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Electric Island: Daimler Trucks North America and Portland General Electric's Heavy-Duty Vehicle Charging Demonstration Site

Jacob Brulc[1], Joe Colett[2]

[1]*Daimler Trucks, EV Charging Infrastructure engineer, 4555 N Channel Ave. Portland, OR 97217, Jacob.brulc@daimler.com*

[2]*PGE, Product Manager - Emerging Technologies, 121 SW Salmon St, Portland, OR 97204 Joe.Colett@pgn.com*

Summary

Electric vehicle technology is developing at a staggering pace, which requires vehicle manufacturers, charging infrastructure suppliers, and utilities to work together to ensure positive customer outcomes. This is especially true for heavy-duty vehicles, which will likely require charging rates far exceeding today's electric light duty passenger vehicles and transit buses. To better understand the challenges associated with charging electric heavy-duty vehicles, Portland General Electric (PGE), Oregon's largest electric utility, and Daimler Trucks North America (DTNA), the U.S. market leader in heavy-duty vehicles, are co-developing the U.S.'s first public, purpose-built heavy-duty truck charging demonstration site. PGE and DTNA will use the site to gather valuable learnings about site design, charging infrastructure deployment and operation, and the grid impacts of vehicle charging rates in excess of one megawatt. The site will also host complimentary grid edge infrastructure, including energy storage and solar generation, and allow for both parties to experiment with cutting edge vehicle-to-grid and second life battery technologies. While the site is still in the engineering and design phase, early learnings have included the importance of utility and municipal engagement, optimal site layout methodologies, and the challenges of designing for fast charging infrastructure that is not yet widely deployed.

Keywords: BEV (battery electric vehicle), heavy-duty, demonstration, DC Fast Charging, infrastructure

1 Introduction

In October 2018, the U.S. reached an important milestone as the one millionth light-duty electric vehicle was sold. Current estimates project sales to accelerate rapidly, with the next million electric vehicles hitting U.S. roads in early 2021[1]. The acceleration in transportation electrification is also expanding the types of vehicles being electrified. In August of 2019, Daimler Trucks North America (DTNA), the U.S. market leader in heavy-duty vehicles, introduced the eCascadia, an all-electric Class 8 on-highway semi-truck.

Today, DTNA has over 20 eCascadias deployed at customer sites for evaluation and testing as part of the Freightliner Electric Innovation Fleet.

To move up to 80,000 pounds of equipment and goods for hundreds of miles at highway speeds, electric semi-trucks are equipped with much larger batteries than typical light-duty vehicles. Battery capacities can exceed 500 kilowatt-hours (kWh) and, to keep vehicles on the road as much as possible, must be recharged quickly. Charging infrastructure that can provide power at levels exceeding one MW will be required to deliver large amounts of energy in a short period-of-time. DTNA partnered with Portland General Electric (PGE) to explore the challenges associated with deploying charging infrastructure for heavy-duty vehicles. PGE and DTNA will build the first public, purpose-built heavy-duty truck charging site in the U.S., referred to as Electric Island. This partnership will allow both parties to capture valuable learnings in infrastructure design, deployment and grid impacts. The sections below further detail the partnership, challenges to be explored, site design and layout, and the learnings captured so far.

2 Strategic Partnership Opportunity

2.1 Utility perspective

PGE conducts a wide range of research and development activities to ensure future customer needs are anticipated and met. These efforts include participation in industry-funded research programs, market research and customer interviews, pilot program development and deployments, and strategic partnerships with customers. PGE staff also maintain regular contact with customers about industry trends and their future energy needs, including the eMobility group at DTNA. These interactions quickly revealed a shared interest in learning more about heavy-duty truck charging infrastructure and an opportunity for the co-development of a heavy-duty charging infrastructure demonstration site (referred to as Electric Island) in PGE's service area.

In a future where electric truck charging infrastructure may require grid connections in excess of ten megawatts at distribution centers and fueling stations, PGE must learn how to quickly serve these new loads in a way that creates a positive customer experience and positive impacts for the grid. Partnering on the deployment of heavy-duty truck charging infrastructure at Electric Island offered PGE an opportunity to participate in the design, deployment, commissioning, and operation of heavy-duty charging infrastructure far in advance of more widespread deployments and gain key insights that can be applied to future products and services.

