

**Convergence:**

The Gas Station and the Future of Electric Vehicle Infrastructure

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**Abstract**

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This thesis presents a future vision for the next iteration of the gas station. The gas station as it functions today is an important component of the U.S. infrastructure network. However, the current network is not resilient enough to withstand the effects of climate change and it does not adequately serve or respect the holistic needs of its users and the larger environment. While the adoption of the electric vehicle is one of the best next steps towards a cleaner, more robust infrastructure network, an extensive build-out of networked charging stations is critical to support this transition. The existing network of gas stations across the U.S. can be reimagined in a manner that is respectful to the environment, builds upon what is already a community hub in many rural and suburban areas, and serves as a catalyst for the emerging EV infrastructure network. Through the speculative design of two gas stations, this thesis proposes a networked strategy and toolkit for the reinvention of the fueling network. Balancing site-specific conditions against the need for a network application, the design proposal speaks to the unique needs of the surrounding landscape while presenting a flexible strategy for application across the expanding EV network. It defines an architectural method of system change that can support positive community and environmental health, while reinforcing the critical impact of everyday architecture.

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A Note of Gratitude:

To Graeme (+ Zoey):

Architecture school is truly a family effort. This project would not have been possible without your patient love and support, persistent optimism, and countless home-cooked meals every day of this project and of my graduate school journey. I am so grateful for you—thank you.

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Thank you for your support, thoughtful insights and conversations, enthusiasm, and the reminder that no matter what is happening in our chaotic world, the questions and ideas that design and architecture can generate continue to matter, and can shape the world around us for the better.

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# Preface

*Convergence*, the title of this work, and within the context of this thesis, illustrates the moment of highest potential energy in a system. It highlights the point where energy changes phase. This thesis suggests that the gas stations in the United States comprise a system, one that can be transformed with the coming transition to electric vehicles and the growing need for charging stations. This systematic change can also be seen as a convergence, with an explicit energy use shift from petroleum to electricity. The charging station itself too creates an energy phase change, one that transforms electrical energy transported across our grids to kinetic energy in the form of fuel for our electric vehicles, a physical touchpoint within a system that is largely invisible to the everyday observer. But perhaps most importantly, this convergence of energy is also a point where great experiential potential exists. As a function and symbol of everyday architecture, the gas station can serve as prototypical teacher of the potential to transform our everyday landscape into a built environment that promotes the well-being of people and the environment.

This thesis is also a convergence of my own interests. With a background in electrical engineering, I've always looked for the pragmatic ways that architecture can support, reinforce, or even shift emergent technologies. And as the product of a small town, I've always questioned why the study of architecture so often exclusively focuses on the urban condition, often at the exclusion of rural and peri-urban populations. This thesis aims to explore the intersection of these topics and my hope is that while it may not provide all the answers, it can ask and engage with larger questions about the function of architecture in our lives.

[man] must be everyday, or he will not be at all.  
-henri lefebvre, critique de la vie quotidienne, 1947

# 1 Introduction

The gas station in America is a ubiquitous place. While often overlooked, gas stations support our essential transportation networks and exist in nearly every community—large and small—across the country. And while gas stations have evolved throughout their history to function as a complex symbol of geographical mobility, this is often at the expense of our environment.

Gas stations are one component of the larger United States infrastructure network that is not resilient enough to respond to the increasing risks of climate change, nor to respond to the subsequent transition away from fossil fuels. To meet climate goals and reduce the effects of climate change, the United States infrastructure network requires systemic change. Adopting electric vehicles (EVs) is one of the best next steps towards the creation of a transportation network with a substantially reduced carbon footprint. To support this transition, the clean energy grid must



*fig. 1: Ruscha, Edward. Burning Gas Station.*

expand significantly. In conjunction with this, an extensive build-out of networked charging stations will facilitate the transition towards a cleaner, more energy-efficient transportation system across the country. However, charging an electric vehicle is inherently different from filling an automobile with gasoline or diesel fuel; therefore the new network of charging stations will require new building infrastructure to support it. This present time of evolution offers a unique architectural opportunity to leverage this change. It is possible to create refueling systems that support electric vehicle use while also supporting healthier communities. However, rather than completely rebuilding a new fueling network, it is possible to alter our already existing system in this next evolution of the refueling station.

This thesis proposes the next iteration of the gas station typology that has been continuously

changing and adapting throughout the 20th century. The existing network of gas stations across the US can be reimagined in a manner that is respectful to the environment while serving as a catalyst for rapid development of the emerging EV infrastructure network. This thesis highlights the critical role of refueling networks as access to mobility in rural and suburban communities by focusing on the re-design of existing refueling stations within these settings. While the design emphasizes the incorporation of new technologies, it also builds on an understanding that gas stations have often served as community hubs in many areas.

Proposing the speculative design of an architectural toolkit for a revised refueling system, this thesis revisits the gas station type in the U.S. while also investigating its role in the larger infrastructure network and challenging the current cultural narrative that surrounds it. A three-part framework is proposed at three increasing levels of scale, from a micro, site-dependent study, to a macro network level view, to study the gas station at a systemic scale. The framework is then utilized as a lens to study the history, current conditions, and future predictions for gas stations as well as existing electric vehicle charging stations, with a particular focus on their intersecting characteristics. Informed by this former and current landscape of energy delivery, the thesis proposes a map-based design scheme that balances site specific considerations with a critical need for flexibility that allows for broad, network-wide applications and future technical innovation. This thesis speculates that the gas station, in its next iteration as charging station, can act as a center for positive community and environmental health, and that architecture has a meaningful role in realizing this opportunity.

## 2 History + Typology

The gas station as architectural type has evolved rapidly since its origins in the late 19th century. This progression of the gas station as built form parallels its changing role as cultural artifact. In particular, the progression of the typology across time illustrates the increasing significance of the station as a purveyor and influencer of popular culture and as an increasingly important, and increasingly ubiquitous, aspect of everyday life. The history of the gas station traces its transformation from a system of decentralized manual delivery services for petroleum products to the highly homogenized, highly systematized network of refueling stations that spans the United States today. The understanding of this progression is critical to the understanding of the significance of the iconography of the gas station. The development of its built form reflects the duality of its roles—it tells a history of the filling station as both commercial enterprise and as sociocultural product (fig. 2). However, the gas station is changing and has potential for a wide variety of future iterations, particularly for the support and the adoption of EV infrastructure.



*fig. 2: Walker, Evans. Gas Station, Reedsville, West Virginia.*

## Past

Prior to 1905, automobile ownership was a rare attribute exclusive of the rich and adventurous. Refueling an automobile prior to 1905 was equally adventurous and often dangerous, as gasoline was usually stored in large bulk storage tanks near the edges of towns and communities. Petroleum was then transferred to glass or metal containers or buckets and carried by hand to automobiles awaiting refueling (Randl 2008). During this time period, automobiles were considered a novelty and driving a leisure activity of the privileged, rather than a reliable method of transportation. The highly decentralized and unregulated dispersion of refueling infrastructure mirrored the novelty of the early and experimental automobile.

As automobiles grew in popularity, so did the refueling network to support them. The infrastructure evolved in response to the nature of the commodity itself—a highly combustible liquid—as safer alternatives for distribution developed. Initially, horse drawn wagons served as the original tanker trucks, carrying large quantities of fuel from the outlying depot stations to populated areas. They functioned as mobile petroleum dispensaries, reducing the distance between gasoline refiners and consumers. Resourceful entrepreneurs also peddled gasoline from hand carts and buckets in order to supply communities directly (Vieyra 1979, 3-6). As the demand for petroleum products grew, the mechanization of the delivery system began.

In 1905, Sylvanus F. Bowser invented the first gas pump (Vieyra 1979, 3-6). The technological innovation of the gas pump and the burgeoning demand for automobiles spurred many grocers, general stores, and other small business owners to install gas pumps in front of their businesses at the curbside and offer gasoline as an additional commodity item (fig. 3)(Randl 2008). The addition of the gas pump to the typical storefront, meant that gasoline was sold like any other commodity. The purchase of nonrenewable resources became an increasingly normalized and commoditized part of our daily routines. Although people did not consider the vast economic and environmental implications then, the gas pump had a major and lasting effect on American life.



*fig. 3: Goss, Arthur. Premier Gas Station, Pleasant Boulevard near Yonge Street.*

With the invention of the gas pump, the first versions of the precursor to the contemporary gas stations started to appear throughout the United States. According to Chester Liebs, from 1905 through the first decade of the 20th century, the first dedicated gas station building, or filling station, was the “shed” type. Shed style stations were the first to utilize a larger footprint to accommodate vehicles being refueled (fig. 4). Incorporating “drive-in” space for vehicles meant gas stations had to be positioned on larger lots with enough space for vehicles to exit the street, refuel, and return to the street while allowing enough space for additional customers. Gas stations began to occupy prominent locations in towns and communities, often requiring the removal of existing structures. The form of the station itself often followed the style of a “shed”, a simple storage structure of wood or corrugated metal used for storage of automotive supplies (tires, oil, etc.) (Randl 2008; Liebs 1985, 97-98). However, John Jakle has noted that this building was not designed for human habitation and reflected characteristics of a manufacturing or storage facility, rather than a consumer facing business (Jakle 1994, 137).

While shed type stations were popular in more densely populated areas, the standard type of the station in rural areas started to diverge. During the 1910s, rural stations tended to affix gas pumps or full stations to existing community resources—such as hotels, restaurants, and general stores (Randl 2008). Randl argues these “appendage” stations were the first iteration of the gas station that began to insert itself directly into rural community life (fig 7).

The 1920s and 30s brought about rapid changes to the form and function of the filling station. As oil companies expanded distribution networks into residential areas, petroleum companies sought to acclimate to their surroundings and build a trustworthy reputation with neighbors and consumers. According to John Jakle, this corporate strategy drove a shift from the shed style filling stations to stations that resembled houses. “House” style stations now provided interior space that could offer additional amenities to the customer, such as restrooms (fig. 5). The influx of motorists in the 1920s had created more demand for repair services for vehicles, which many stations began to provide. Some also created dedicated space for washing cars (Jakle 1994, 137-144; Liebs 1985, 100-102). The domestication of the gas station in this era brought the idea of the “service station” into the life of the consumer. The domestic form of the service station as a place where attendants took care of one’s vehicle took hold as a typical fixture of daily life.

In the mid-20th century, modernist architectural styles influenced the design of the gas station; shifting it away from more ornate, domesticated forms towards what has become the “oblong box” model of the station (fig 6). Vieyra suggests that with this type of station, oil companies sought to make their buildings stand out, rather than blending in with their contexts. They used vivid building forms and signage to market themselves as purveyors of modernity and technological progress. Gable roofs were replaced by flat roofs, and ornament and textured materials were replaced by simple, “modern” materials of steel, glass, and enamel (Jakle 1994, 144-150; Vieyra 1979, 56-71). The oblong box style led to the homogenization of station architecture, as it allowed oil companies to produce buildings with a high level of repeatability. The stations’ clean lines and simple forms showcased the oil company and its products as a future looking enterprise (Randl 2008). However, as the buildings resorted to more modest forms, station owners found the need to



fig. 4: Smithsonian Institution. Shed-Style Station.



fig. 5: Margolies, John. Stone Gas Station [House-style Station].



*fig. 6: MBAFB Gas Station in the 1950s [Oblong box-style Station].*



*fig. 7: Small Restaurant in Colorado [Appendage-style Station].*

differentiate themselves from other roadside businesses through the design of the canopy. While initially limited in size and solely designed to protect station attendants from the weather, newer canopies sought to cover a wider area and were designed to function as large-scale advertising for the station (Jakle 1994, 153-154). The development of the dominating canopy and the legacy and homogenization of stations that occurred during the middle of the 20th century continues to influence station design to this day.

The 1970s and 80s brought about the growth of the independent retailer. The “chain” model of gas station ownership was popularized during this era with many stations making the move towards self-service filling pumps, as opposed to the full-service pumps (with attendants) of the past. The gas shortage of the early 1970s further prompted station owners to look for cost cutting measures such as self-service pumps and the reduction of services such as repair shops. John Margolies also notes that operating convenience stores offered a potential reduction in expenses (Margolies 1996, 113). Coupling the convenience store with the filling station proved a highly successful model for independent operators and the “chain” model of stations proliferated across the country (fig. 8). Utilizing the chain method, the homogenized boxes of the middle of the century continued to prove one of the best types for growth of the petroleum distribution network throughout the end of the 20th century. The self-service station linked with convenience store model mirrors the original gas station, with its curbside pump linked to a general store (Margolies 1996, 120). In this model, petroleum products are once again marketed alongside sundry items. However, with their automated delivery pumps, a highly standardized and automated purchasing process, and often the removal of the station attendant from the consumer’s experience, the act of obtaining gasoline has become a mundane experience. This allows, even encourages, consumers to detach from the implications of the product they are buying (Jakle 1994, 18-19). Consumers do not see the environmental costs of petroleum extraction, its processing, and its use. This process has continued without interruption for the past four decades. Since the convenience store model emerged in the 1980s, gas stations have changed very little in the United States; however, the emergence and steadily growing demand for electric vehicles is already altering the gas station as type.



*fig. 8: Rivera, Michael. Sunoco Gas Station.*

## Present

According to the NACS (The Association for Convenience and Fuel Retailing), there are approximately 150,000 gas stations operating within the United States today. Of these, over 127,000 also function as convenience stores. This network is well suited to support the next iteration of refueling stations, and EV chargers provide a viable economic path forward for existing convenience store owners, 60% of which are considered small businesses (American Petroleum Institute, n.d.).

Currently, electric vehicle chargers comprise a patchwork network across the United States that is quickly being built and installed by a variety of private companies, municipalities, and individuals (fig. 9). Some building codes now require parking structures for new construction to include a set number of chargers and provide capacity for additional charging stations (International Code Council 2021). Charging pedestals are being installed at current gas stations to supplement the gasoline dispensing pumps. Many municipalities are even looking to install chargers near public parking spaces, reminiscent of the original highly dispersed network of gas pumps from the turn of the 20th century, placed along roadways or outside shops (Liebs 1985, 95-97). However, the current charging landscape is complex and unregulated, encompassing a variety of charging platforms with varying equipment and connector requirements, payment structures, and reliability ratings. It once again parallels the adventurous, unpredictable early years of the gasoline automobile and its disconnected refueling network.

Currently, the two largest electric vehicle charging networks in the United States are the Tesla Supercharger Network and Electrify America. The Supercharger network has approximately 30,000 chargers and the Electrify America network is comprised of approximately 3,000 chargers and growing across 700 sites throughout the country (Golson 2022). The Tesla network is considered by many as the current gold standard in this space, with a robust network throughout the majority of the contiguous United States. The chargers are fast, easy to use, and are user friendly with the use of an accompanying app that is integrated with Tesla vehicles. However, the chargers are typically hosted by secondary businesses, and the charging stations themselves do not provide any type of



fig. 9: Electric Vehicle Charging Stations. Oregon Convention Center, Portland, Oregon, USA.

amenity space for the users (Garfield 2022). Additionally, while there is a small pilot program to expand the availability of Supercharger stations to all vehicles, the vast majority of Superchargers are only available to Tesla vehicle owners (Golson 2022). For all other makes and models of electric vehicles, the Electrify America network is the largest networked option for charging vehicles. While significantly smaller than the Tesla network, the network is planning to expand to over 1,800 stations by 2025 (Golson 2022). However, Electrify America chargers are also typically placed in parking lots of retail stores or parking garages, with no dedicated amenities. Considering the length of time required to charge a vehicle, there are not many services for electric vehicle users. As Brian Sullivan observed in his electric vehicle road trip test for CNBC, sometimes not even a shade structure in desert locations (Sullivan and Taylor 2021). While the emerging network continues to add individual, dispersed chargers to existing businesses and locations, Sullivan sums up the

current conditions of the U.S. charging network in his description of his electric vehicle road trip experience:

We didn't see a shortage of chargers. Even in the desert we found chargers to use. There is, however, a shortage of chargers in places you really want to stop. Ultimately, I think the EV play [strategy] is less about cars and more about real estate (Sullivan and Taylor 2021).

To help consumers navigate this complex and confusing charging environment, crowd-sourcing applications such as PlugShare have been developed. PlugShare users are able to locate nearby charging stations and compare rates as well as access performance reviews from a community of EV owners (PlugShare, n.d.). While app-based services will continue to play an important role in the evolving EV charging market, the built environment can also contribute to a more efficient network. To mitigate the ever-expanding complexity of the EV charging landscape, spatial nodes of collocated charging stations, such as within existing gas station footprints, could help simplify and streamline the charging process. Additionally, while the range of electric vehicles has grown dramatically in recent years, now averaging 250 miles per charge, it is still lower than many conventionally powered vehicles (Vehicle Technologies Office, n.d.). With a lower range, vehicles will need to be refueled more often, and while refueling rates vary, a full charge can take one hour or longer, dramatically increasing the length of time drivers will spend at refueling stations (Domonoske 2020). The combination of the demand for a streamlined charging experience with the technical limitation of more frequent charging and longer charging times, creates an opportunity to rethink the gas station model.

Several explorations and collaborations between architects and business owners have resulted in new iterations of the gas station. Cobe Architects (Denmark) have collaborated with electric charging company Clever to create a modular charging station design. The first of the Cobe designed stations was completed in 2019 in Frederica, Denmark, with another forty-eight proposed. The stations use a modular canopy system that can be adapted to a variety of site sizes and conditions.

The canopies, built of sustainably harvested timber, are designed for easy assembly and future disassembly on site (fig. 11). This construction also allowed Cobe to create a material connection with nature and contribute to an overall experience of a more natural landscape (fig. 10). Without the toxic fumes and the potential for oil and gasoline leaks and spills from gasoline powered vehicles, Cobe was able to use the charging stations as opportunities to incorporate natural elements into the construction materials as well as to incorporate natural plants and landscaping. Additionally, acknowledging the increased time required for charging a vehicle versus petroleum refueling, the charging stations were designed to create “meaningful breaks” for the drivers of 30 minutes to one hour. Elements such as benches, swings, and parklike areas for recreation are included in the built and forthcoming charging stations (Liese 2021, 48-53; Cobe, n.d.). Many of the components of the Cobe projects are important elements to incorporate into future EV charging stations, such as places for “meaningful breaks” and the future proofing philosophy of easy assembly and disassembly (fig. 12) (Cobe, n.d.).

Graft Architects has similarly designed a fast-charging station prototype for an E.On drive network of stations throughout Germany. Graft’s design similarly features a modular canopy system that can be adapted for multiple size sites and usage types, including future expansion of existing sites (fig. 14). The canopy modules provide illumination and seating, as well as protection from the elements. Canopy design also provides the option for an integrated photovoltaic system or a green roof. Graft’s designs also provide an option for the addition of a modular lounge space, providing areas for rest, work, and relaxation while vehicle charging occurs (fig. 13). The canopy design also creates a distinctive brand identity for their client. As of this writing, the Graft charging design is in prototype and first design implementation stages (Graft, n.d.). The Graft stations are excellent examples of the importance of providing sheltered lounge spaces as well as the benefits of creating a distinctive modular language.



fig. 10: Hjortshoj, Rasmus. Cobe. Frederika Charging Station, Chargers.



fig. 11: Hjortshoj, Rasmus. Cobe. Frederika Charging Station, Canopy.

