicles.*

Figure 7-10: *Illustration of a dual-port DC fast charger installation showing vehicle positioning, cable reach, and layout within a parking deck environment.*