In this partnership, PGE will be responsible for the installation and operation of all civil and electrical infrastructure required for the installation of the heavy-duty truck charging station, referred to as make-ready, and, in the future, a utility-owned energy storage system. Make-ready infrastructure and energy storage systems are becoming key utility assets that may be part of future PGE products and services. Infrastructure ownership and desired learnings are further detailed in Table 1.

Table 1.Electric Island Ownership Structure and Desired Learnings.

Site Component	Ownership	Desired Learning
Make-Ready Infrastructure	PGE	• Unique distribution planning and service design requirements for 5+ MW of concentrated new loads at commercial locations • Civil and electrical infrastructure design and layout best practices
Charging Stations	DTNA	• Heavy-duty charging infrastructure load profiles • Grid impacts of multiple heavy-duty charging stations cycling on and off
Showcase Building	DTNA	• Opportunity to learn from customers visiting the site • Opportunity to share learnings by hosting education and training events
Energy Storage	PGE and DTNA	• Use of energy storage to counteract grid impacts of heavy-duty charging • Use of second-life vehicle batteries to provide grid services
Solar Generation	DTNA	• Incorporation of grid edge generation assets to integrate with heavy-duty charging

2.2 Commercial Vehicle OEM Perspective

DTNA works closely with its customers and dealers to make sure they meet the changing market requirements with industry leading commercial vehicles and supporting technologies. To this end, DTNA started several programs including the electric commercial vehicle programs including Freightliner Electric Innovation Fleet [2], Freightliner Customer Experience Fleet [3], and eTruck Charging Initiative [4]. The Freightliner Electric Innovation Fleet and Customer Experience Fleet programs focus on helping customers learn how to integrate electric trucks into their day-to-day operations. The eTruck Charging Initiative is an effort to consult customers and dealers on how to install and maintain charging infrastructure to support electric commercial vehicles. It is important to mention that programs like Freightliner Electric Innovation Fleet would not be possible without the support of partners like South Coast Air Quality Management District (SCAQMD), who partially funded the Innovation Fleet with a nearly $16 million grant.

DTNA outreach programs lead it to talk with our local utility, PGE, which lead to a collaboration opportunity. This collaboration will enable DTNA to better consult its fleet customers on EV charging infrastructure design recommendations.

3 Unique Challenges to Commercial Vehicle Manufacturers

In recent years, many heavy-duty commercial vehicle manufacturers have made announcements about future electric truck offerings. These trucks look and feel similar to the diesel equivalent, but generally have shorter ranges and require long charge times. In the short term, fleets must use these commercial EV's in shorter-range applications with long - typically overnight - charging times. In the near future, new technology will enable vehicle ranges to be extended and charge times reduced.

A common question from fleet owners is how to charge these new EV's while meeting internal economic targets like return on investment (ROI). This question has inspired organizations like CharIN to develop a new charging standard for commercial vehicles that focuses on charging vehicles at two MW or greater [5]. Increased charging power will help decrease the time needed to charge vehicle batteries and increase the amount of time vehicles are in revenue service (deliveries, freight hauling, etc.). Another method to improve ROI for fleets is for utilities to incentivize the charging infrastructure installations and defer demand charges like Southern California Edison has with their fleet charging and make-ready programs [6]. These are just two of many examples of the industry, utilities, and commercial vehicle manufacturers working together to electrify commercial vehicles.

4 Unique Challenges to Utilities

Electric utilities play a key role in providing electricity as a transportation fuel. This is especially true in Oregon, where investor owned utilities are tasked with accelerating transportation electrification through Oregon Senate Bills 1547 [7] and 1044 [8] and Executive Order 20-04 (March 10th, 2020) [9]. PGE has a long history of leadership in transportation electrification, from deploying the U.S.'s first public DC fast charger in the parking garage of their headquarters building in 2011, to the piloting of DC fast charging in the public right-of-way at Electric Avenue in 2015. These activities have grown to include the build out of utility-owned public fast charging and transit charging infrastructure through PGE's 2016 Transportation Electrification Plan [10].