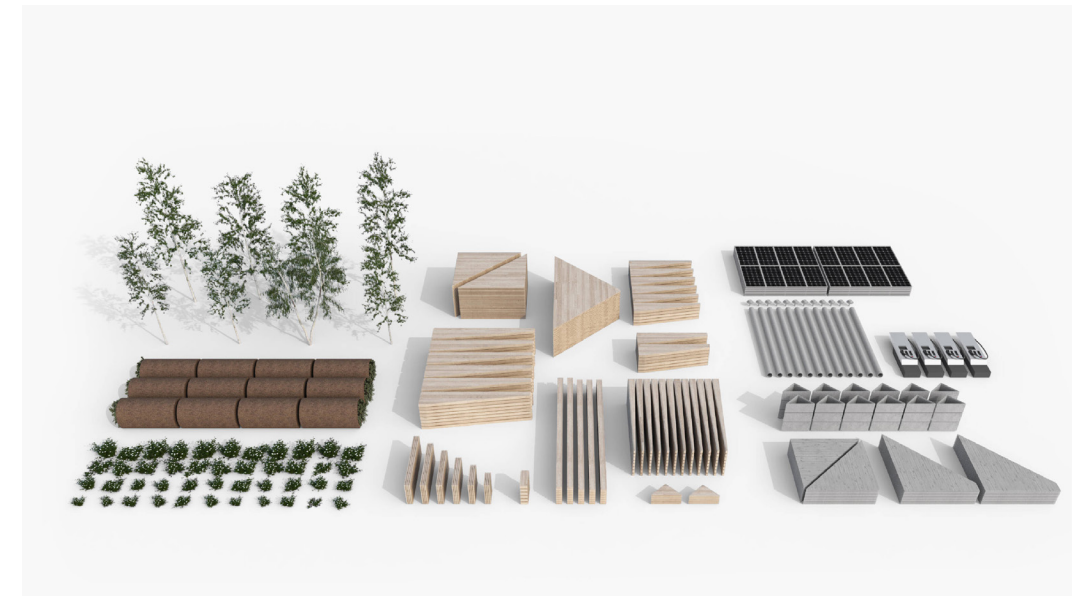


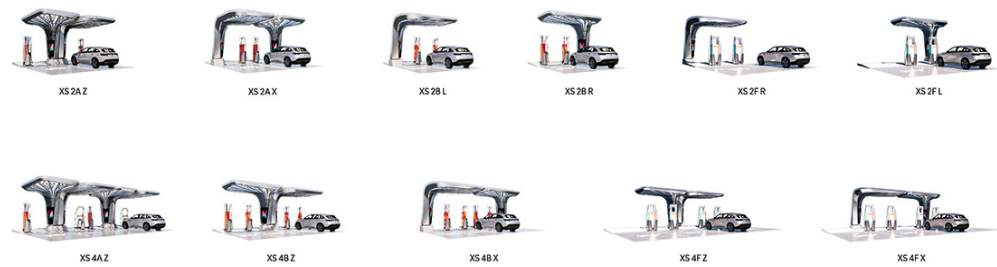
fig. 12: Hjortshoj, Rasmus. Cobe Frederika Charging Station, Modular Components.



fig. 13: Romstock, Michael. Graft Prototype Charging Station, Canopy.

**E.ON ULTRA FAST CHARGING STATIONS**

Module System XS/S  
Matrix XS



**GRAFT**

fig. 14: Graft. Prototype Charging Station, Modular Design.

## Future

By 2030, an estimated 20 million electric vehicles are projected to join the existing 2 million electric vehicles in the United States today (The White House, 2021). Correlated growth in the country's charging infrastructure is required to support this rapid expansion. Adaptively reusing existing gas stations and their locations offers a sustainable opportunity to support this new development in the transportation sector. Gas stations can be excellent sites for adaptive reuse projects, and many case study examples can be found across the United States today that demonstrate the immense potential existing gas stations hold for adaptive reuse.

A prominent example in North America is the Nuns' Island Standard Oil station near Quebec, Canada (fig. 16). Originally designed by Mies Van der Rohe's office in 1968, the station continued operations as a conventional gas station through 2008 (Burrows 2013, 22-25; Canadian Architect 2014, 50-51). The station embodied the traditional features of the gas station type, with rectilinear volumes for car servicing and sales transactions and a large unifying canopy connecting the spaces and covering the pump area. In 2009, after the city of Montreal conferred heritage status on the structure, the architecture firm FABG initiated a restoration project on the station to adaptively reuse the space as an intergenerational community center (Canadian Architect 2014, 50-51). While not reused as a charging station, the building is an excellent example of the ability of gas stations to be reimagined for community use. Located prominently in the small community of Verdun, La Station community center adapts the interior volumes into flex spaces for community gathering and events. Furthermore, faced with increased mechanical needs to support the building's new functions, geothermal wells were installed with cleverly placed stainless steel "gas pump" air intakes in the existing pump area (Burrows 2013, 22-25). The integration of sustainable energy initiatives into the project further amplifies the impact of the transition of the station as a place that is supportive of both the environment and the local community.

While the Nun's Island station was designated a historic landmark, there are many everyday gas stations without landmark designation that already go on to live a variety of second uses.



*fig. 15: Pump House Coffee; Deadwood, SD.*



*fig. 16: Montpetit, Steve. Nun's Island Gas Station.*

Gas stations have been reused for many commercial functions, everything from restaurants and coffee shops to a variety of small businesses (Jordan 2019). Many stations' central locations lend themselves to reintegration into the fabric of the community (fig. 15).

Numerous recent proposals offer examples of the reuse of gas stations as electric vehicle charging locations. One example is the University of Southern California sponsored annual "Pump to Plug Symposium". For the past three years, USC has invited architects and electric vehicle advocates to reimagine and redesign the existing gas station typology to support EV charging infrastructure. The 2021 symposium emphasized the need to employ flexible, temporary architectural interventions in the space to support the rapidly evolving nature of EV charging technology. Many participants chose modular construction assemblies, to provide a maximum amount of versatility (fig. 17). The symposium also questioned how space will need to be reallocated to provide a service across an increasing time domain for refueling. Most importantly, participants in the conference reiterated the growing need for EV infrastructure across much of the United States (USC, 2021).

While there are many speculative investigations into EV charging infrastructure solutions, the design of the stations themselves have received less attention and few have been implemented at a large scale. But the time has come to plan, design, and invest in centralized charging locations. Centralized charging provides maximum access to charging locales and creates a flexible nodal infrastructure that can be updated as technology continues to advance. Future charging locations must consider the increased time domain of the electric charging experience and subsequently provide additional services/amenities and improved site conditions to accommodate people and vehicles for longer periods of time. The increased time domain also provides an opportunity to promote amenities at charging stations that allow for the reintegration of the station into the societal fabric of the community. The nature of the service station is changing. It is moving from a petroleum based, inherently toxic, and polluting landscape, to one powered by a cleaner energy grid and cleaner refueling process. This shift creates an opportunity to create a restorative relationship between the charging station and the surrounding environment, as well as to improve the human experience of the site. Stated in the IPCC 2021 climate change report, "Climate change is already

affecting every inhabited region across the globe with human influence contributing to many observed changes in weather and climate extremes” (Masson-Delmotte et al. 2021). Government agencies and private industries have recognized the pressing need to reduce CO2 emissions, including transitioning major transportation networks away from petroleum products. To support this goal, in 2021 the United States government announced over 40 billion dollars of federal grant funding allocated for EV charging infrastructure (The White House 2021). With the rapid development and proliferation of electric vehicles and the current demand and interest in charging infrastructure, the time is now to realize the potential opportunities in future electric vehicle charging networks.

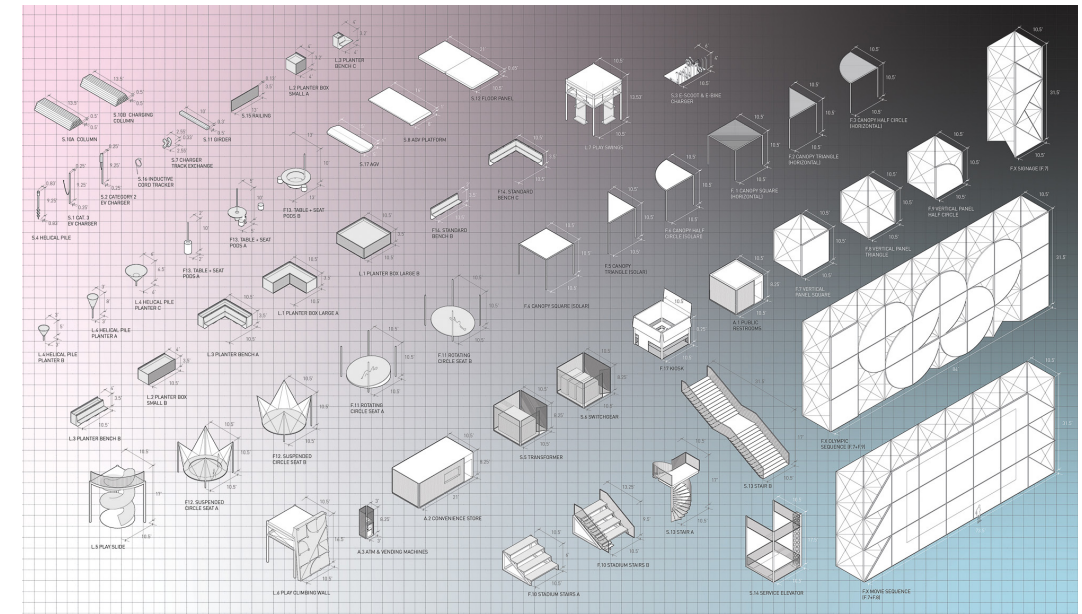


fig. 17: SAW Architects. Pump to Plug Symposium Entry; Modular Component Design.

### 3 Conceptual Framework

The existing network of gas stations across the U.S is an important form to study because it is a common aspect of many people’s daily lives. However, few scholars have seriously examined the gas station as a component of contemporary architecture and design. Overlooked for its architectural significance, the gas station is typically considered a utilitarian structure, dismissed as little more than a mundane component of the backdrop of everyday life. For the most part, architectural literature has treated this building type as a component of roadside architecture - a spectacle at best, unremarkable at worst. In *Learning from Las Vegas*, Robert Venturi and Denise Scott Brown studied roadside architecture, but considered the gas station as object and symbol, rather than as a component in a broader infrastructure system (Brown and Venturi 1977). The station as

symbol and object is important to consider, but it does not address the broader impacts of the type. Inspiring lasting interest in “decorated sheds” as a subject, many subsequent works in the latter half of the 20th century continued to explore the role of gas station architecture as object, or as a building type isolated from the impact and influence of its surroundings. For example, John Margolies’ *Pump and Circumstance*, Chester Liebs’ *Main Street to Miracle Mile*, and Daniel Vieyra’s *Fill er’ Up* focus on the architectural history of the filling station through a detailing of architectural styles and components but provide little insight into the social and cultural influence of the type (Liebs 1985; Margolies 1996; Vieyra 1979). Additionally, while the gas station remains a pervasive presence in the built environment because it is an important refueling component within our critical infrastructure network—moving people, products, and services across the country—relatively little has been written about this building type as it has evolved in the 21st century, particularly from an architectural perspective.

This thesis aims to begin to fill this void in order to prioritize the role of everyday architecture through the reimagining of the existing gas station network. This future network can support the necessary buildout of electric vehicle charging stations to create a more resilient infrastructure network in the face of climate change, and provide the opportunity to create healthier, more human

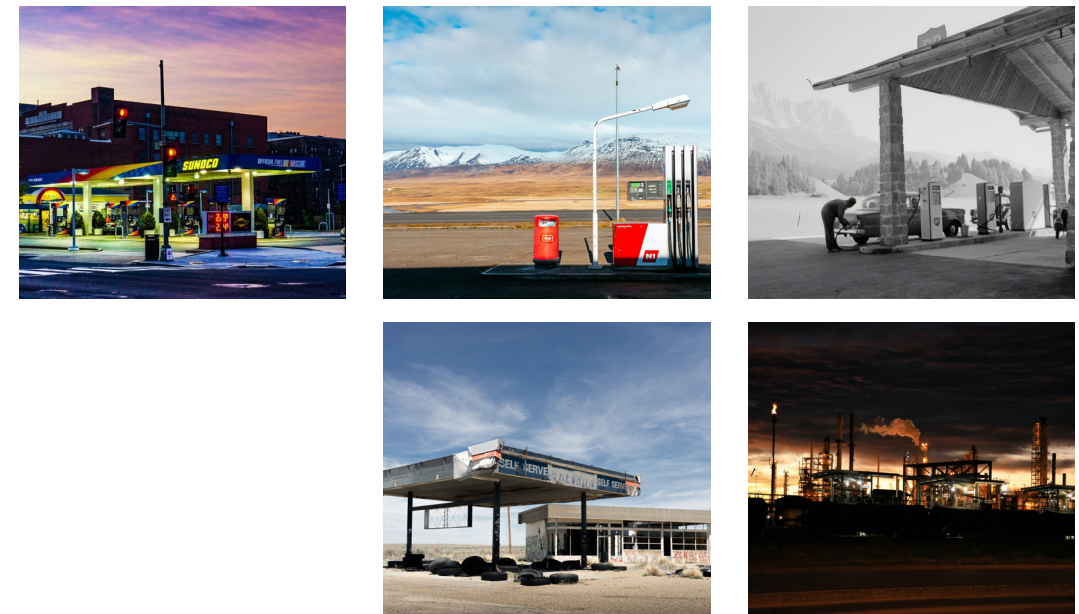
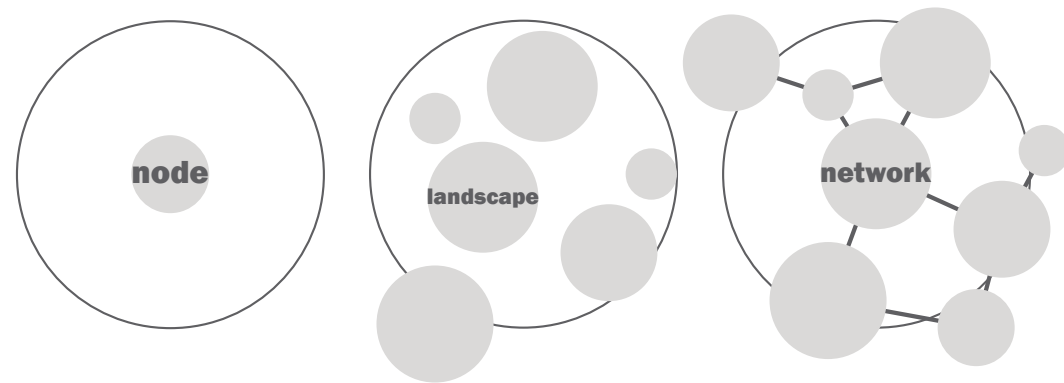


fig. 18: The Many Identities of the Gas Station.



*fig. 19: Framework Scale Diagram.*

oriented spaces. To understand why existing stations are well suited to support this new network, this thesis analyzes the architecture of the gas station from three levels of scale. The station is considered in place, or as **Node**, within the broader environmental context as **Landscape**, and finally as a component of a larger infrastructure **Network** (fig. 19). Considering the gas station type from all three levels of scale provides a framework for the proposed design project that is similarly situated at the intersections of the social and cultural, economic, technical, and environmental forces that act upon it (fig. 18).

## Node

The Oxford English Dictionary defines 'node' as the following:

Node, **n.**:

“a point of significance...a place at which roads, etc., meet; a junction; a point of intersection or convergence”

The individual node in the network is its finest grain, and the primary level of analysis that comprises a singular gas station. At this granular scale, the gas station is a compilation of components related to a station as a singular, independent entity. In the U.S., it stands as a cultural symbol of movement that connects people to broader environmental and economic forces. The gas station generally includes five primary components: the box (or convenience store), the canopy, the refueling pumps, the pavement, and the sign. In this thesis, each of these components is reconsidered and transformed as the gas station typology evolves to accommodate EV charging infrastructure. This individual unit is then positioned within the surrounding landscape, and combined with all other nodes, in order to constitute the broader network of stations across the United States.

Symbolically, the gas station has been a physical embodiment of Americans' connection with their

arrive

depart

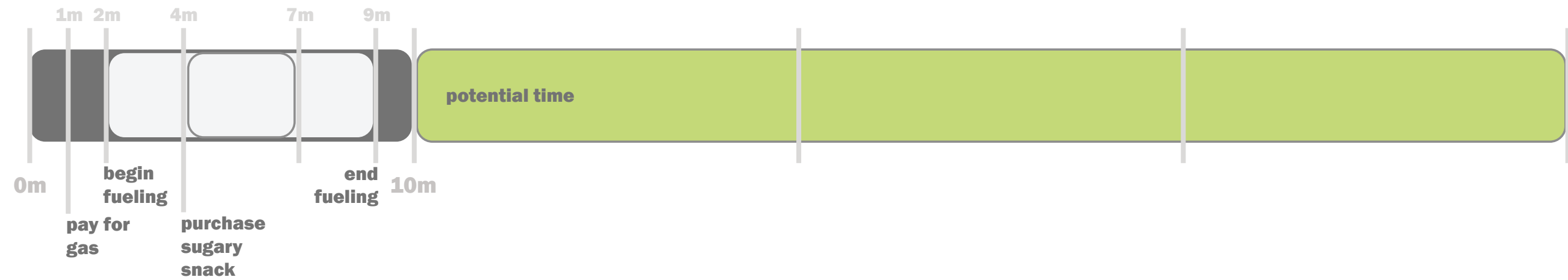
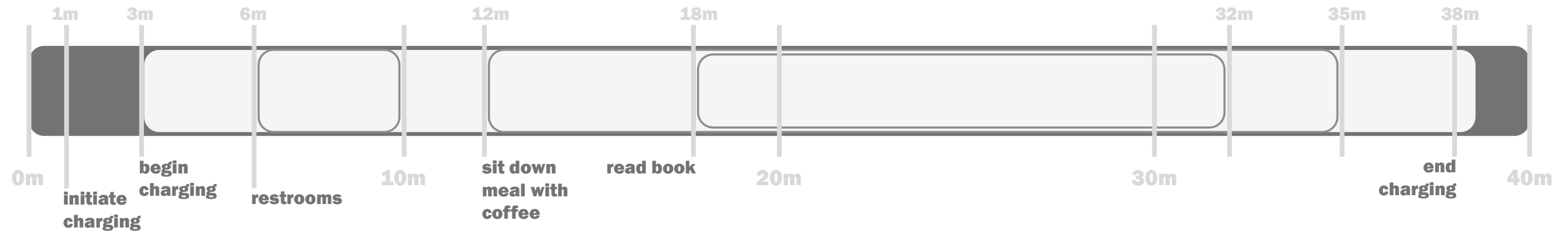




fig. 21: Drost, Eric. Muni Lot. [Car Culture].

vehicles. Automobiles symbolize movement and speed, and they exist as a part of our national culture—from parades and tailgate parties to pandemic testing facilities (fig. 21) (USC 2021). John Jakle points out in his book, *The Gas Station in America*, that the gas station extends this symbol of geographical mobility of the automobile into the built environment. However, as Jakle observes, while the gas station contributes to this mobility narrative, the station itself serves a unique function. The station is naturally seated “where movement stops”, a unique time and space dimension within the culture of movement (Jakle 1994, 228). This place of pause serves as an opportunity to build connections between people, as they step out of their individualized vehicles. Furthermore, Jakle alludes to the possibility that the station could evolve to become a center for social activities and gatherings (Jakle 1994, 228-229). However, in the nearly 30 years since he wrote the book, this ideal has not been fully realized. In the station’s current form, it offers few spatial conditions created for gathering and socialization. Gas stations generally feature transactional

spaces for purchasing products and petroleum, but rarely have places to sit, to rest, or gather. However, with the implementation of charging stations, these types of gathering and socialization spaces will become increasingly important.

With the introduction of EV charging modules, which take far longer to “refuel” a car than at a gas pump, patrons will need to spend more time at these stations—fundamentally expanding the time domain that they encompass (fig. 20). While there are a variety of different types of chargers now available, even the most efficient direct current fast chargers will take 20-45 minutes to charge a vehicle’s battery to 80% capacity, the preferred level for maximizing battery life (Yen 2022). The expansion of automobile refueling time offers an excellent opportunity to expand and invest into what Jakle refers to as the “potential for pause” already possible within the typical gas station.

While the gas station is an important cultural symbol, it also serves as a physical manifestation of national and global environmental and economic forces. The practice of visiting a gas station seems unremarkable in American contemporary life, but it is important because, as Bradley Macpherson and Mark De Socio explain, “...the act of obtaining gasoline to fuel modern mobility is performative in nature, an everyday geographical and cultural practice in which individuals intersect with wider social, economic, and political forces” (Macpherson and Socio 2013, 25). In other words, the consumer is choosing to financially support the continuation of petroleum extraction, and the political influences and environmental effects associated with it, even if they do so unintentionally. Transitioning away from gasoline powered vehicles and their refueling practices towards electric vehicles will change people’s relationships with these forces, but electric vehicles will necessarily bring their own complexities to the performative aspects of refueling (Alternative Fuels Data Center, n.d.).

But for most people visiting gas stations, these issues are not a major consideration. Typically, the gas station simply offers a set of understood expectations. Refueling a car is conventionalized; it uses a standardized pricing structure, and a fueling station generally offers several expected services including a (well-lit, safe) self-service gas pump, a small shop for purchasing consumer

goods (normally at any time of night or day) and publicly available restrooms (though sometimes requiring a key from the gas station attendant). These services are so ordinary that they become familiar, unexamined fixtures of daily life. Consequently, these settings for behavior are continuously reinforced as they grow to be ordinary. Gas stations have evolved to accommodate these expectations, and in this way their forms reflect our values and the overarching structure of our societies (Jakle 1994, 18-20; Jackson 1997, 118).

Today, rapidly changing technologies are transforming the habits associated with refueling a vehicle and will significantly affect the fueling station and the values associated with it. According to NREL's EV charger database, the number of charging stations in the US doubled between 2015 and 2019. Just in 2019, the number of stations reported increased by 28%. The technology supporting the EV stations is expanding just as quickly, with a variety of level 1 (120V), level 2 (240V), and DC fast chargers (480V+) continuing to come online with ever increasing power capacities. Additionally, 2018 saw the introduction of extreme fast charging (XFC) technology, although many light-duty vehicles produced today are not yet capable of utilizing XFC power inputs (Brown et al. 2020). Due to this rapid state of change, any attempts to populate an EV charging network should be designed to allow for maximum flexibility and "future proof" design methods wherever possible.

Providing an architectural response that can easily adapt to this type of technological change is also important. One architectural strategy to mitigate the challenges of future adaptation is to rely less on permanence and incorporate the approaches of temporary architecture. In their book *The Temporary City*, Peter Bishop and Lesley Williams reframe the idea of permanence as an eternally elusive goal, and challenge urban planners and architects to look towards temporary structures and participatory works of architecture—often created outside the boundaries of traditional architecture and planning methods—for inspiration. One such example in Bishop and Williams' book is the Cineroleum in Clerkenwell, London (fig. 22). The Cineroleum was a temporary movie theatre constructed out of an abandoned gas station. The temporary installation highlights the ability to transform typical gas station elements into new elements of social gathering spaces (Bishop and Williams 2012, 151). Incorporating the philosophy of temporary structures by



fig. 22: Assemble. The Cineroleum.

designing spaces that can change function, form, or use over time can help support the rapidly changing EV infrastructure landscape. The demand for increasing electric vehicle charging capacity heightens the challenge of understanding these important intersections of the gas station as node in order to decode the distinctiveness of the gas station as type and frame the interventions necessary to create the next iteration of the fueling station.

## Landscape

While traditionally considered as an independent object, that is spatially removed from its surroundings, the station exists within a larger landscape. In addition to their role in the social and cultural landscape, gas stations also impact their greater environmental landscape. Prolonged exposure to petroleum refueling sites may have negative consequences for both people and the surrounding environment. Exposure to cumulative concentrations of gasoline vapors has been linked with a variety of cancers and chronic medical conditions in gas station employees and tanker truck drivers (Hilpert et al. 2015, 412).

More broadly, light-duty vehicles account for 58% of the transportation sector's greenhouse gas emissions, with the total transportation sector accounting for 29% of total greenhouse gas emissions (EPA 2021). Therefore, the practices of petroleum refueling of individual automobiles is associated with a large proportion of overall greenhouse gas emissions. The gas station, in its current form, represents the use of a finite natural resource, the negative environmental impact of its manufacture, and the lasting environmental impacts of its use.

Fortunately, electric vehicles have significantly lower emission rates than their gas-powered counterparts. With an increasingly clean electric grid, electric vehicles have the potential to

substantially lower contributions to climate change (EPA, n.d.). With millions of new electric vehicles expected to join the roadways by 2030, it is becoming increasingly important to increase EV charging infrastructure (Edison Electric Institute, n.d.).

Petroleum leaks and spills at gas stations can also contribute harmful vapors and pollutants to the atmosphere and have the potential to infiltrate subsurface soils, water sources, and groundwater supplies (Hilpert et al. 2015, 413-415). Petroleum products are typically stored in underground storage tanks, creating additional opportunities for potential petroleum leaks into the surrounding environment. While tanks are now host to a variety of environmental regulations to protect surrounding ecosystems, those built prior to 1980 typically did not utilize the more robust construction methods required today. Older gas stations pose especially difficult environmental risks, including decommissioned locations (Yasenchak 2013, 2-3). Transitioning the refueling station away from petroleum products and towards electric charging distribution creates an opportunity to reframe the landscape surrounding the filling station. Remediation becomes an important physical as well as symbolic stage in the transition from petroleum to electric refueling. Fortunately, remediation efforts for underground petroleum tanks are largely understood and uncomplicated to employ but funding typically presents a larger challenge to remediation than does technical knowledge (Yasenchak 2013, 187-188). Electric vehicle charging stations emit fewer pollutants and present much lower risk of toxic spills or leaks than gas stations. The new, cleaner site conditions at EV charging stations provide an opportunity for revitalized refueling stations to support local ecosystems through landscaping, material choices, and systems selections. These redesigned EV charging stations can symbolize a new commitment to the natural environment.

The integration of EV charging infrastructure presents an opportunity to modify the gas station type. Station designs that combine sustainable building practices with connections to the broader natural surroundings can function as an important architectural symbol of the transition to cleaner energy transportation. Sustainable architectural and building systems interventions will further reduce emissions associated with refueling infrastructure. Intentional design choices that foster a connection to nature throughout the evolved station design can also yield a variety of benefits

for users of the space. Creating spaces with a connection to nature has been shown to lower stress levels, improve positive mood associations, and improve cognition and memory (Ryan et al. 2014, 64). Focusing on the amenity spaces is particularly important given the longer EV charging cycles. Additionally, social psychologists have argued that opportunities to connect with natural systems can promote pro-environmental behaviors (Richardson and Butler 2021, 36). The next iteration of the gas station typology could serve as a physical recommitment to prioritizing connections between our natural surroundings and our built spaces.



*fig. 23: U.S. Highway Infrastructure + Network Collage.*

## Network

At the largest scale, the broader landscape of the gas station comprises the physical location and surroundings of the station, but also includes connections with the greater infrastructural network (fig. 23). These associations are especially true of rural gas stations. According to Stephanie Desjardins, rural communities are continually challenged to provide essential services to their residents, as they are often overlooked in favor of larger settlements. However, refueling stations can be considered as offering an essential “quality of life” service, thus investing in them in small communities has been linked to increases in social cohesion within communities (Desjardins et al. 2002, 17-22). Therefore, as the nation converts to the use of EVs, stations in more rural locations merit additional study because they create an opportunity not only to support the transportation network but to make an impact on a community’s social network as well.

However, there is no singular definition of “rural” in terms of community location or size. As defined by the United States census bureau, “rural” denotes any area not defined as “urban”—with a population over 50,000. The Census Bureau also defines an “urban cluster” as any area with a population between 2,500 and 50,000 (U.S. Census Bureau, n.d.). For the purposes of this thesis, “rural” is more broadly defined as areas within rural or urban clusters. Urban areas do account for a majority of the population of the United States, but 28.8% of the nations’ population still lives within rural or urban clustered areas (fig. 24) (U.S. Census Bureau, “Story Map”, n.d.). This thesis focuses on the smaller community structures of rural and urban cluster areas because of the importance of also providing essential services to the millions of people who have often been overlooked as EV technology arrives. This population also depends greatly on private vehicles for transportation. According to the U.S. Federal Highway Administration, as of 2017, 96.9% of households in rural areas had access to at least one personal vehicle (U.S. Department of Transportation Federal Highway Administration 2021). Furthermore, with poverty rates generally higher in rural areas than urban communities, and disproportionately affecting families with children and marginalized people, it becomes even more important to intentionally invest into essential services in small towns and settlements (Institute for Research on Poverty 2020).

Further complicating the definition of rural, with growing complexity and interdependence between global supply chains and communication technologies, the pragmatic distinctions between urban and rural are losing their precision. According to Neil Brenner’s theory of *planetary urbanization*, the concept of a rural/urban distinction is an outmoded view of a contemporary world that is so highly socially, politically, economically, and spatially intertwined that the effects of urbanization have had a universal impact. According to Brenner, there is no part of the world that is untouched by the effects of mass urbanization, from transoceanic communications infrastructure to the greenhouse gas emissions in the atmosphere the world over (Gandy 2011). While Brenner’s theory is convincing, the hypothesis does not mean that the conditions across what are more “conventional” urban and rural boundaries are the same, just that their outcomes are linked. The futures of rural communities can thus be seen as inextricably connected with the futures of their more urban location neighbors. This perspective thus elevates the priority of rural infrastructure planning as compared to that of its urban counterparts.

Location and proximity will also affect the organization and placement of the evolving electric vehicle charging network. Over 97% of the United States’ total land mass is considered rural (fig. 24) (U.S. Census Bureau, “Story Map”, n.d.). The critical transportation networks required to continue to provide movement of people, goods, and services will consequently be built and maintained across countless miles of rural terrain. An existing network of gas stations is already in place all across this territory. The American Petroleum Institute estimates there are over 150,000 gas station locations distributed across the United States (American Petroleum Institute, n.d.). This existing network of gas stations offers logical locations to build the burgeoning EV charging network.

The framework of node, landscape and network provides a critical analysis tool to evaluate the characteristics of the gas station according to three levels of scale. Each of these lenses is important to consider to fully understand the gas station as an architectural type and to understand its wider physical, social, and environmental impacts. At the node level the gas station type is understood as a place, at the landscape level the type is understood as a component in the broader environmental

context, and finally at the network level the gas station can be located within a wider transportation structure. The three lenses work together to build a comprehensive understanding of the gas station as type. This informed perspective of the gas station as it currently functions can suggest possibilities for future iterations and relationships with the emergent EV network.

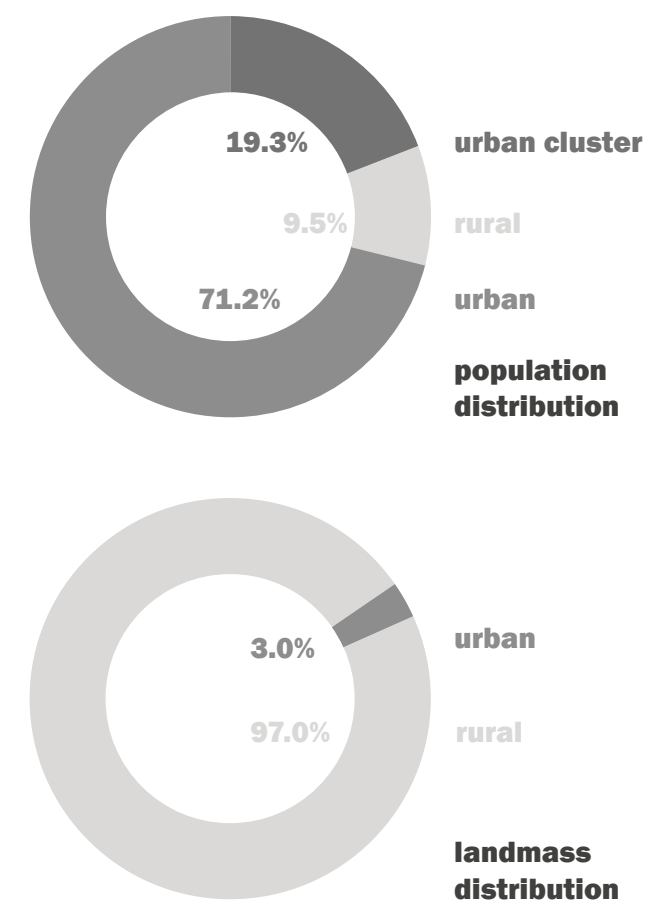


fig. 24: Population Maps Infographic.

## 4 Methodology

Recognizing the immediate relevancy and need for a robust EV charging network across the U.S., this thesis proposes a design methodology and a subsequent charging station prototype that is flexible enough to be applied at a network level. Utilizing the established three scale framework, the design project begins with a site selection and analysis process. Interpretation of the site analysis data informed a component analysis of the existing stations, the programmatic analysis, and the determination of both the specifics and the scope of the charging station program. The synthesis of the information comprises a “component map” and functions as a method for decision making throughout the design process. This map ideally serves as a design guide for townships, counties, and private owners to restructure existing gas stations according to their communities’ needs.

## Site Selection

The framework lenses of node, landscape, and network informed a qualitative analysis of potential sites. Evaluation of the existing, as well as surrounding site context was essential for understanding each site as node. Analysis of the broader surrounding environment helped build an understanding of each site and the landscape scale. Framing the project within the largest network scale reveals that the selected sites must be typical enough to represent many of the attributes of the existing gas station type across the existing network. Site selection requires a careful balancing of the three lenses of the framework.

The site selection process begins with the identification of two individual sites to represent typical nodes within the larger network of gas stations/future charging stations. The goal is to select two similarly scaled sites with similar spatial characteristics, yet that are geographically distant. This selection allowed for the balancing of individualized design interventions for their particular context, with a necessary level of standardization that allows for different network-wide applications. The most common scales of current gas stations are documented in fig. 25. The smallest stations include a single pump appended to an existing structure, while the largest include multi-functional truck stops along major highways. This thesis focuses on the middle scale (‘03 gas station + convenience’), which is the most common, is often centrally located in small communities, and has a record of successful adaptive reuse interventions. Furthermore, choosing two stations with a similar scale and function further reinforced the ability to provide meaningful interventions at the neighborhood level, while simultaneously considering the larger network scale. Choosing a site within a rural community or urban cluster region was also important to support the growth of clean energy infrastructure beyond the city. This type of infrastructure growth supports both rural communities and, by extension, adjacent urban centers, as supply chains and infrastructure systems across rural areas supply urban areas as well. As per the U.S. Census Bureau, rural and urban clusters are defined as regions with populations less than 50,000 inhabitants (Ratcliffe 2017). Selecting sites in these types of settlements that are also close to main arterials or existing highway systems provides convenient access for vehicles. Additionally, the chosen locations have

prominent levels of accessibility and visibility to make the site more attractive to motorists seeking to charge their vehicles. Availability of space to allow for necessary changes to traffic flow was also an important consideration. Selected sites must also accommodate the increased sizes and quantity of electrical equipment to support the increased power needs of charging modules. In addition to space for equipment, the sites must also have excess space for guest amenities and landscaping. Finally, locations were selected in the United States that the author could access for field work in order to facilitate a more thorough site analysis for a project of this scope and scale.

The preliminary search of existing gas stations resulted in six finalists, from which the two sites chosen for the design emerged: an existing station in the town of Belvidere, Illinois, and a station near Interstate 5 in Centralia, Washington (figs. 27, 28). These mid-sized sites fulfilled all of the general requirements listed above, while their relative locations and geographic disparity created important and distinct contextual considerations to explore during the site analysis (fig. 26) and design (See Appendix A for detailed site analysis data).

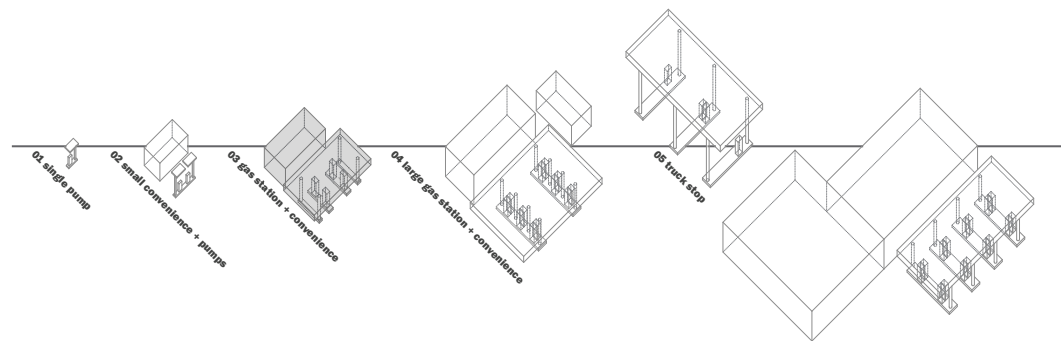


fig. 25: Scales Diagram.

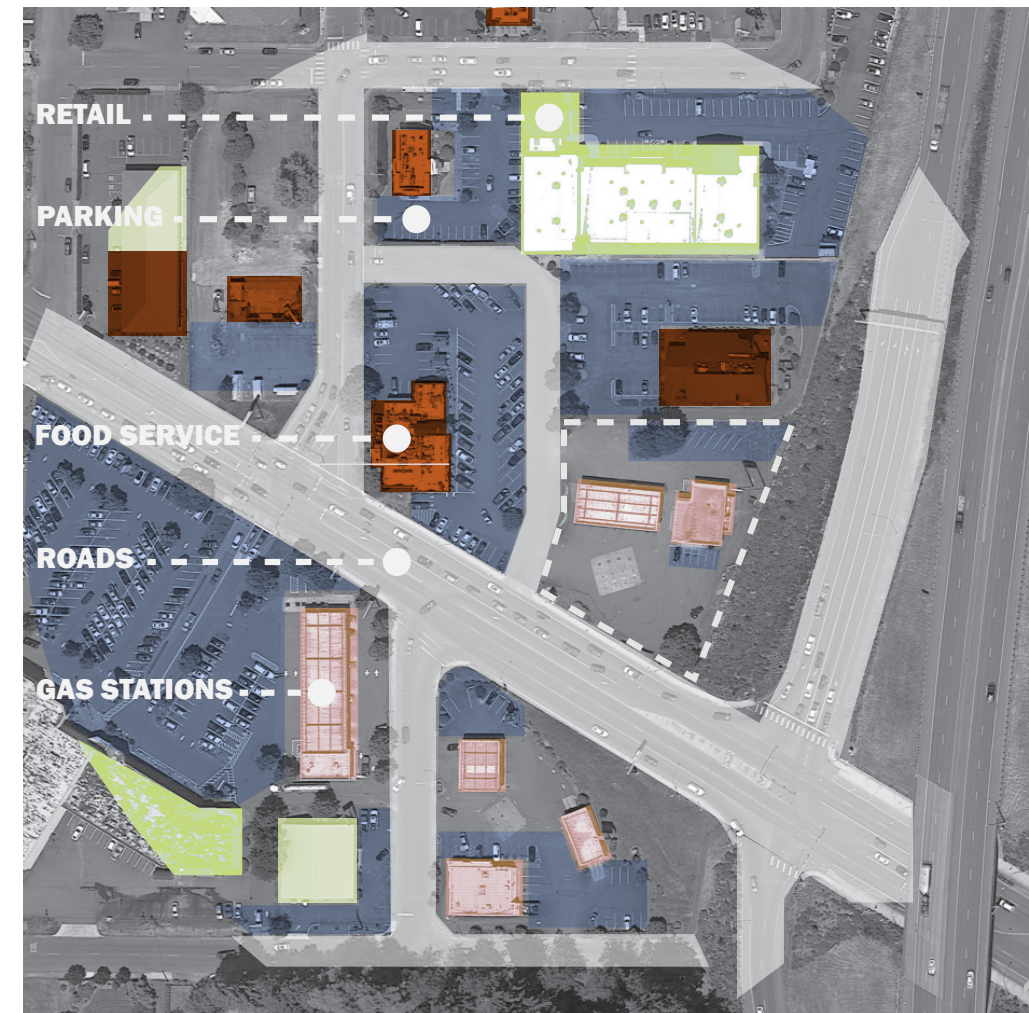
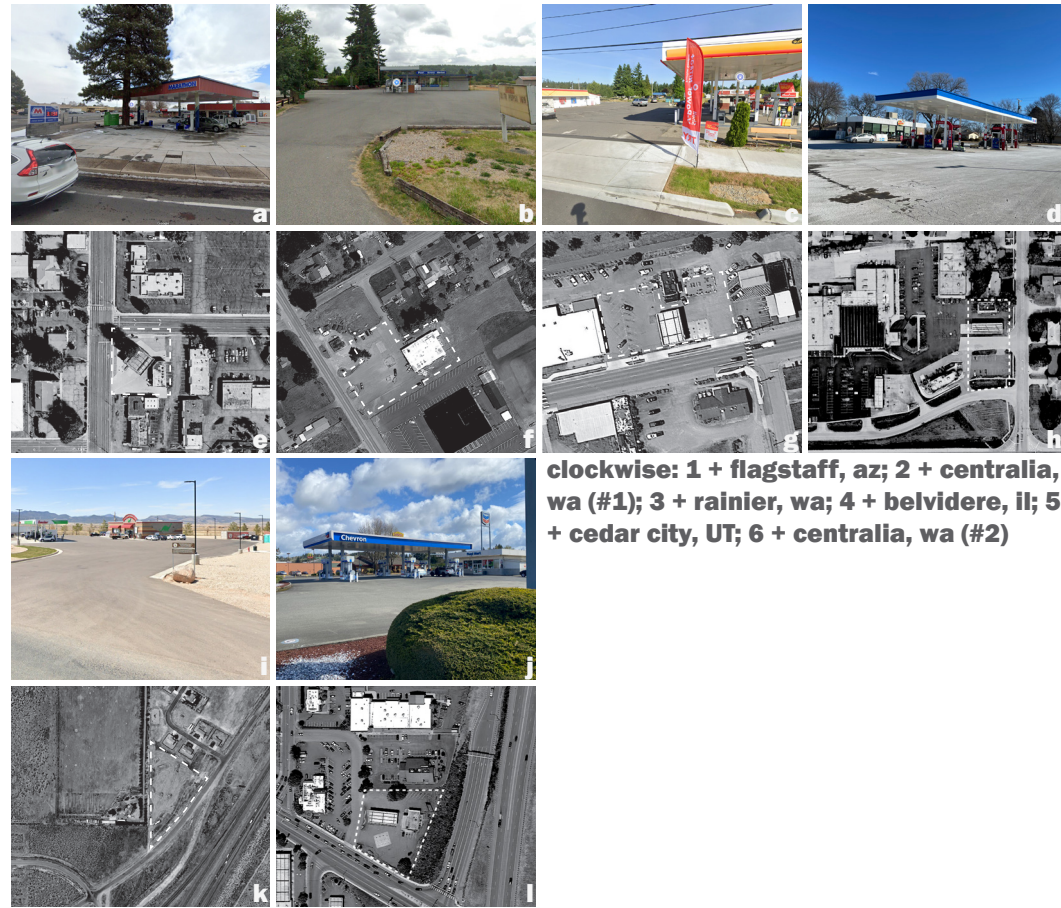


fig. 26: Sample Site Analysis.



clockwise: 1 + flagstaff, az; 2 + centralia, wa (#1); 3 + rainier, wa; 4 + belvidere, il; 5 + cedar city, UT; 6 + centralia, wa (#2)

fig. 27: Potential Sites.