PGE also plays a key role in enabling customer installations of charging infrastructure, including dedicated technical outreach staff that help customers evaluate, select, design, install, and interconnect commercial and fleet charging infrastructure. Interactions with customers and learnings from infrastructure deployments feed directly back into the design and deployment of new PGE programs.

PGE has been closely tracking recent increases in infrastructure charging power and the number of stations deployed per location. Both can have impacts on the local distribution grid as maximum loads grow to over one megawatt at individual locations.

This trend is especially true for heavy-duty vehicles. With battery sizes potentially in excess 500 kWh and strong economic incentives to charge as quickly as possible, heavy-duty vehicles may be charging at rates of one MW or higher. In scenarios where multiple heavy-duty vehicles are charging at distribution or refueling centers, peak loads could begin to exceed five to ten megawatts. Heavy-duty vehicle charging may also create new and unique load profiles as multiple vehicles begin and end charging sessions, creating large peaks and valleys in power requirements. These and other anticipated challenges unique to heavy-duty charging are detailed below in Table 2.

Table 2. Commercial vehicle charging infrastructure technical requirements and challenges.

Technical Requirements	**Description**	**Challenge**
Charging power in excess of 1 MW per charger	Heavy-duty vehicles may charge at rates in excess of 1 MW to keep charging session times short	Existing electrical service and distribution network may not have capacity to serve large new loads without extensive upgrades
Fast charging rate ramp-up / ramp-down	Charging sessions increase power delivery to maximum output in seconds and can end sessions quickly if customer needs to depart before full charge	May cause power quality issues on local distribution grid
Multiple high-powered chargers in one location	Multiple trucks will likely need to be charged at each commercial distribution or refueling center	Existing electrical service and distribution network unlikely to be adequate for 5 - 10+ MW of new load without extensive upgrades
Chargers installed at commercial facilities	Charging stations may be located at commercial buildings without adequate existing service	Commercial facilities may not have adequate existing electrical service and require upgrades
Chargers installed in rural locations	Charging stations may be located in rural areas with limited distribution infrastructure	If existing local distribution network lacks capacity, upgrades may become more cumbersome as distances to nearest substation may be further

The research conducted at Electric Island will help PGE develop new products and services and better understand how grid edge technologies, including managed charging, energy storage, and distributed generation, can help address these challenges.

5 Site Layout and Design

5.1 Site Components

PGE and DTNA worked with engineering and design contractor Black and Veatch to create a site layout that includes:

- A showcase building with restrooms, an educational space, and room to display electric heavy-duty vehicles
- The capacity to simultaneously charge up to six heavy-duty electric vehicles via four charging islands
- Capacity for up to twelve heavy-duty vehicle charging dispensers (three dispensers per island)
- Transformer and equipment pad area with:
  - Two utility transformer vaults capable of supporting two 2,500 kVA transformers
  - Two 3,000A switchgears
  - Up to thirty AC to DC power conversion electronics enclosures
  - Additional room for energy storage system inverters and communications equipment

- Up to two battery energy storage systems (total of 1 MW / 2 MWh of storage)
- Capacity for on-site solar generation
- Four light duty vehicle Level 2 charging stations

The overall site layout is further detailed in Figure 1.

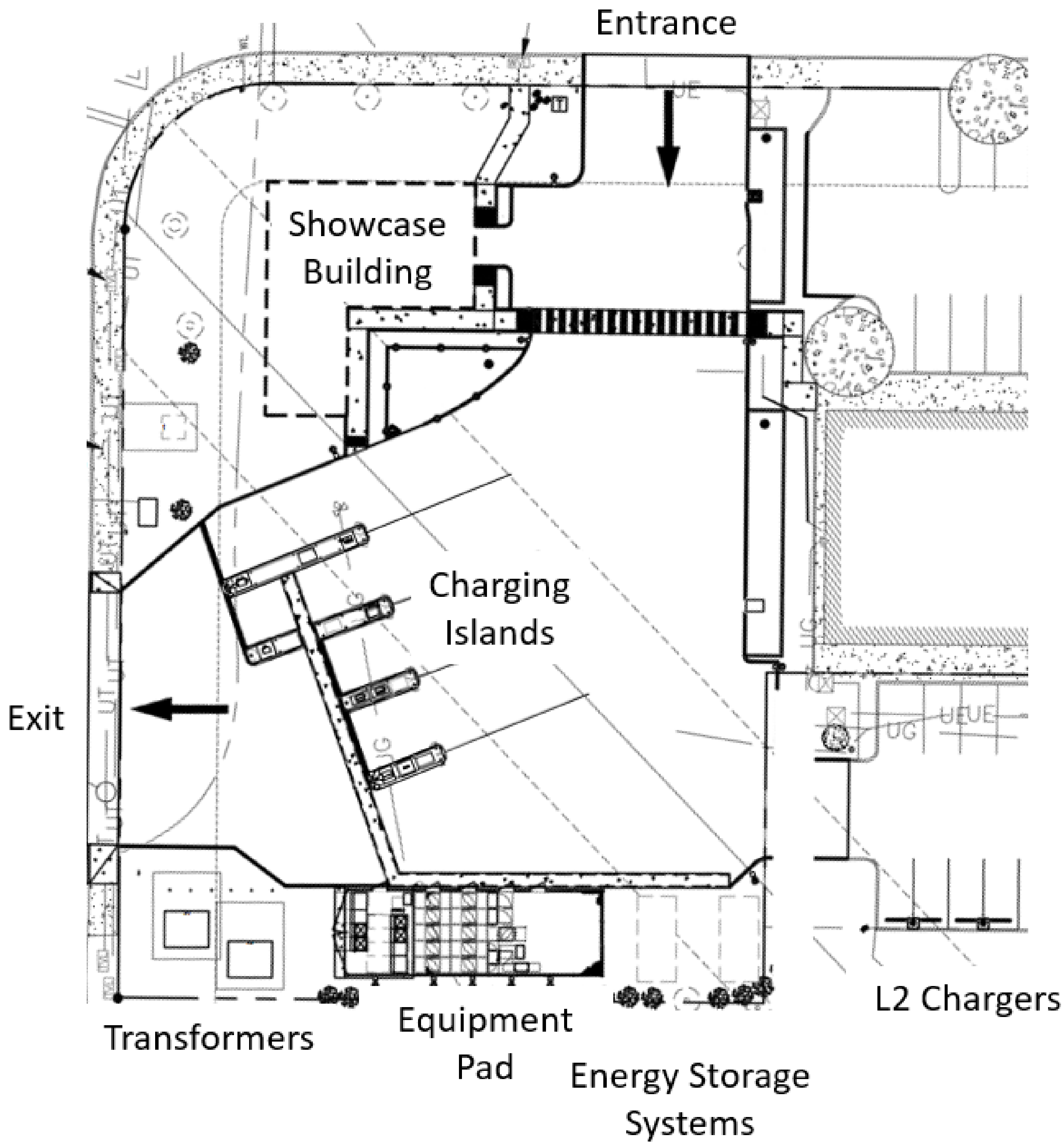

Figure 1. Electric Island site layout.

5.2 Unique Attributes

The general layout was created to ensure that heavy-duty trucks pulling 53’ trailers can easily navigate to any of the four charging islands, shown below in Figure 2. The northernmost charging islands can also accommodate two heavy-duty trucks, each without trailers, in a nose-to-tail configuration. This provides the flexibility need to demonstrate multiple charging use cases.