**6 + centralia, wa (#2)**  
**station scale: 03**  
**population: 18,183 (2020)**  
**distance to major freeway: <0.5mi**  
**climate: marine (4)**

**4 + belvidere, il**  
**station scale: 03**  
**population: 25,339 (2020)**  
**distance to major freeway: 3.4mi**  
**climate: cold (5)**

fig. 28: Final Sites.

# Components

In an analysis of the existing two stations, five primary components of the station were observed (fig. 29). The canopy, the sign, the “box” or convenience store, the pump, and the pavement surfaces constitute the five primary elements of a conventional service station. These five primary elements became the focus of the redevelopment of these sites as EV charging stations. Each architectural element has evolved through time to serve a specific function. The *canopy* provides shelter, respite from the elements, and can act as a symbolic representation for the building and brand. The *sign* communicates prices and information, the *convenience store* provides consumer goods and food products, and the *pump* supplies the gasoline or other form of energy for sale. Finally, the surface *pavement* makes possible circulation and vehicle access through the site. While each of these elements performs relatively effectively for petroleum distribution, the program and function of the station is static. The development of a charging station creates the opportunity to reimagine each of the components of the station within a dynamic lens – one that can allow for present as well as future uses. It allows for the design of a space that functions more efficiently for electric vehicle charging, but also more effectively serves the health and satisfaction of the occupants (fig. 30).



fig. 29: Site Component Analysis. [Standard Gas Station].

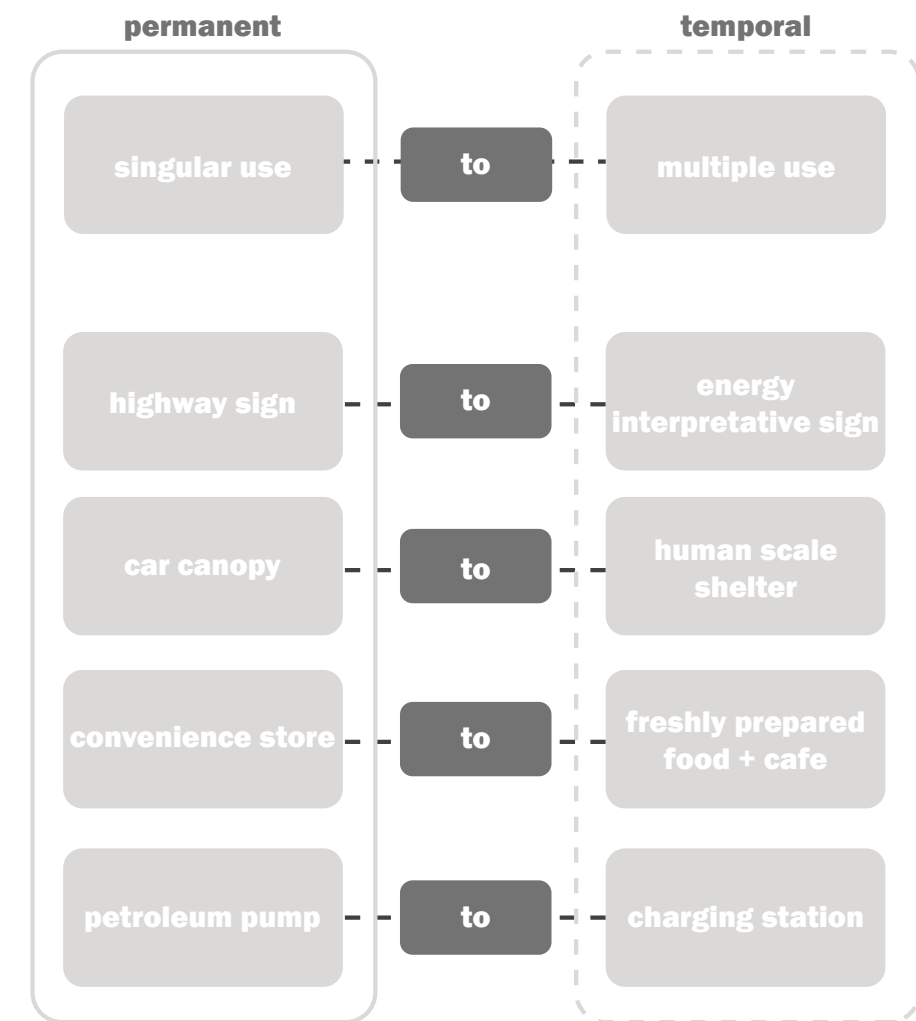


fig. 30: Program Shift Diagram.

# Program

The program of the proposed charging station was thus established by expanding on the basic component analysis. Determining program conditions required careful and critical analysis of programmatic components of existing gas stations as well as existing charging stations. The analysis also made use of research into future charging station needs to allow the evolving typology to best respond to the future experience and needs of occupants. This analysis resulted in a shift in program for the typology from single-use components to a collection of components supporting a multiple-use charging station. Finally, evaluating the program at a finer grain helps to understand how to design for a shift from a “car-centric” gas station typology with few additional services for people, to a design for a “people-centric” charging station typology with additional services for charging vehicles (fig. 31).

# Design Map

The design proposal for an EV charging station follows a design map that was created to synthesize the component analysis, the programmatic features, and the role of the three framework scales of node, landscape, and network. Detailing each of the five components and how they can be imagined in the new charging station typology, the design map (fig. 32) focuses the design priorities and highlights key experiential categories. Importantly, each category ties to one of the three framework scales—node, landscape, and network. This determination drives key design choices in regard to modularity versus contextual considerations. For example, a network designation indicates that this aspect of the design should be standardized and able to be deployed across the charging network. A node designation indicates a design category that is highly contextual and better adapted to the local conditions of the localized site. Finally, a landscape designation indicates the highest level of site interdependence and will be specific to a given site and its surroundings.

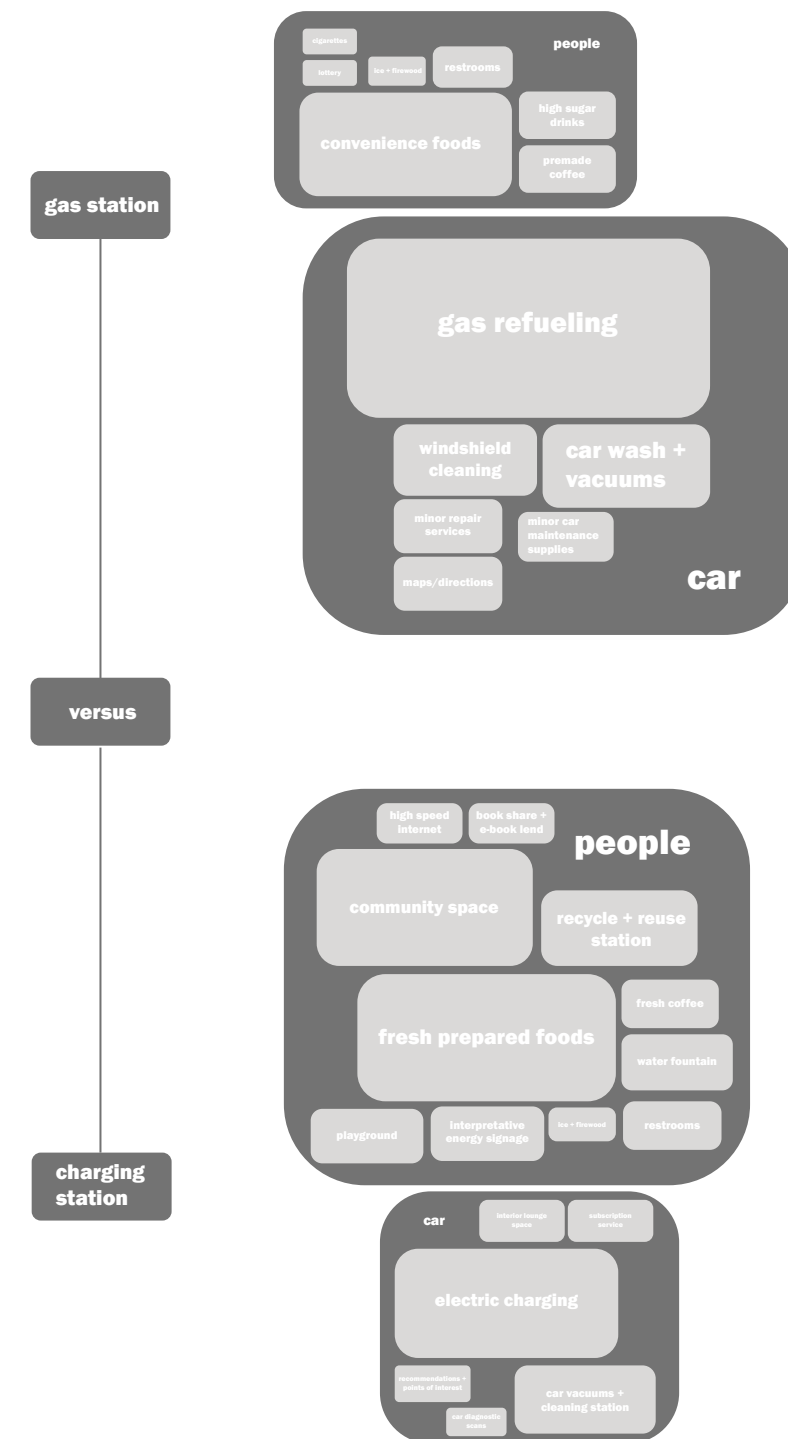


fig. 31: Program Diagram.



fig. 32: Design Map.

# Conclusions

In this thesis, two existing gas stations are used as sites for the proposed design of EV charging stations. However, only one site (Belvidere, IL site) is detailed beyond a basic massing and concept phase in order to obtain a higher level of detail. While this strategy also allowed for a closer reading of specific site conditions, the proposed project is readily applicable as an example for additional charging stations within the network.

The design map method illustrating the key priorities and essential experiences allowed for the design process to focus on the most important needs of a future charging network. Over time, the proposal evolved to incorporate all of the design map components into an architectural expression with three major parts. The design proposal is composed of a landscape or surface that operates as an Outdoor Room. Charging bars house EV charging access and associated infrastructure. And finally, a Collector Canopy creates sheltered spaces for gathering, merges interior spaces slipped beneath its eaves, and unifies the component parts into one cohesive experience.

The primary goal of the design effort in this thesis is to meet the imminent needs of the next iteration of mobility infrastructure, but also important is planning for growth and future uses, particularly when dealing with emergent technologies such as electric vehicle charging. This reality forced a number of considerations to be taken during the design process. The project prioritized the need to provide charging pedestal mounts with maintenance access and footprints large enough to support multiple iterations of chargers of assorted sizes and weights. The station is also designed to provide sufficient square footage for spare electrical capacity to incorporate increases in charging speed and capacity. The vehicle and pedestrian pathways also allow for changes in charging times and volumes of users. Both interior and exterior spaces are designed to be flexible enough so that they can be easily converted for evolving community uses, or adaptively reused if vehicle charging is no longer necessary in its present form. Finally, the material selection should consider a construction methodology that allows materials to be sourced from recycled materials, and/or easily reused or recycled at the charging stations' end of life cycle. Ultimately, the design project seeks to provide maximum flexibility within a modular charging station model.

# 5 Design

## A Network Proposal: Belvidere + Centralia

The station design first responds to the physical conditions of the selected sites. Typical of the gas station type, both the Centralia and Belvidere sites operate on large, fully paved footprints with large amounts of underutilized space. Structures are clustered in the center of both sites with multiple curb cuts and points of vehicle entry from the adjacent streets. Although sidewalks are present near both sites, pedestrian access to the station is limited, and typically combined with vehicle access (fig. 33). In both cases, the revision of the site circulation scheme was the first step in responding to the demands of the site.

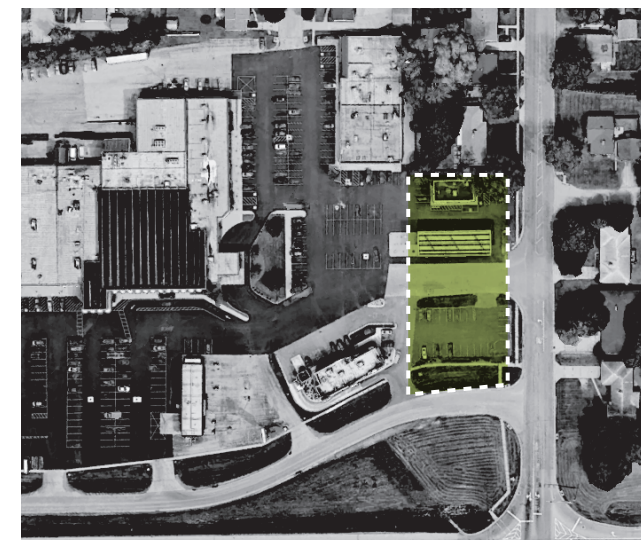
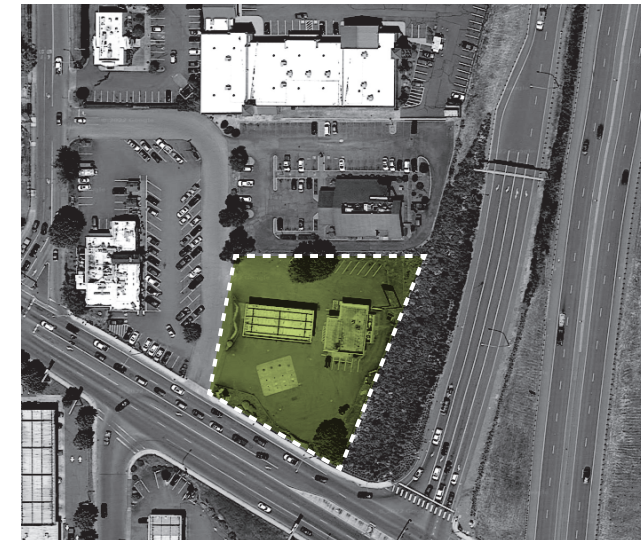
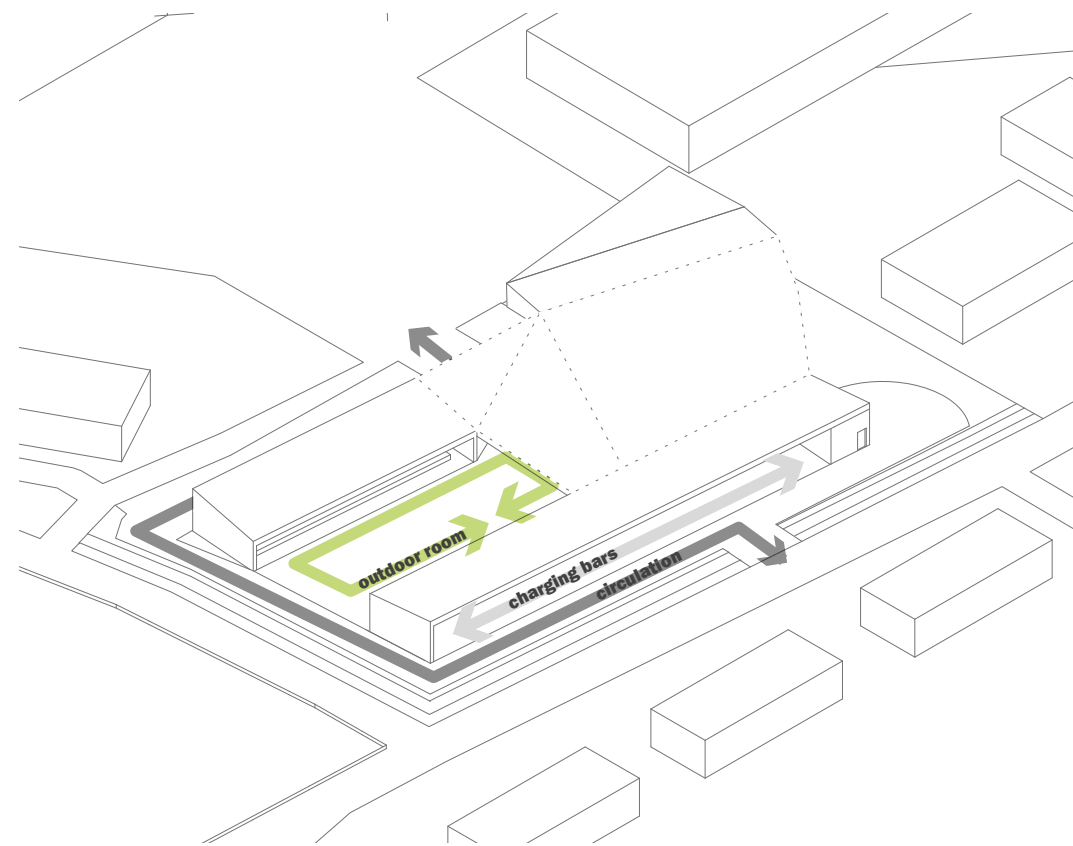


fig. 33: Aerial View Selected Sites.



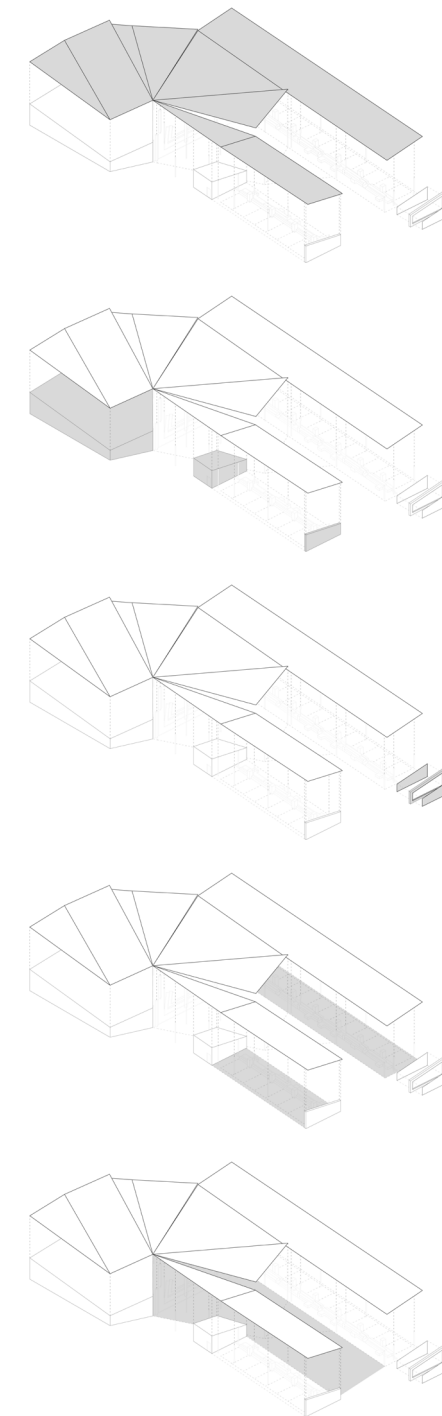
*fig. 34: Circulation Diagram.*

Generally, car circulation, that currently occurs throughout the site, is moved to the outside edge of the site (fig. 34). This allows vehicles to access long bars of charging modules, optimizing the number of cars that can charge at one time. Rather than a vehicle having to wait for a turn at the pump, as in a more traditional gas station layout, this configuration maintains open access to circulation pathways irrespective of the varying lengths of charging times. This circulation pattern also creates a protected interior courtyard for pedestrians, shielding human activities from the vehicle paths. The interior courtyard is flanked by the charging bars, typically on two sides, but is open on at least one edge to the public space. This pedestrian entry point is important to maintain to create a sense of openness and engagement with the charging stations' greater surroundings.