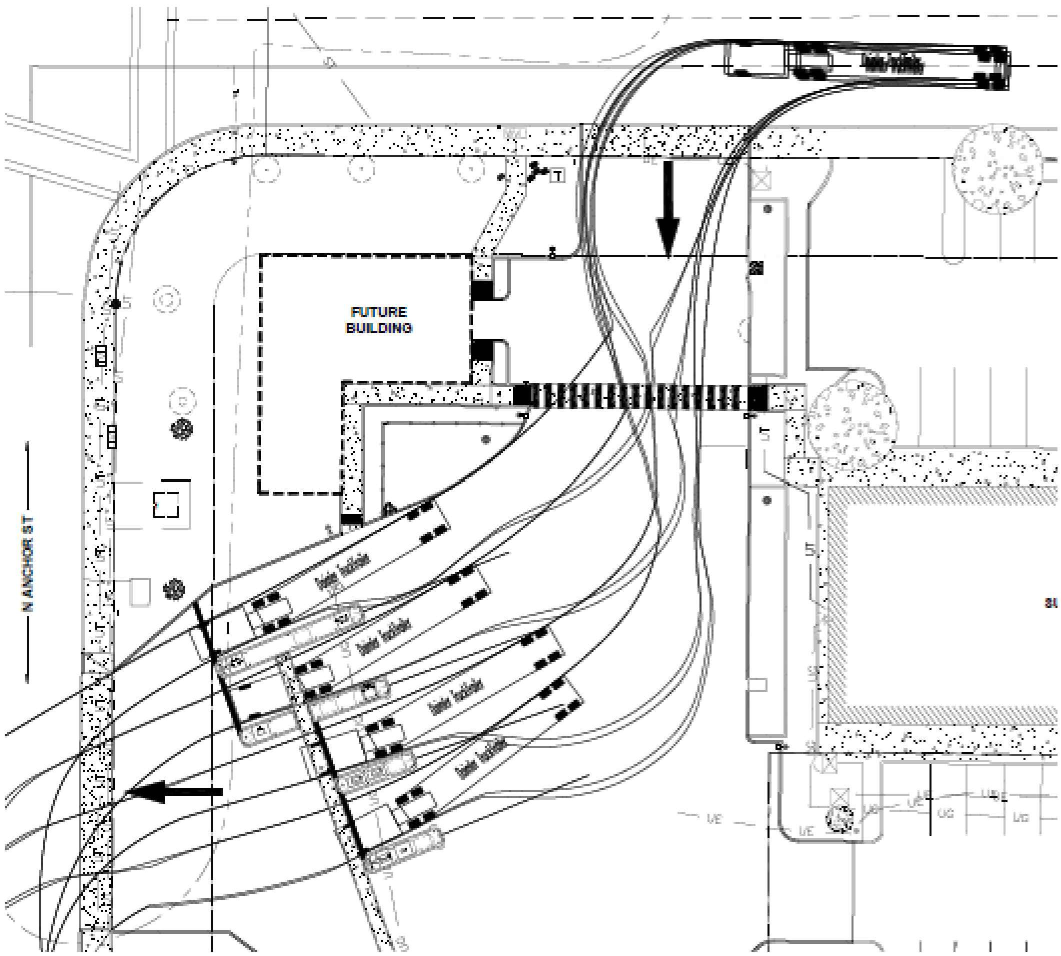

Figure 2. Semi-truck traffic flow patterns at Electric Island.

The make-ready infrastructure, including the equipment pad and charging islands, were designed to maximize the ease of equipment installation, modification, and removal. This was achieved on the equipment pad by specifying a floating floor made of steel grating, shown in Figure 3. Charging infrastructure can be anchored to the steel grating and conductors freely routed in the precast concrete trenches below.

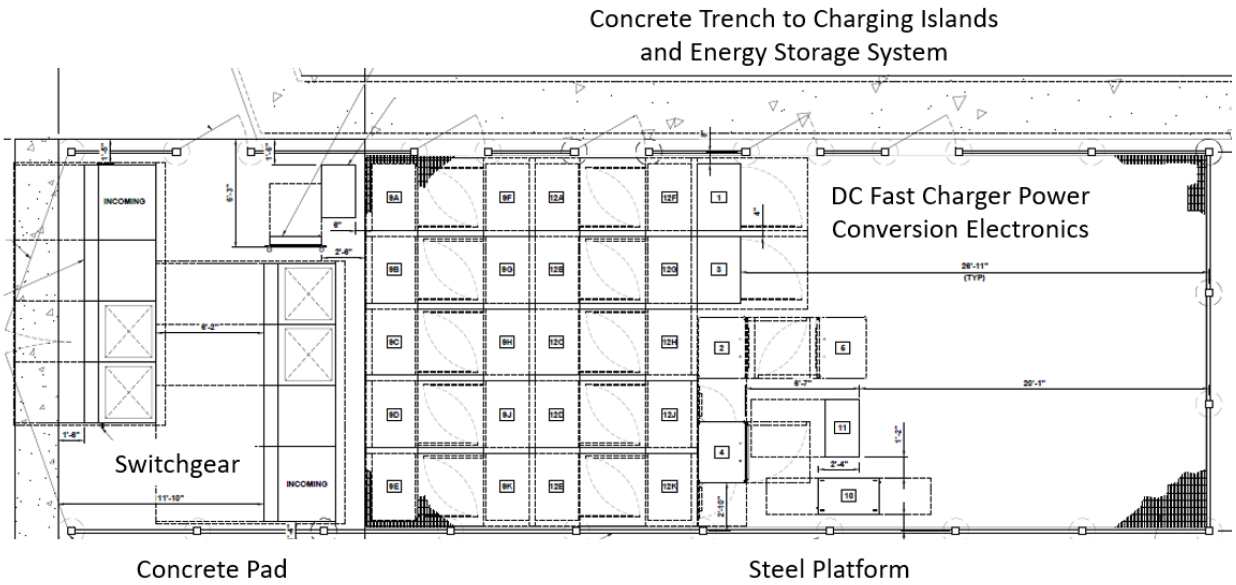

Figure 3. Equipment pad for switchgear and power conversion electronics**.**

The equipment pad is connected to the charging islands using a precast concrete trench, shown below in Figure 4, to allow AC power, DC power, and communications connections between any location on the equipment pad to any of the four charging islands.

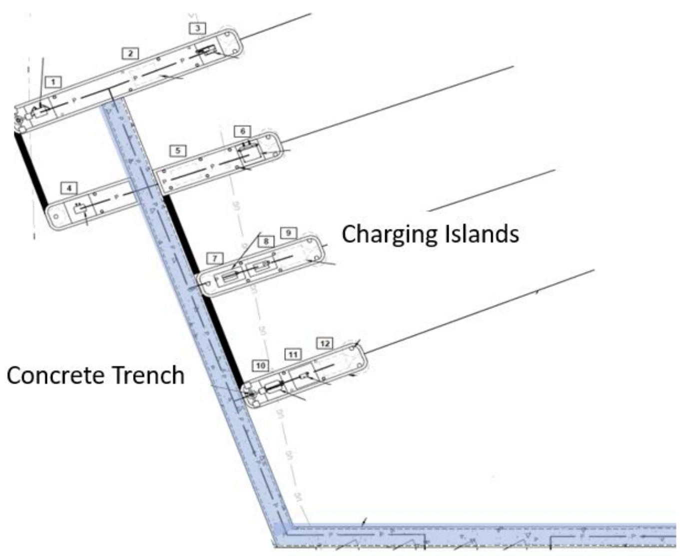

Figure 4. Concrete trenches connect the equipment pad and charging islands.

The site is ready for future high power charging through the inclusion of upsized utility transformer vaults, secondary conduit runs between the transformer vaults and switchgears, and switchgears.

5.3 Showcase building

During the Electric Island site design process, DTNA & PGE set aside a location for a future showcase building. The building will have a space to house electric trucks, educate customers, and provide real-time visual feedback on the charging activity.

6 Research Goals

6.1 Utility Learning Objectives

PGE and DTNA's co-development of Electric Island enables PGE to gain many valuable insights into the design, deployment, and operation of heavy-duty truck charging infrastructure. These learnings will have impacts throughout the company by providing new information to the Distribution Planning, Service Design, Product Development and Grid Edge Solutions teams. Desired learnings and their impacts are further detailed below in Table 3.

Table 3. Desired utility learnings, applications, and value to ratepayers.