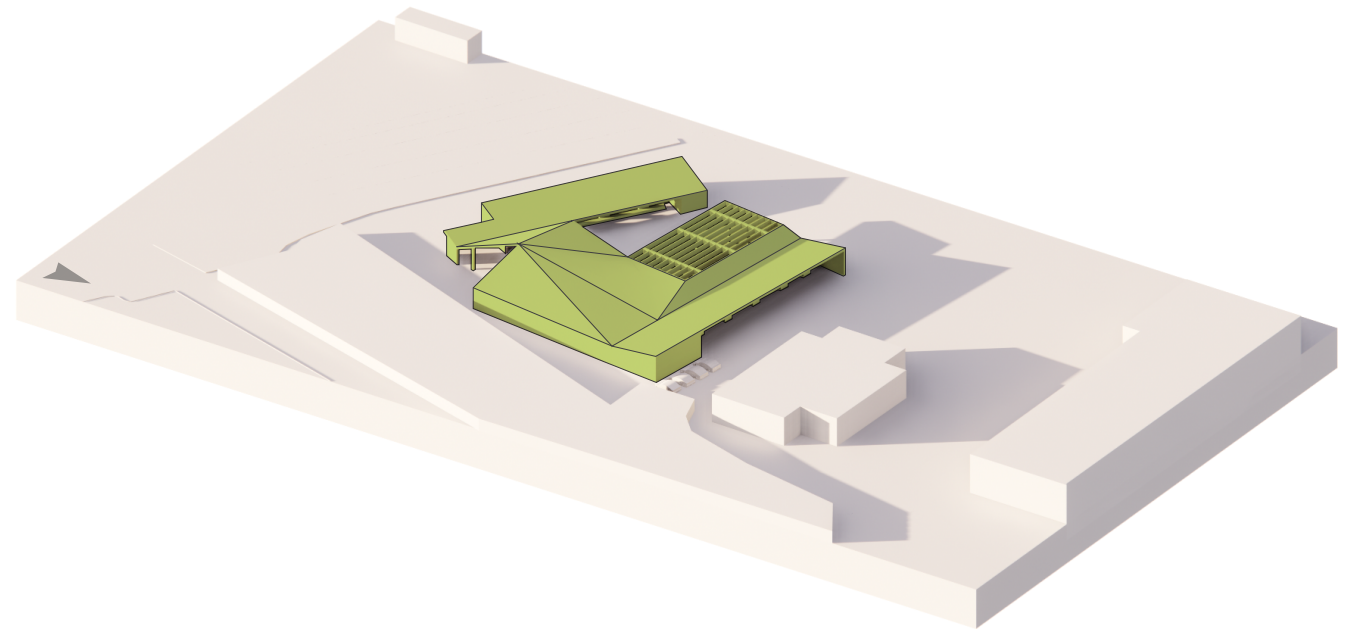
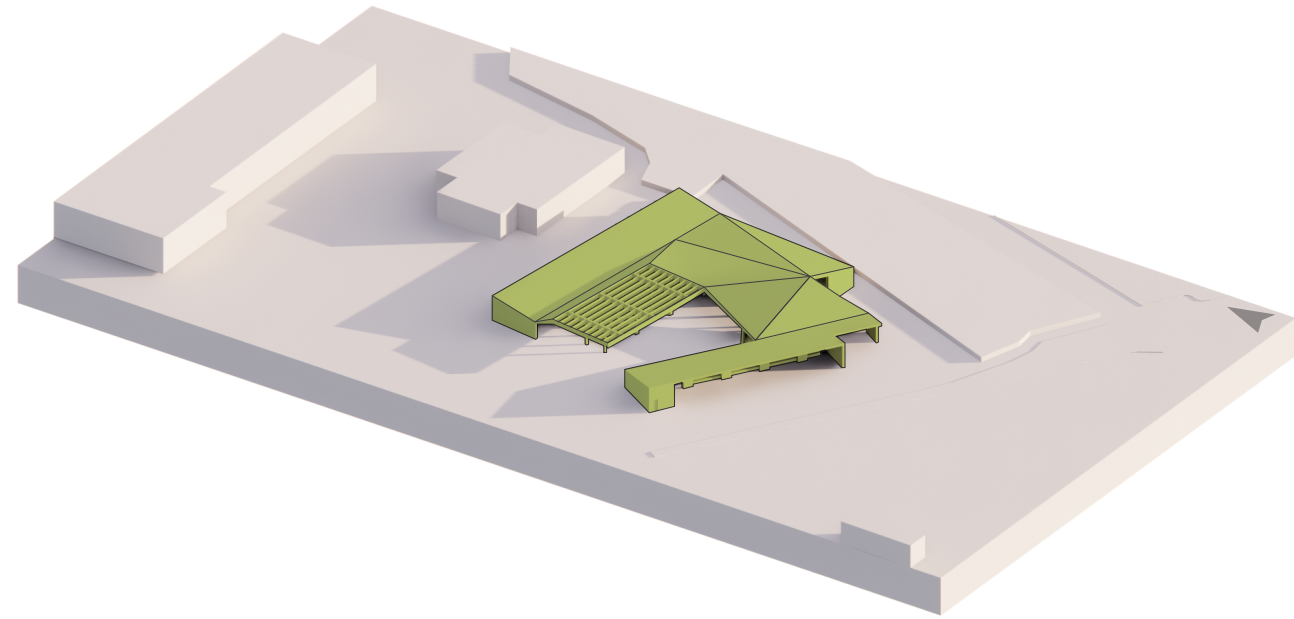
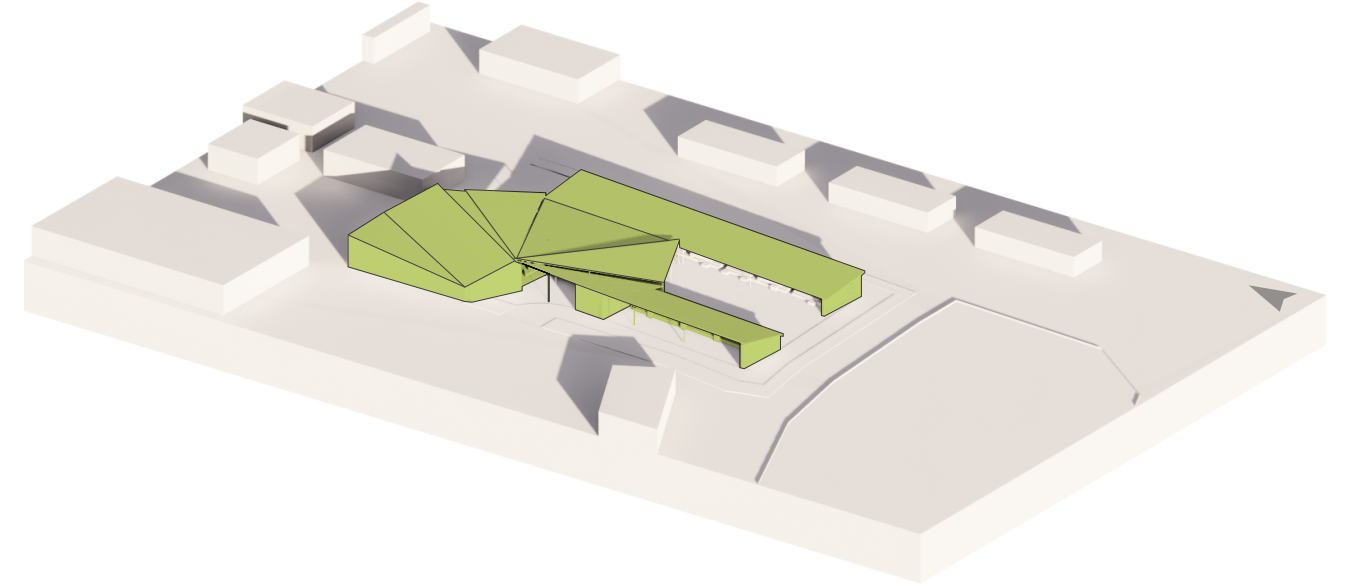
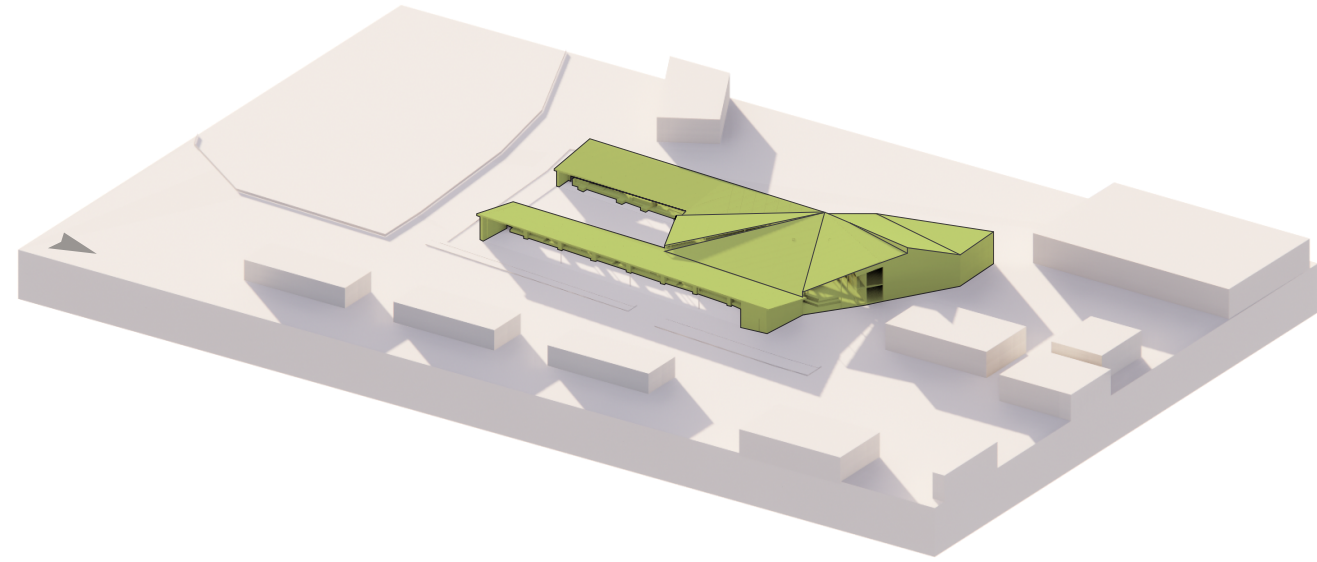
The massing of the charging station responds to this circulation pattern and begins to mold the components of the design map into an architectural response (fig. 35). The folding and unfolding canopy becomes a shelter not only for cars, but also for people. The box station becomes the sheltered lounge and interior spaces. The sign maintains its original meaning as a source of visibility and communication for the station, but also takes on an additional, more interactive meaning as a teaching tool and an opportunity to share charging and energy use data with customers and guests. The charging bars themselves are a modular construction that can be fit to the site and gather together charging, mechanical/electrical equipment, and sheltered waiting spaces. Finally, the waiting spaces help to make the transition from the charging bars for the cars to the outdoor room. The outdoor room provides a canvas for local plantings and vegetation, with a specific focus on amenities scaled for people—the new version of the former relentless expanse of concrete suitable for cars at the typical gas station.

Synthesizing the built components, the massing of the two sites expresses a similar, yet distinct architectural language (figs. 36, 37). The charging bars run parallel to the site edges while sheltering the outdoor room. The building forms slip beneath the overarching canopy, which connects the site elements.

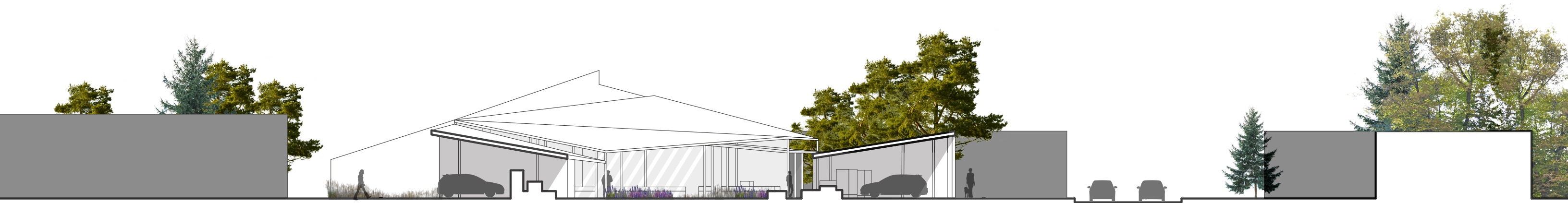
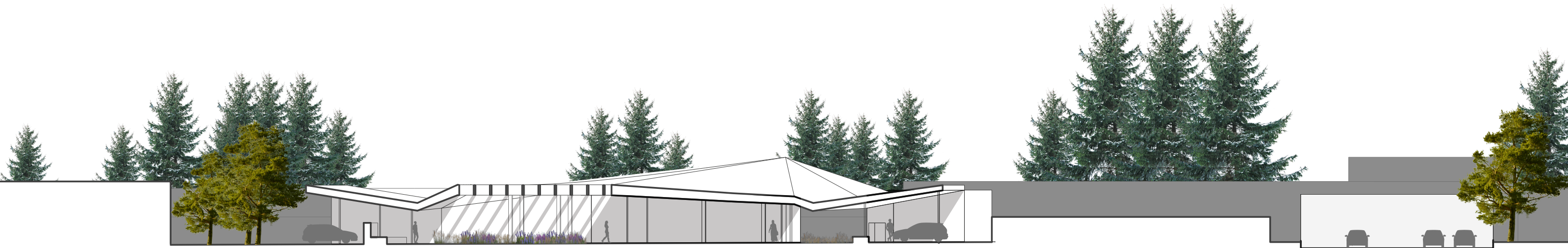
The shed rooflines of the charging bars tilt inwards towards the outdoor room. The roofline provides a 14-foot height vehicle clearance at the charging stall entry and descends to nine feet at the edge of the outdoor room, creating a more comfortable ceiling height in the covered seating areas. The linear seating areas feature built-in benches that create a sense of separation from vehicular traffic without creating a strict barrier or a loss of visibility (figs. 38, 39). Additionally, the designs for both sites aim to maintain or reuse existing materials where possible. The Centralia design retains the existing canopy structure and incorporates it into the new folding canopy. Lacking fewer preservable elements, the Belvidere site design reuses the existing columns to help support the new canopy.



*fig. 35: Component Diagram.*



*fig. 36(above): Belvidere Massing Diagram.  
fig. 37: Centralia Massing Diagram.*

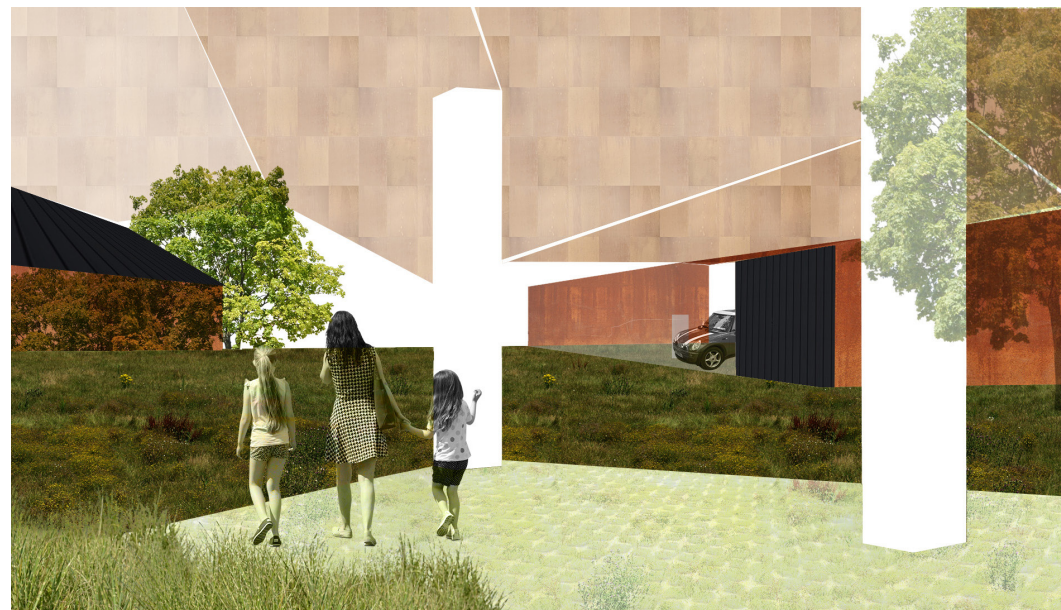


Programmatically, the proposed buildings are minimal and flexible. Providing spaces for conditioned lounge spaces, a café, and restrooms. Mechanical spaces are distributed in the charging bars. In addition to the outdoor room, the interior courtyard contains outdoor covered seating beneath the canopy and a small playground. The flexible approach to programming allows the functions to vary according to the specific needs of each site. For example, in addition to the basic elements, the Centralia station also accommodates a hanging garden from the existing canopy structure, a dog run adjacent to the lounge, and additional over-height charging stalls. The garden is suited to the specific layout of the site, and the dog run and over height stalls are appropriate for a station directly next to the highway, as they are amenities more likely needed for travelers and tourists (figs. 40, 41).

Both proposed design interventions focus on creating intentional spaces for community and for gathering. While still providing a necessary service, the proposed EV charging stations seek to shift the attention from the automobile facilities to the people experiencing the space (figs. 42, 43).



fig. 40(above): Centralia Plan.  
fig. 41: Belvidere Plan.

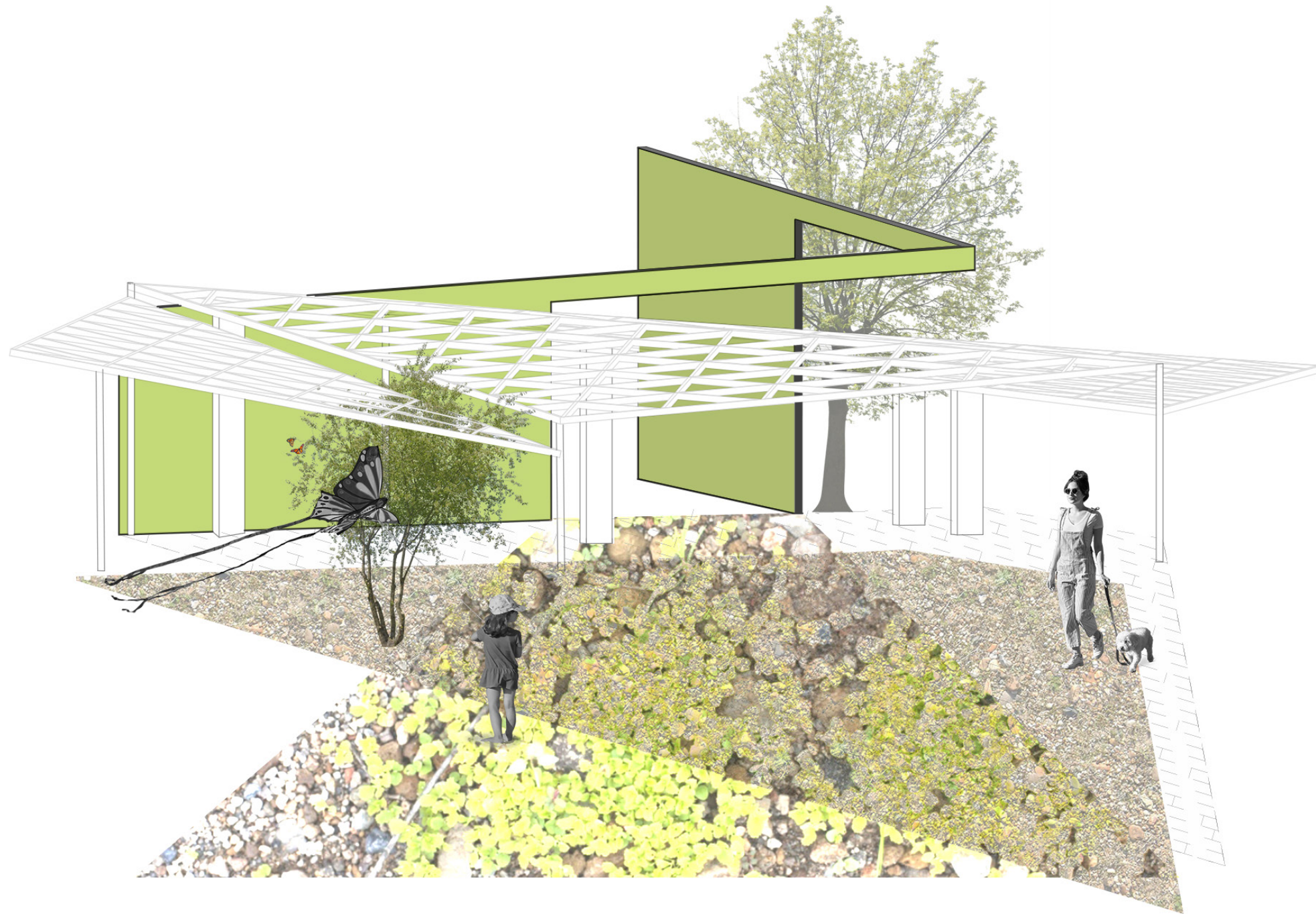


*fig. 42 (above): Centralia Canopy Perspective.  
fig. 43: Belvidere Canopy Perspective.*

## Prototype Proposal: Belvidere

Preliminary massing and designs at the Belvidere and Centralia test sites provide evidence that the design proposal is flexible enough for application at multiple sites. The following section focuses on the continued refinement of a singular prototype to consider the design proposal at a higher level of detail. The Belvidere site is selected for this analysis and design development process.