Desired Learning	Relevance to Future PGE Products and Services	Value to Ratepayers
• Distribution planning and service design requirements for 5+ MW of concentrated new loads at commercial locations	• Informs distribution planning for forthcoming Transit and Fleet charging programs • Helps identify suitable locations for heavy-duty charging	• Minimizes or defers the cost of future distribution grid upgrades
• Civil and electrical infrastructure design and layout best practices	• Informs make-ready construction design for forthcoming Commercial, Transit, and Fleet charging programs • Informs standard design practices • Improves infrastructure cost estimating tools • Increases the speed of future deployments	• Minimizes costs of make-ready infrastructure • Optimizes potential future-proofing activities • Reduces customer friction when deploying charging infrastructure
• Heavy duty charging infrastructure load profiles • Grid impacts of multiple heavy-duty charging stations cycling on and off	• Ensures Transit and Fleet programs account for potential grid impacts of large-scale charging infrastructure deployments	• Minimizes disruption to distribution grid as more customers electrify their fleets
• Opportunity to learn from customers visiting the site	• Incorporation of customer feedback in Transit and Fleet programs	• Focuses spending on products and services most desired by customers
• Use of energy storage or on-site generation to counteract grid impacts of heavy-duty charging • Use of second-life vehicle batteries to provide grid services	• Potential incorporation of grid edge technologies into future programs	• Minimizes or defers costs of utility gird upgrades • Minimizes disruptions to distribution grid

6.2 Commercial vehicle OEM Learning Objectives

DTNA is not only selling industry leading vehicles, but also the supporting the customer with a whole eco-system around the vehicle. A focus for DTNA is offering EV charging infrastructure customer support. The learnings from this site will enable DTNA in recommending the right charging infrastructure solutions to its fleet customers and dealers. Some of these desired learnings and their impacts are further detailed in Table 4.

Table 4: Desired learning, Relevance to DTNA, and value to rate payers

Desired Learning	**Relevance to DTNA**	**Value to Fleet Customers**
• Long term reliability of charging hardware	• First-hand experience with a variety of charger hardware	• OEM recommendations of what chargers work best in each application
• Long term testing of chargers management software	• Understanding of which software features are best for customers	• OEM recommendations of what software features work best in each application
• Deep understanding of public commercial vehicle charging aspects	• OEM understands what is needed for public charging	• Customers feel like public charging is an option for their needs
• How energy storage system (ESS) can be used with chargers to support customer charging and ROI targets	• Ability to integrate ESS to chargers and its value to fleet	• OEM experience in ESS supports adoption of charger/ESS systems
• Demonstrate Vehicle to Grid (V2G) with DTNA vehicles	• First-hand experience with V2G increases customer confidence in feature	• OEM expertise supports demand for V2G enabled vehicles

7 Learnings to date

DTNA and PGE have learned much by going through site design, engineering, and demolition activities. Early learnings include:

- Utility planning and distribution review should be conducted early to identify available capacity on the local distribution grid.
- Equipment pad layout optimization techniques for easy equipment installation, upgrade, and removal.
- Education is required for permitting departments that may be new to multi-charger installations and may require new applications of existing codes and standards.
    - Examples include land use classification, equipment screening requirements, and vehicle queuing minimums.
- Higher speed fast charging infrastructure footprint and input power requirements are still unknown and require flexible planning.
- Understanding fleet charging use cases is key to optimizing commercial EV charger layouts.

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Authors

Jake Brulc is in the Charging Infrastructure team within Daimler Trucks North America (DTNA). This team works directly with DTNA's fleet customers to help them find charging solutions to support their EV applications. He currently divides his time between customer consulting for series production eM2 and eCascadia, and supporting Freightliner Electric Innovation Fleet chargers in Los Angeles. Jake holds a bachelor's degree in Renewable Energy Engineering from Oregon Tech.

Joe Colett is part of Portland General Electric's Grid Edge Solutions Team where he focuses on pilot project implementation. His recent projects include the expansion of PGE's public fast charging network and a partnership with the local transit authority to support the deployment of electric bus charging stations. Joe holds a bachelors degree in mechanical engineering from Oregon State University and masters degrees in mechanical engineering and sustainable systems from the University of Michigan.