The outdoor room and the canopy are spatially prominent aspects of the design that also express the symbolic significance of the new EV charging station. The shift from petroleum to cleaner EV charging creates an opportunity to promote ecologically healthier landscapes, both physically and symbolically, by providing spaces where natural plant life can flourish. The canopy structure functions as bridge between the outdoor room and the conditioned spaces. While borrowing the lightweight metal structural language of the existing gas station canopy, the new canopy focuses on providing shelter for people. The canopy design shifts and folds at its seams to provide additional light within the gathering spaces below (figs. 44, 46).



*fig. 44: Canopy Development.*

In plan, the relationship between the conditioned spaces and the landscape is clearly evident. The design proposal shifts from a building placed in a paved landscape, to one continuous space merging landscape and pavement. The lounge and café spill into a generous covered patio beneath the canopy and within the outdoor room (fig. 47). Inside the lounge space, a mezzanine provides valuable additional waiting and gathering spaces for visitors (fig. 48). Here, the lounge roofline responds to the language of the canopy—lifted at its seam to reveal a skylight—that brings in light and helps make the transition to the outdoor room (figure 47).



*fig. 45: Perspective from Charging Bar; Looking north.  
fig. 46: Perspective Lounge, Mezzanine.*

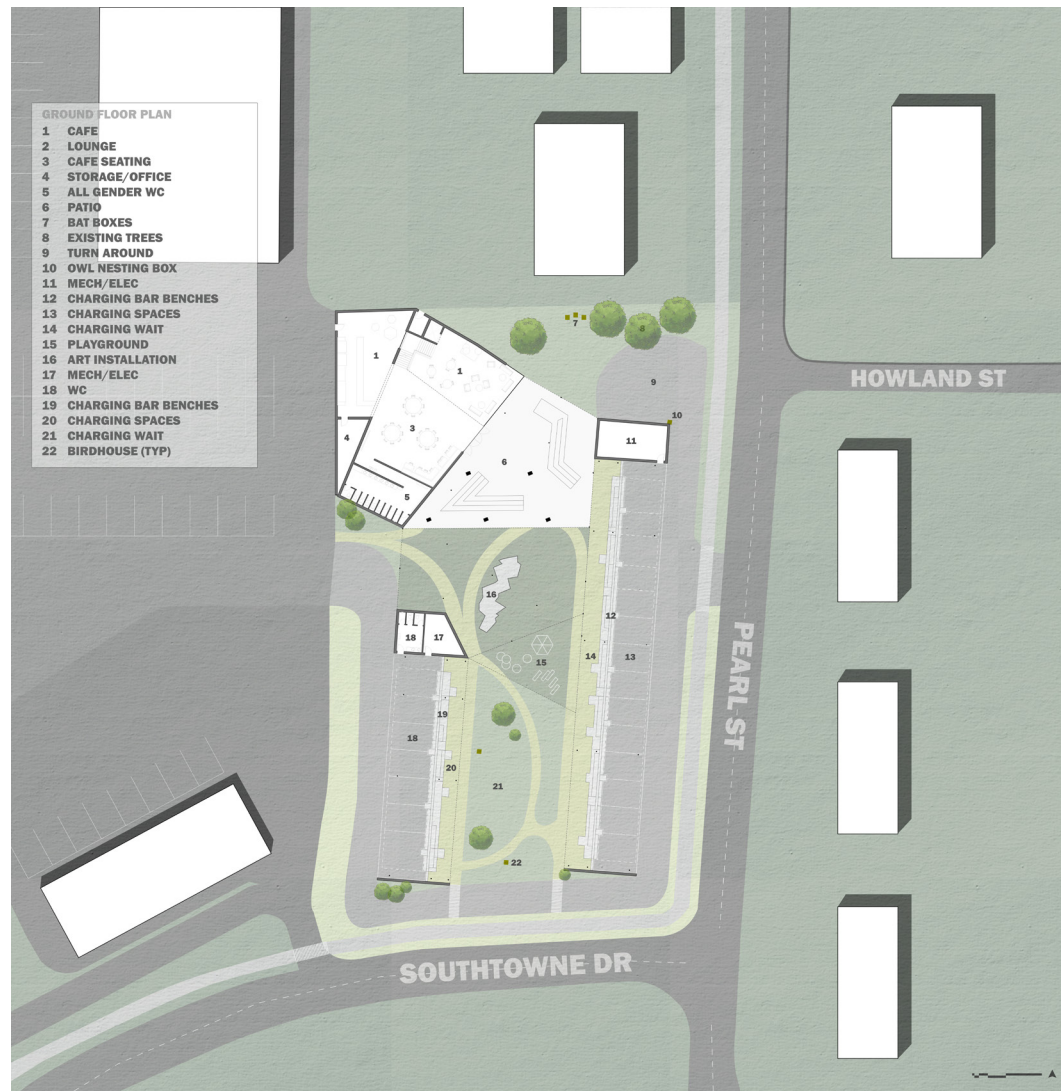
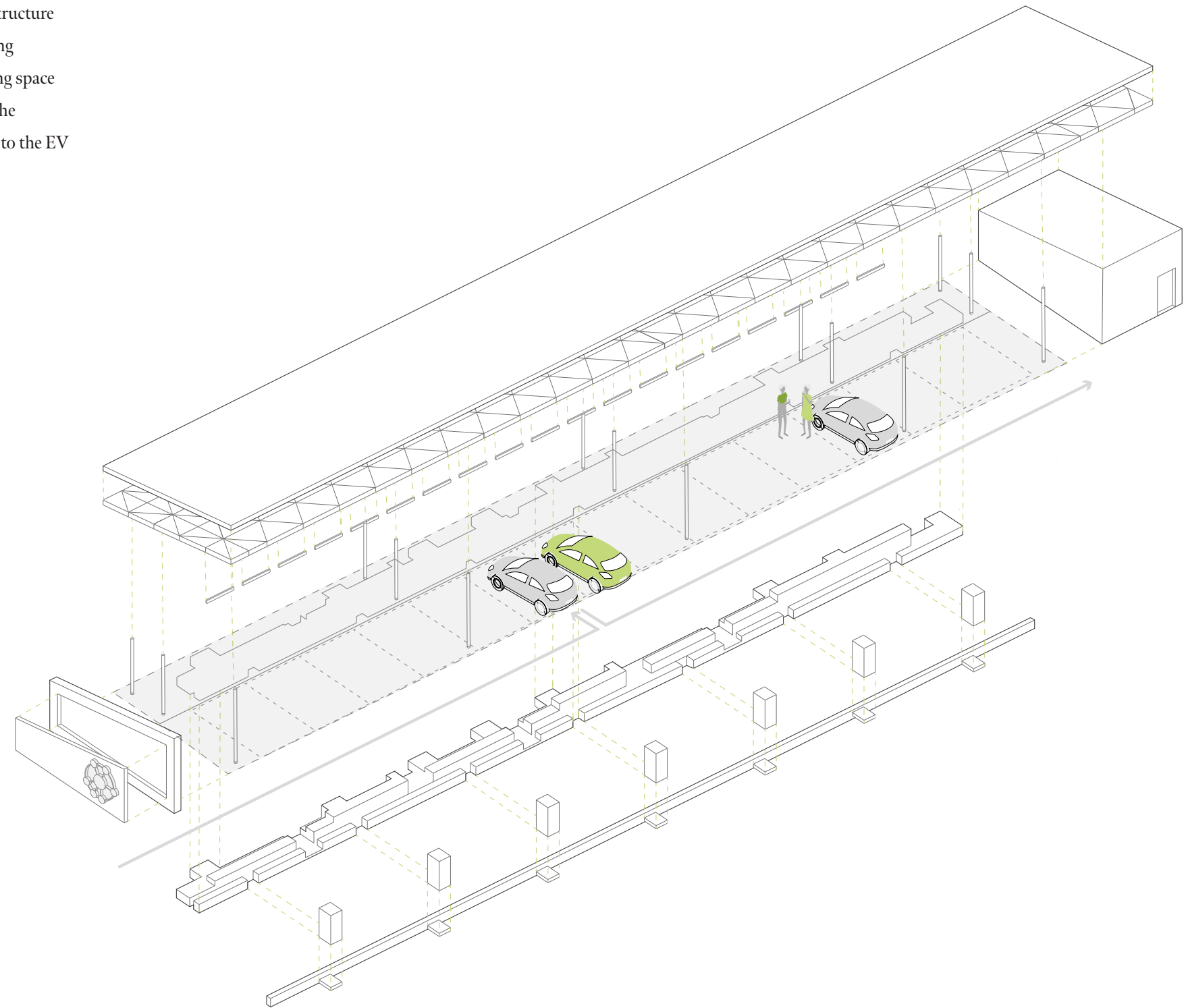


fig. 47: Plan; Ground.



fig. 48: Plan; Mezzanine.

The charging bars highlight the modular components of the design proposal. The shed structure is open, continuing the steel structure of the canopy, and providing shelter for the charging modules. Bench seating is built-in and constructed to wrap around the chargers, providing space to accommodate a majority of currently available chargers. A raceway is also integral to the construction, providing maintenance access and a degree of flexibility for future changes to the EV chargers (fig. 49).



*fig. 49: Charging Bar Axonometric.*

From a systems standpoint, the design of the building is an opportunity to use the canopy as a collection system. Rainwater is collected and stored in underground storage tanks. Where in the past the gas station used to store petroleum in underground storage tanks, the EV charging station can now store rainwater underground for reuse in building services and irrigation. The continuous plane of the canopy roof also creates an opportunity for the installation of solar photovoltaic arrays. PV arrays can generate power for the site amenities and supply supplemental power for the vehicle chargers (fig. 50).

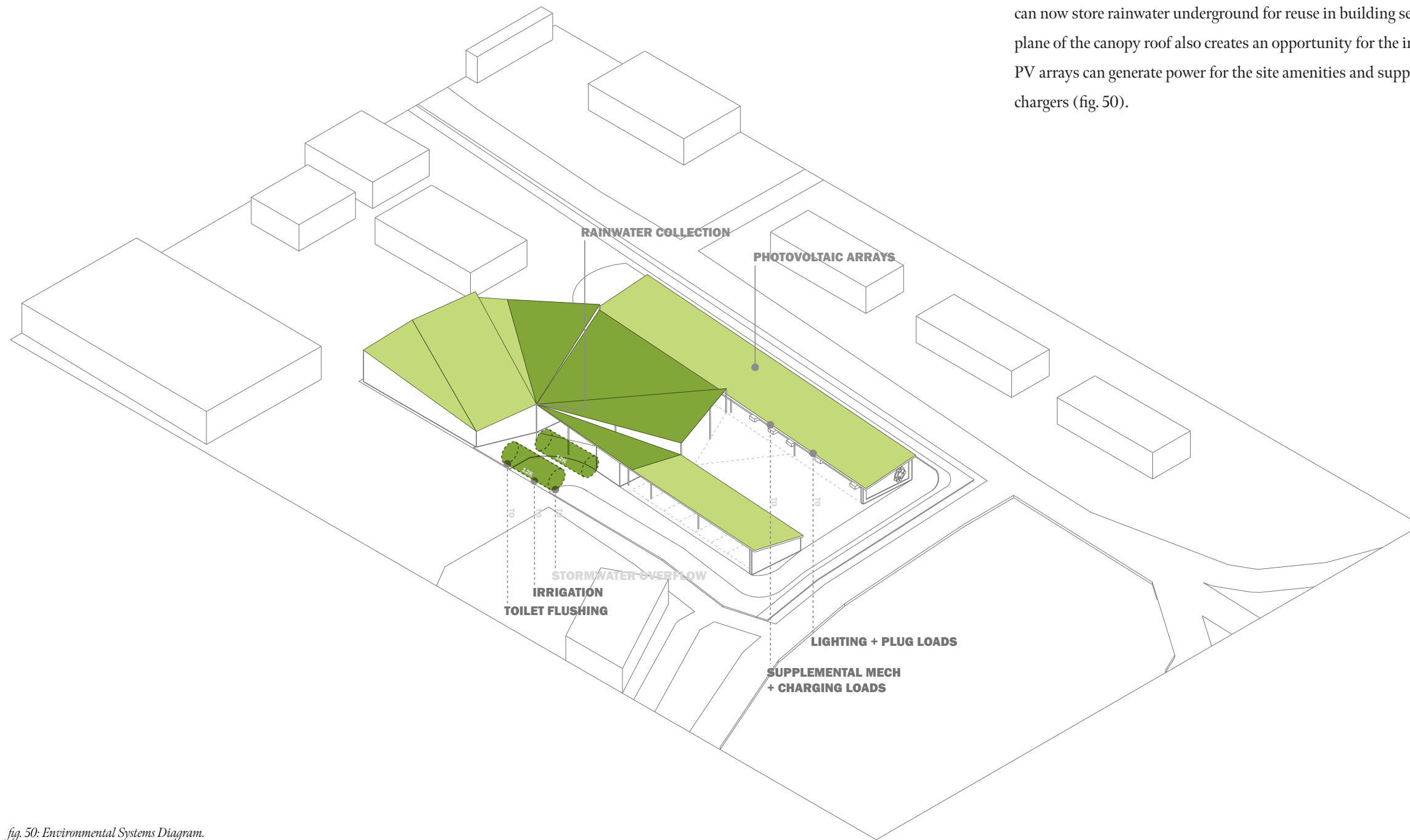


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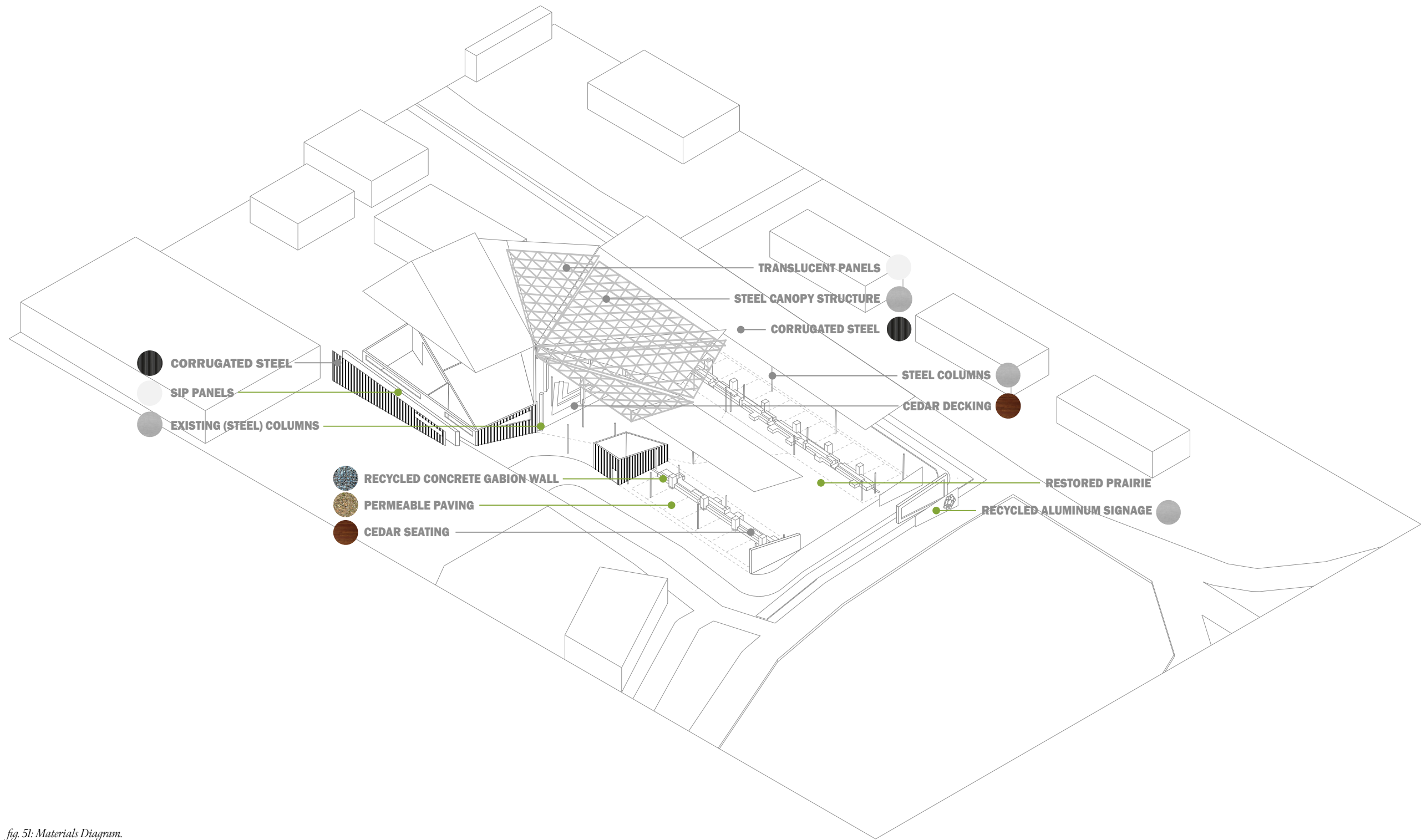
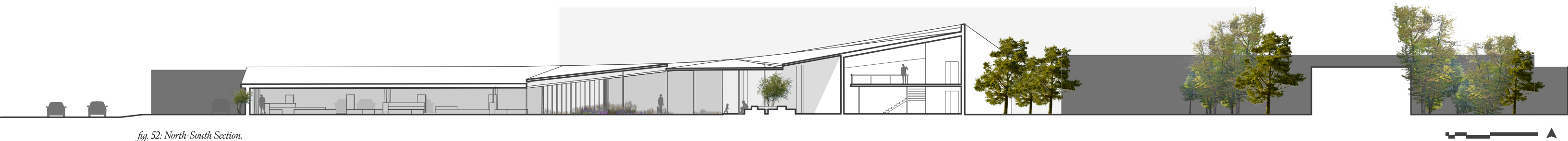


fig. 51: Materials Diagram.

The proposal utilizes a relatively simple range of building materials. Materials are reused wherever possible. While a majority of the concrete pavement on the site is replaced with permeable paving, the concrete is reused as fill for the gabion wall foundations of the charging bar benches (fig. 51).

In section, the prototype emphasizes the continuous flow of the space from interior to exterior. The overall horizontality of the section is reminiscent of historical examples of the gas station type, yet the function and scale of the space is reimagined to prioritize people over the automobile (fig. 52).

The patio adjacent to the lounge is designed for gathering. Outdoor benches provide spaces for people to rest. The patio and the outdoor room also create a flexible space for a variety of potential uses beyond car charging. The patio space is an ideal location for pop-up shops and temporary installations, movie nights, or any number of community events. This open space is also flexible enough to be reused in the future, perhaps when car charging stations are obsolete (fig. 53).



*fig. 52: North-South Section.*

Additional site considerations include the need for a sitewide lighting scheme. Similar to gas stations today, the charging facility will necessarily operate on a 24/7 schedule. These operating hours require maintaining light levels across the site that promote a sense of security and safety for all guests and staff. The canopy roof provides a means to incorporate lighting that is consistent with the design language (fig. 54).

Finally, the proposed design considers the implications of the EV station operating as a year-round facility in many regions of the country with inclement weather. The charging bars provide shade when it is hot and can support ceiling-mounted radiant heaters when it is cold. The conditioned interior waiting space provides refuge from the elements as well as all-gender restrooms in addition to useful amenities for guests year-round (fig. 55). While these additional spaces are simple, they are important for the comfort of guests during the duration of EV charging cycles. Furthermore, this type of flexible facility can reach a wider audience beyond EV charger customers, providing gathering spaces and benefits to the larger community. As architectural expression of the design map, the EV charging station prototype offers an example of the synthesis of the three framework scales of node, landscape, and network in its design of the canopy, the lounge, the charging bars, and the outdoor room.



*fig. 53: Canopy Seating.*  
*fig. 54: Charging Bar Lighting Scheme.*



fig. 55: Winter Weather.

## 6 Conclusions

The design strategies underlying the EV charging station proposal presented in this thesis are the descendant of its utilitarian counterpart—the gas station. Informed by the past and present conditions of the gas station typology, the current landscape of emerging EV charging stations, and the existing network of gas stations across the United States, the thesis proposal suggests an alternative vision to the future of the U.S. refueling network. This vision creates a system that better respects people and the environment by prioritizing sustainable building strategies and creating spaces that support local community needs. The three-scale framework makes possible the application of the design approach at increasing levels of scale, allowing for a broad application across a developing EV charging network, while balancing site specific context. This thesis

demonstrates the design strategy with a proposal for both a single station prototype and by testing the design philosophy across two distinct sites. This thesis is timely and important, as we are faced with the increasing challenges of climate change. The systemic shift occurring within the U.S. infrastructure network from vehicles with internal combustion engines to EVs presents us with the rare opportunity to entirely reconsider one of our critical transportation systems. This moment of transition emphasizes the importance of not only prioritizing and questioning our everyday landscape but asking how our infrastructure and built environment can best serve the multiple needs of critical infrastructure, people, and the planet.



*fig. 56: Looking to the Future.*

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# Site Analysis

## Site 1: Centralia, WA

Site 1 is located in Centralia, Washington, approximately 80 miles south of Seattle. The site is located near the center of Centralia and is directly adjacent to interstate 5, the major highway arterial in the region. The location is an ideal location for the new charging station, allowing access for local residents as well as convenient highway access for travelers. An existing gas station currently occupies the site.

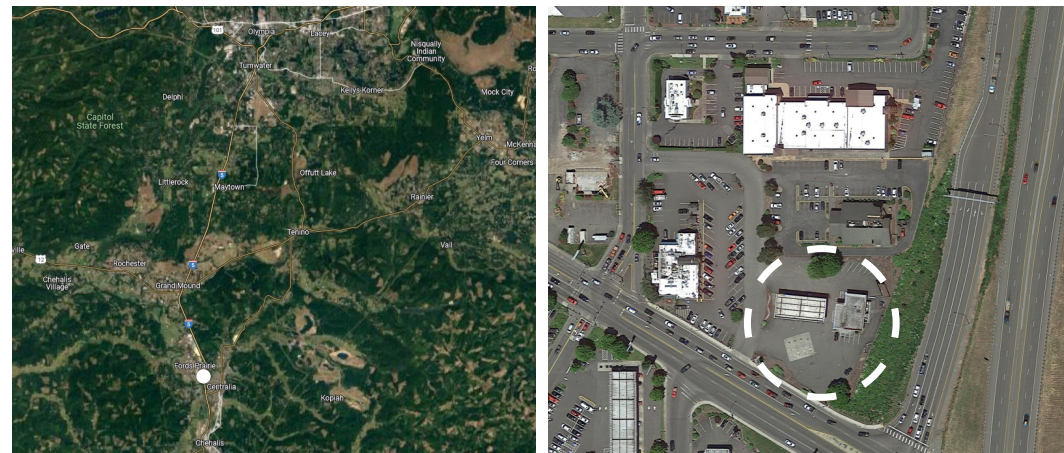


fig. A1: Site Plan Maps. Base Map: Google. "Map view." 2022.

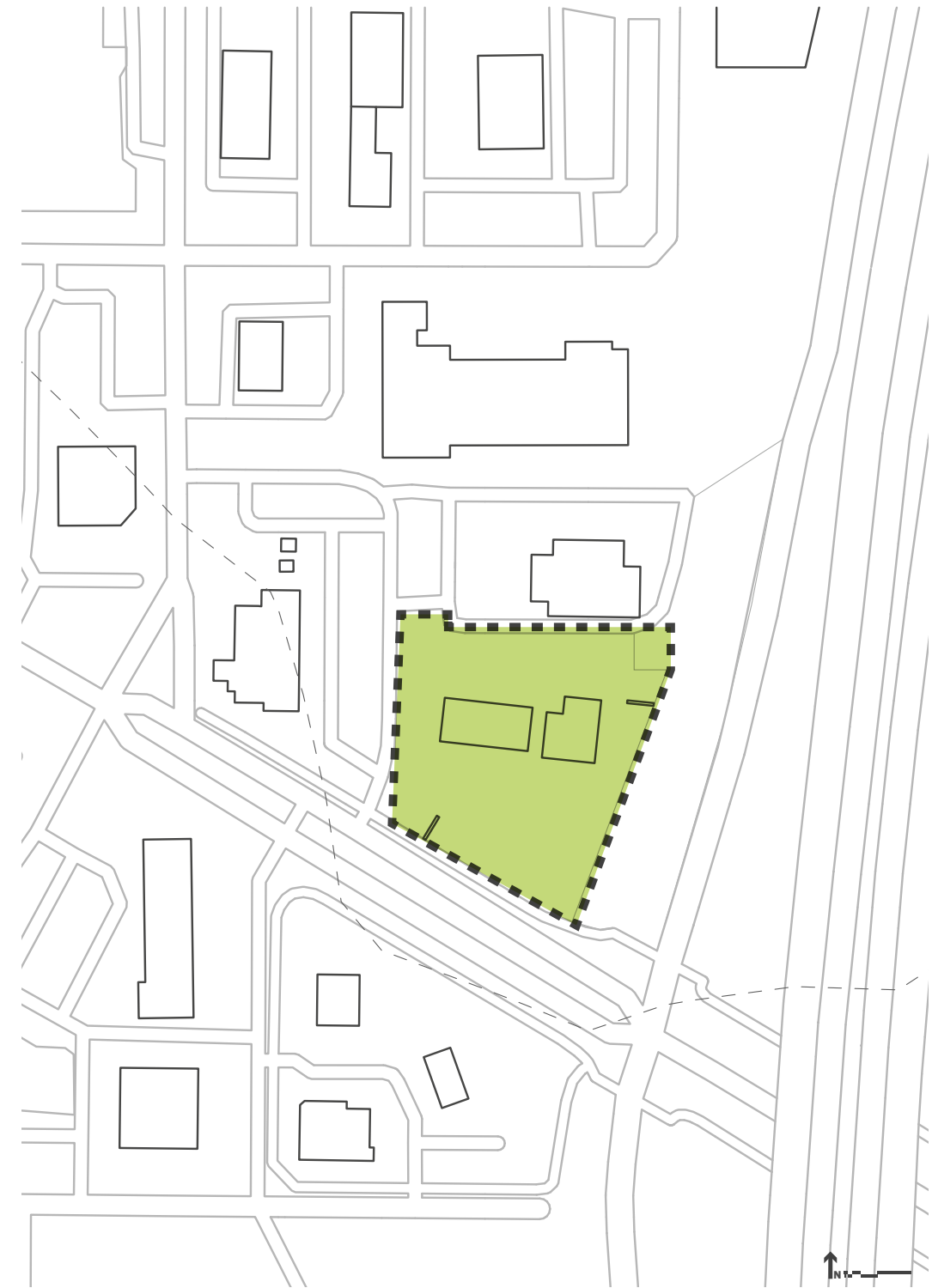


fig. A2: Existing Site Plan.

## Community Information

Originally founded as a railroad depot in 1875, the town of Centralia has a long history as a transportation hub. It continues this tradition today, with many of the local industries focused on transportation and tourism. Furthermore, located halfway between Seattle and Portland, the community leverages this location to publicize the city as an ideal hub for multimodal transportation (City of Centralia, n.d.). This creates an ideal environment for investment into a first-of-its-kind charging station prototype.

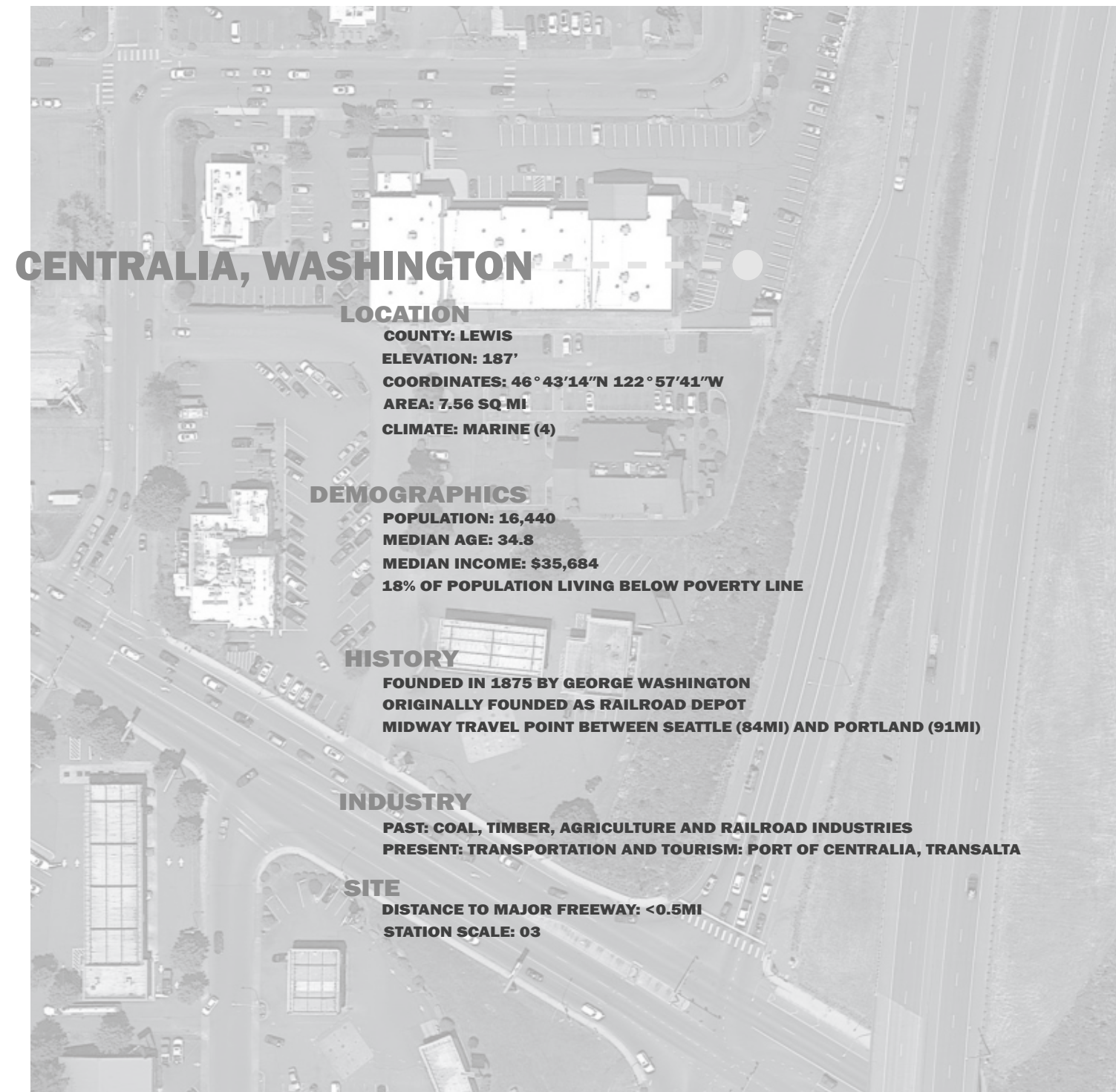


fig. A3: Centralia Analysis. Base Map: Google. "Map view." 2022.

## Existing Site Conditions

Located directly adjacent a highway entrance/exit, the site is surrounded by a variety of businesses. There are two additional gas stations to the south, and multiple restaurants and fast-food restaurants located nearby. The site is located directly off Harrison Avenue, a five-lane highway with a high traffic volume. While Harrison Avenue does have sidewalks, the existing station is set back within a large parking lot shared with two restaurants. Circulation through the site is primarily focused on automobile traffic, and circulation patterns are somewhat unclear. Due to the setback, pedestrian access is currently restricted to the site. There are currently two existing structures on the site, a convenience store in fair condition and a canopy structure in good condition. The current layout is large and open, with nearly half the footprint of the site reserved for petroleum tanker truck deliveries. Removing the need for petroleum trucks, the charging station format will create an opportunity to optimize the site layout and provide additional amenity spaces.



fig. A4: Site Photos.



fig. A5: Site Photos.

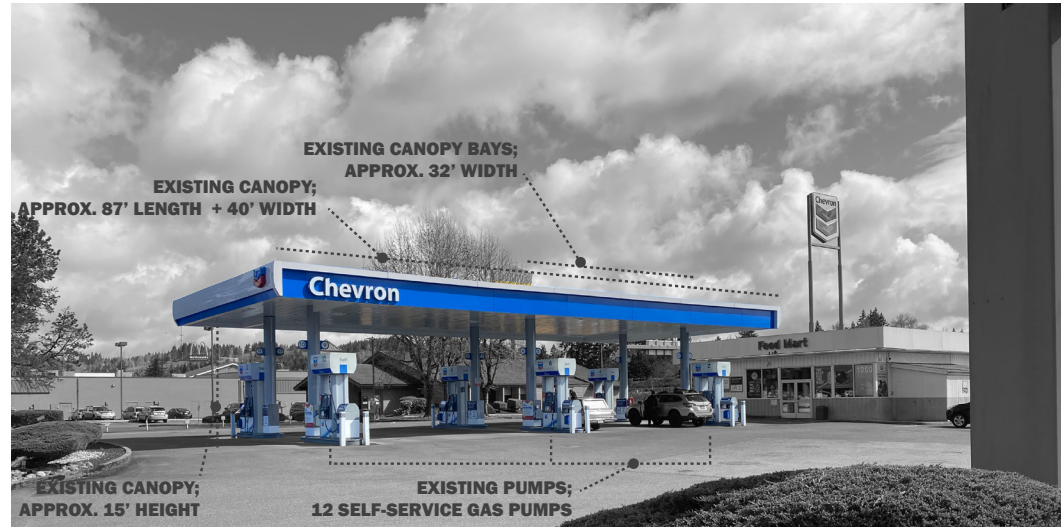


fig. A6: Existing Site Analysis.

SUPERCHARGERS



RETAIL



RESTAURANT



FREEWAY ACCESS



ADD'L GAS STATIONS



fig. A7: Surroundings. Base Map: Google. "Map view." 2022. Locations: Google. "Streetview." 2022.

# INTERSTATE

## ARTERIAL

### LOCAL



fig. A8: Street Types. Base Map: Google. "Map view." 2022.

# CIRCULATION PATTERNS

- DRIVING PATTERNS
- ENTRY
- EXIT
- PEDESTRIAN PATTERNS
- UNDERUTILIZED SPACE

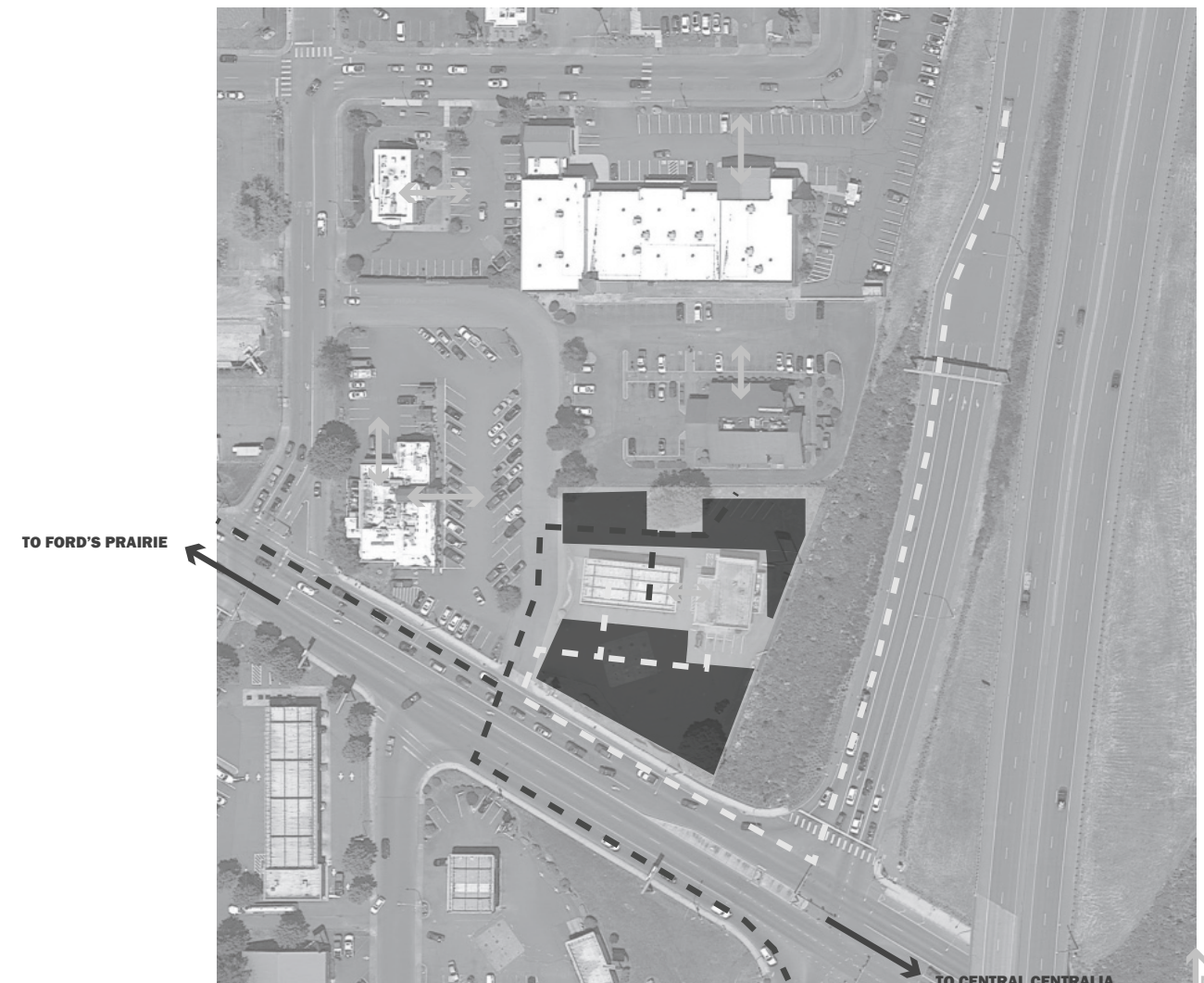


fig. A9: Circulation Pathways. Base Map: Google. "Map view." 2022.

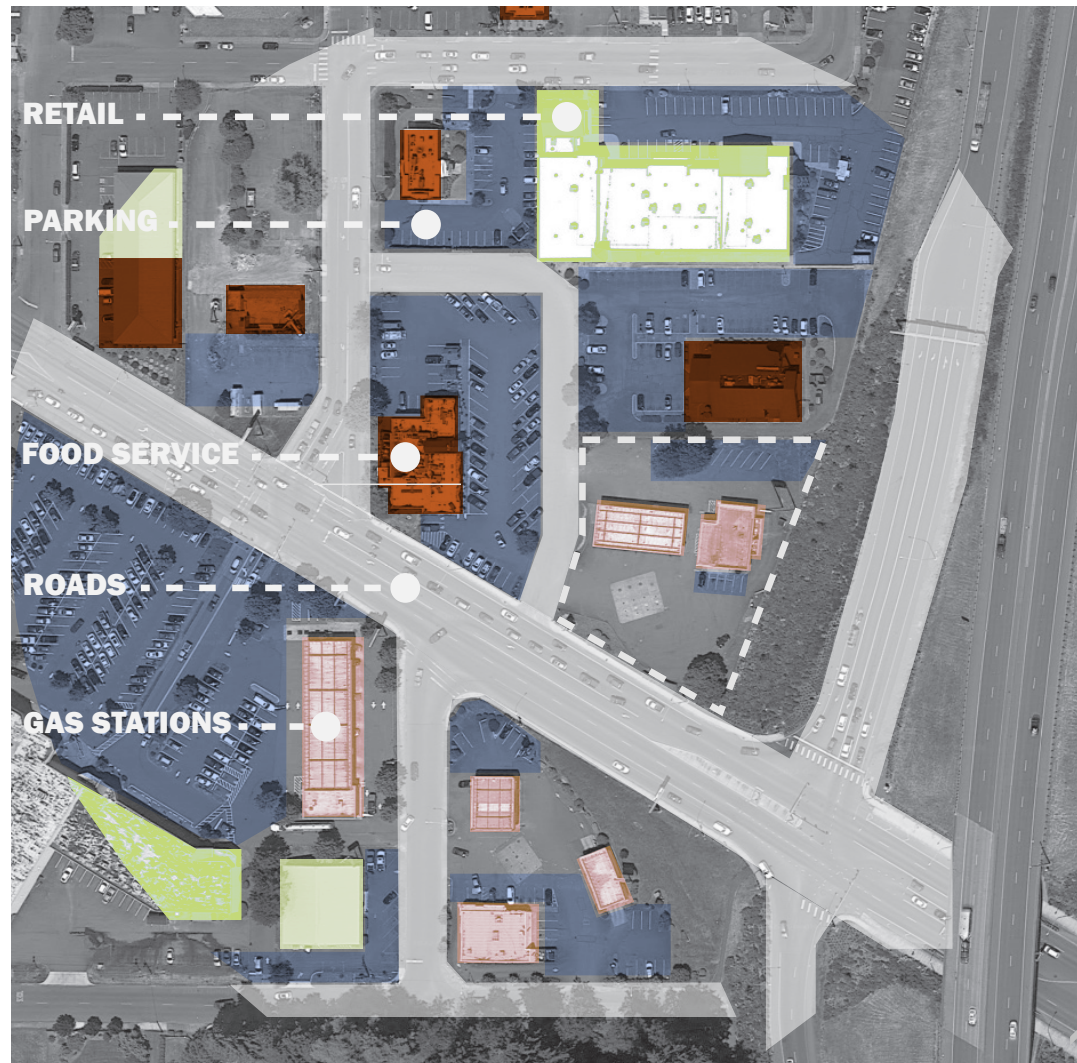


fig. A10: Use by Type. Base Map: Google. "Map view." 2022.



fig. A11: Existing Vegetation. Base Map: Google. "Map view." 2022.

## Underground Petroleum Tanks

A potential challenge of reusing gas stations sites for future uses is the remediation requirements for the site triggered by the existing underground gas tanks on the property. The Centralia station has four tanks on site, three 12,000-gallon tanks for unleaded gasoline and one 10,000-gallon tank for diesel products. The tanks were installed in 1989. According to the Washington State Department of Ecology, all four tanks have leaked non-halogenated solvents, non-halogenated organics and petroleum into surrounding soil and groundwater above cleanup thresholds (Department of Ecology, n.d.). This finding likely indicates that a level of remediation would be required at the site in order to proceed with any substantial redevelopment.

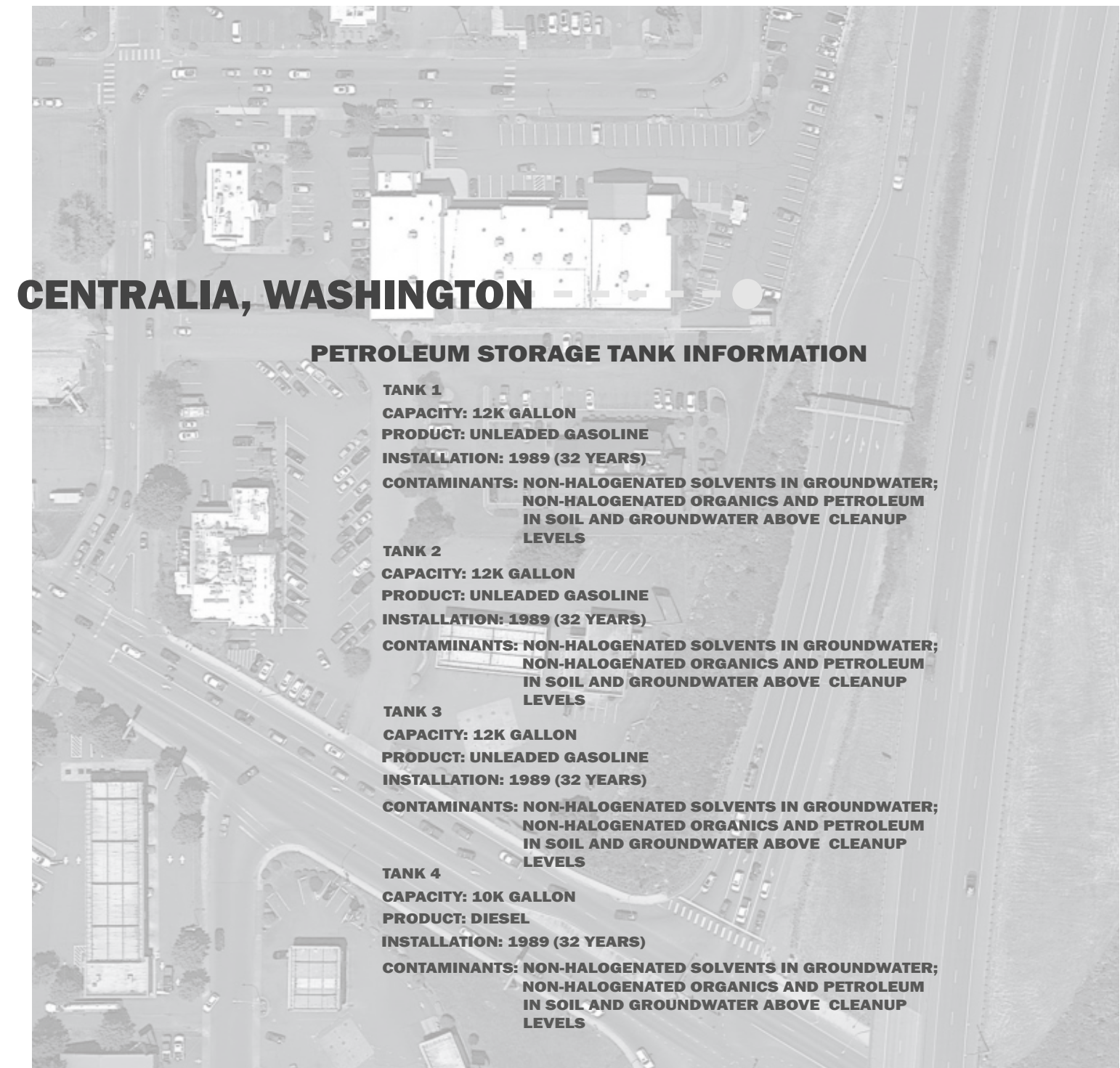


fig. A12: Underground Storage Tank Analysis. Base Map: Google. "Map view" 2022.

# Site Analysis

## Site 2: Belvidere, IL

Site 2 is located in Belvidere, IL, approximately 70 miles west of Chicago. The site is located near the center of Belvidere and is directly adjacent to highway 20, a major arterial in the region. The location is an ideal location for the new charging station, allowing the station to serve local residents as well as commuters and travelers along the regional highway. The station is located in a shopping center with a variety of shops and businesses. An existing gas station currently occupies the site. Currently, an entry to the east of the shopping center bisects the gas station and an adjoining underutilized parking lot.



fig. A13: Site Plan Maps. Base Map: Google. "Map view." 2022.



fig. A14: Existing Site Plan.

## Community Information

Belvidere was originally founded in 1835 as a center for agriculture and manufacturing in the region. Today, major industries in agriculture and manufacturing continue to support the community. While a majority of the land mass within its jurisdiction is dedicated to agriculture, major manufacturing plants such as Chrysler, Green Giant, and General Mills also support the local economy. With a population of 25,000 residents, Belvidere is the county seat of Boone county and boasts a variety of local businesses and an active community presence (City of Belvidere, n.d.).

## BELVIDERE, ILLINOIS

### LOCATION

**COUNTY: BOONE (COUNTY SEAT)**

**ELEVATION: 800'**

**COORDINATES: 42° 15' 17" N 88° 50' 39" W**

**AREA: 12.38 SQ MI**

**CLIMATE: COLD (5)**

**12 MILES EAST OF ROCKFORD AND 75 MILES WEST OF CHICAGO**

**81% OF LAND MASS AGRICULTURAL**

### DEMOGRAPHICS

**POPULATION: 25,339 (2020)**

**MEDIAN AGE: 34.8**

**MEDIAN INCOME: \$42,539**

**10% OF POPULATION LIVING BELOW POVERTY LINE**

### HISTORY

**FOUNDED IN 1835**

**ORIGINALLY FOUNDED AS INDUSTRIAL  
+ AGRICULTURAL HUB**

### INDUSTRY

**PAST: AGRICULTURAL AND MANUFACTURING (NATIONAL  
SEWING MACHINE COMPANY)**

**PRESENT: AGRICULTURAL AND MANUFACTURING (GREEN GIANT,  
GENERAL MILLS, AND CHRYSLER)**

### SITE

**DISTANCE TO MAJOR FREEWAY: 3.4 MI**

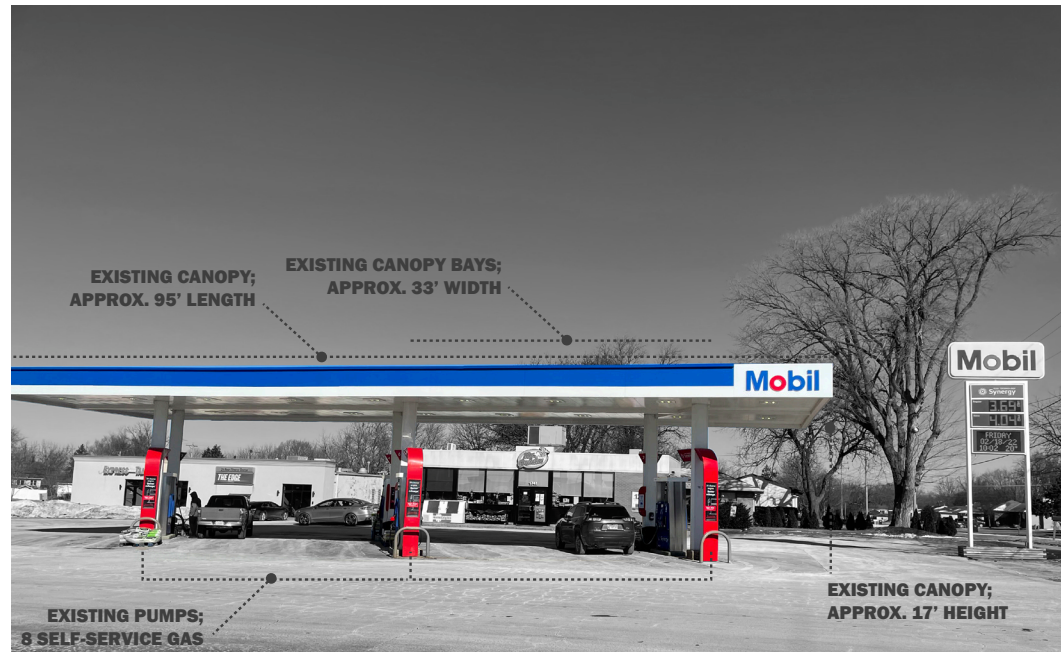
**STATION SCALE: 03**

fig. A15: Belvidere Analysis. Base Map: Google. "Map view." 2022.

## Existing Site Conditions

Located in a shopping center, the existing gas station site is surrounded by a large supermarket chain, several local restaurants and businesses, and several fast-food chain restaurants. The existing station structures are in good condition, with minimal grade change, and several existing trees on the north end of the site. Currently, the site has nearly 100% pavement coverage with a small median separating the existing station circulation from the adjoining parking lot along the south edge.

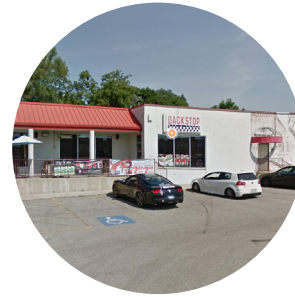




SINGLE FAMILY



LOCAL RESTAURANT



GROCERY



HEALTHCARE



STRIP MALL



fig. A20: Surroundings. Base Map: Google. "Map view." 2022. Locations: Google. "Streetview." 2022.

# INTERSTATE

## ARTERIAL

### LOCAL



fig. A21: Street Types. Base Map: Google. "Map view." 2022.

# CIRCULATION PATTERNS

DRIVING PATTERNS  
 ENTRY   
 EXIT 

PEDESTRIAN PATTERNS 

UNDERUTILIZED SPACE 



fig. A22: Circulation Pathways. Base Map: Google. "Map view." 2022.

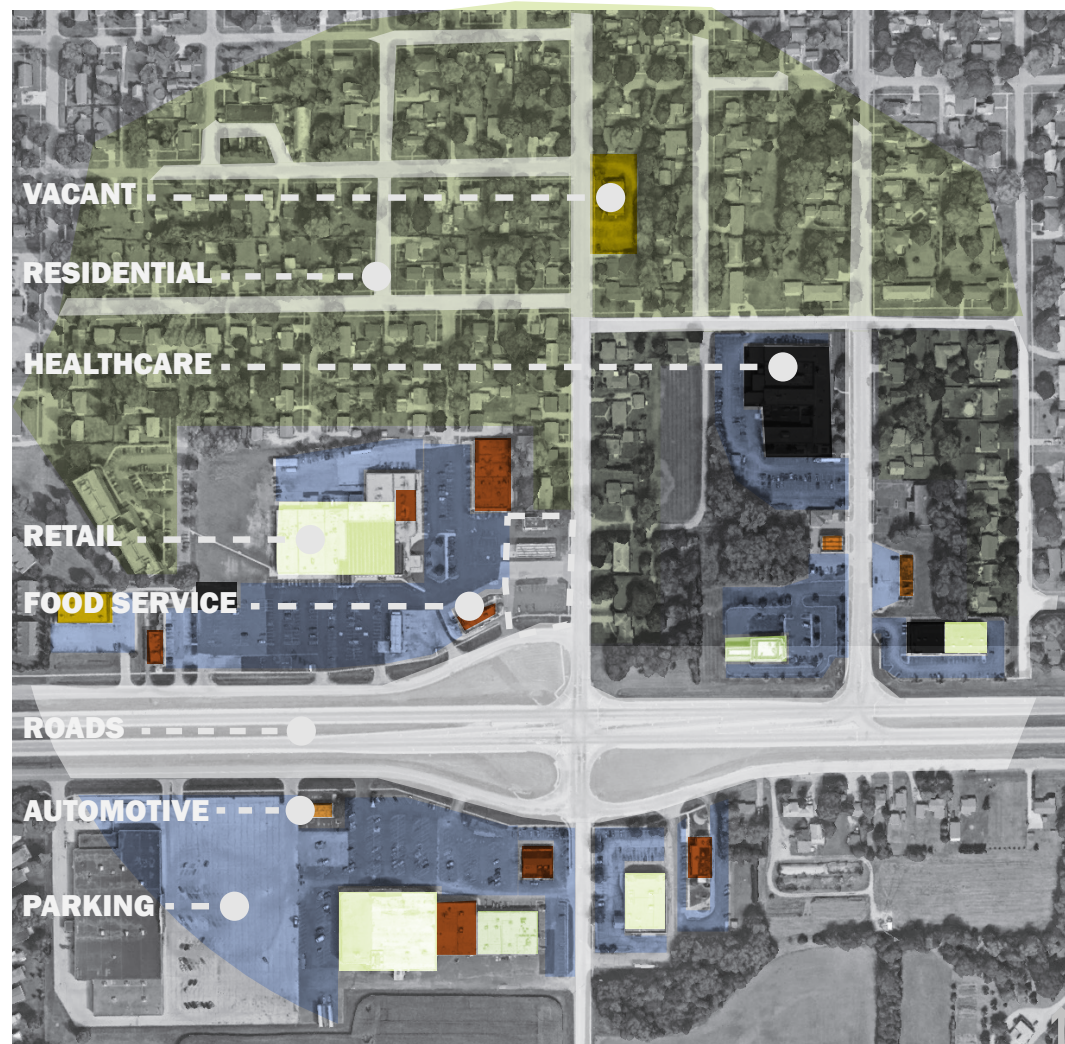


fig. A23: Use by Type. Base Map: Google. "Map view." 2022.



fig. A24: Existing Vegetation. Base Map: Google. "Map view." 2022.

## Underground Petroleum Tanks

Reporting requirements for underground storage tanks vary widely by state. Publicly available information from the state of Illinois includes the number of tanks, the capacity, and the age of the tanks (Division of Petroleum and Chemical Safety, n.d.). Possible contaminants and potential testing requirements are not listed. Therefore, potential required remediation efforts for this site are unknown.

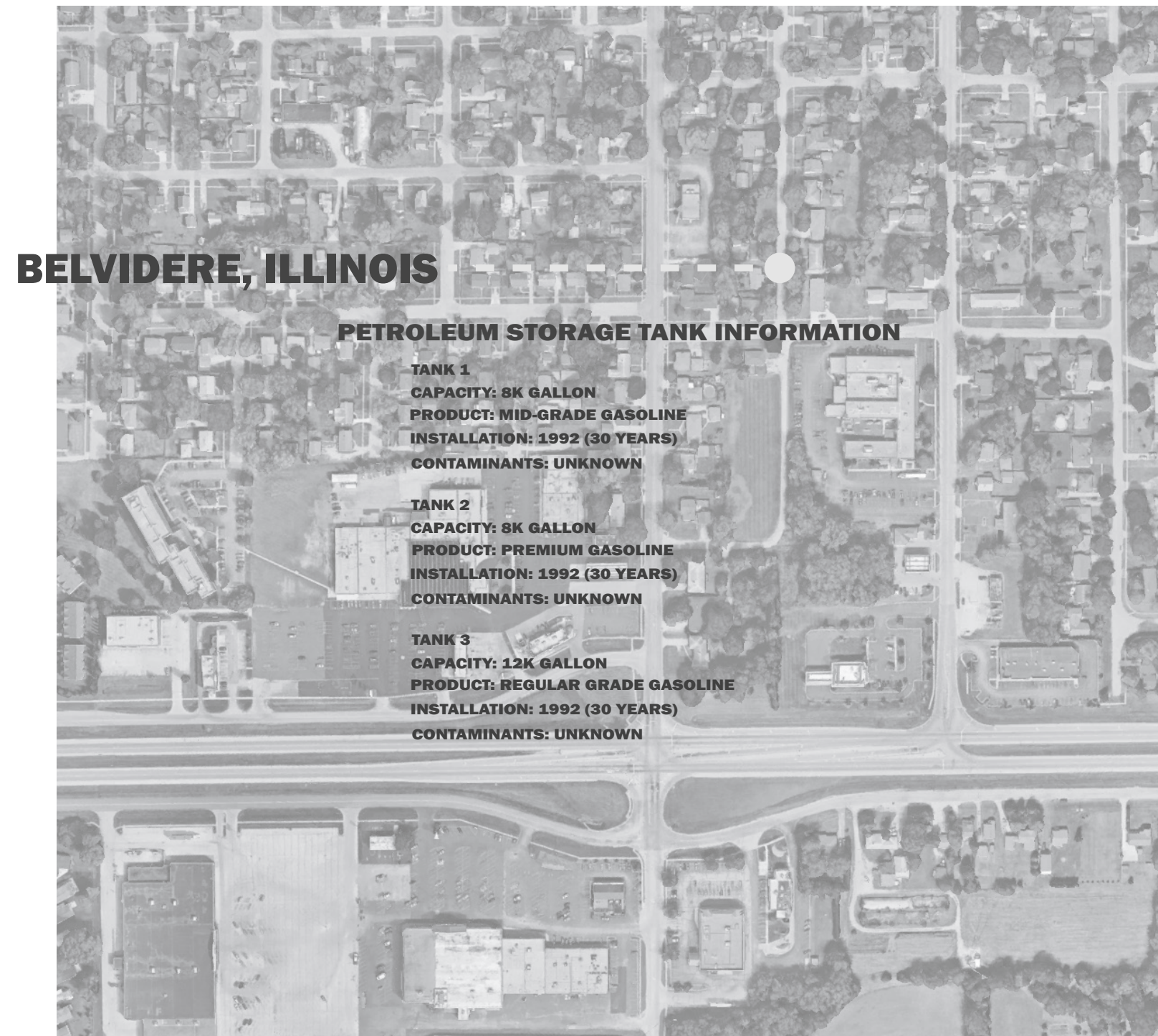


fig. A25: Underground Storage Tank Analysis. Base Map: Google. "Map view." 2022.

**Convergence:**

The Gas Station and the Future of Electric Vehicle Infrastructure.

Nicole Messner Cousins

2022