MASTER OF ARCHITECTURE THESIS
SAVANNAH COLLEGE OF ART AND DESIGN

The Powerhouse

The architecture of the pause
Chapters 1–4

Advaita Kelkar

Savannah, Georgia · 2 November 2026

THE POWERHOUSE

Abstract

Road transport is going electric, and the five-minute stop at the pump is becoming a pause of twenty minutes, an hour or a night. The places built for it have not changed: a row of posts at the edge of a lot, and a driver waiting in the car. This thesis asks how that pause can become part of civic life, and proposes the Powerhouse: a charger at the centre of an open court, the bays as stalls on its edge, and rooms around it chosen for what the neighbourhood lacks, open to people arriving by vehicle, on foot or by bicycle. It is the inversion of the big-box lot: ground at the centre, vehicles at the edge, a way in on foot. Comparative studies of places of waiting, from the caravanserai to the electric forecourt, and of the ground, time, vehicles and rules of charging, lead to a framework for corridor, city and town settings, with a test the design can fail: people must stay longer than their vehicles, and some must come without one.

Hypothesis

An Electric Vehicle Powerhouse complex will turn charging activities into an opportunity for enhanced civic / community engagements.

The programme brings people in; the charge lets them stay.

THE POWERHOUSE

Contents

Introduction 3
1.0 From charging time to civic life 3
1.1 A New Road System 5
1.2 The Pause Today 8
1.3 What Is a Charge Stop? 10
1.4 Programme Makes the Place 12
1.5 The Network Around the Charger 13
1.6 The Proposition 14
1.7 Three Ways of Reading the Pause 16

The Conditions of the Pause 18
2.0 Reading the charging landscape 18
2.1 The Ground of the Road 20
2.2 Where and How We Charge 21
2.3 An Architecture of Waiting 24
2.4 Vehicles, Time and Demand 27
2.5 The Rules of the Stop 28
2.6 The Literal Powerhouse 30

The Place of the Pause 32
3.0 A New Kind of Station 32
3.1 What People Need 34
3.2 A Place Without the Plug 35
3.3 An Icon for the Transition 36
3.4 From Dark Lot to Green Ground 38
3.5 Open, With Rooms That Close 39
3.6 What a Powerhouse Can Hold 40

A Framework for the Pause 43
4.0 From Catalogue to Building 43
4.1 Reading the Site 43
4.2 Three Settings 45
4.3 Arranging the Powerhouse 46
4.4 Across the Day and Night 48
4.5 Measuring the Pause 49
4.6 From Framework to Building 50

Notes 52

Bibliography 54

CHAPTER 01

Introduction

1.0 From charging time to civic life



The pause no one designed for. One car charging at the edge of an otherwise empty forecourt. The infrastructure provides power, but little reason to stay. AI-generated illustration

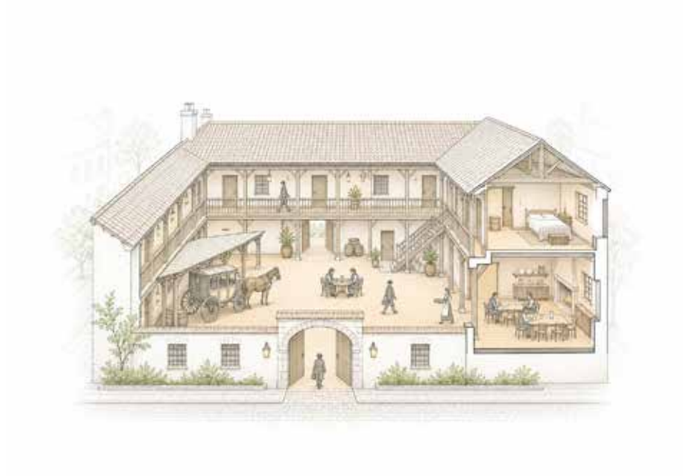
Every way of travelling has built a place for its pause. The caravanserai gave a day’s march its courtyard, the coaching inn gave the stagecoach its supper and its bed, and the railway gave the city its station. The airport made waiting into a building type of its own, and the highway gave the car its service area. Each was sized to the time its pause allowed, and the longer the pause, the more public the building became.

Architecture of the pause: towards the Powerhouse



01 Caravanserai
Caravan routes

→



02 Coaching inn
Stagecoach routes

→



03 Railway station
Rail transport



04 Gas station
Motor road

→



05 Service area
Highway network

→



06 Airport
Air travel

↓



07 The Powerhouse
Electric civic network

Typological sequence towards the thesis proposition; periods overlap. AI-generated interpretive studies, not measured reconstructions or a common scale.

Road transport is now changing faster than at any time since the car replaced the horse. Vehicles are going electric, and in a few cities they have begun to drive themselves. Together these shifts are building a new road transport system, and its pause is changing with it. A car that once stopped for five minutes to fill its tank now stops for twenty minutes to an hour to charge, and a truck or a bus can stop for a whole night. Yet the places built for charging have hardly moved on from the forecourts they replaced: a row of posts at the edge of the tarmac, and a driver waiting in the car.

01

A public pause

Source: The thesis

→

02

A useful programme

Source: The thesis

→

03

A public place

Source: The thesis

This thesis proposes the Powerhouse, an architecture for that pause. At its centre is the charger. Around it is a network of programmes chosen for the neighbourhood, and around that, public space open to everyone. The programme brings people in; the charge lets them stay. It is built for everyone who drives, and for anyone who reaches it on foot, by bus or by bicycle.

Thousands of charging sites will be built over the coming decades, and most are being planned as infrastructure and nothing more. This chapter asks what they could become if they were designed for the people who stop there rather than only for their vehicles. It starts from a simple belief: that the energy transition is a chance to leave behind a better and greener landscape than the one we have now.

The thesis

The programme brings people in; the charge lets them stay.

Source: The thesis

1.1 A New Road System

Transport uses a great deal of energy, and wastes most of it. Of every hundred tonnes of greenhouse gas the United States emits, twenty-eight come from moving people and goods, more than from any other sector.[1] Much of the problem is the engine. Fill a petrol car and roughly seven-tenths of that energy leaves through the exhaust and the radiator as heat; only about three-tenths moves the car. An electric car turns the ratio around, putting close to nine-tenths of what is in its battery to work.[2] It makes the same journey on about a third of the energy. It is only as clean as the grid behind it, though. A decade ago, economists who priced the damage from driving electric across the United States found a clear benefit in California and a net harm in coal-heavy states.[3] This is one reason the Powerhouse makes and stores its own energy.



A new road system. Transmission lines and roads cross the same landscape. Pylons stand on open ground beyond the highway, with their conductors visible against white. Interpretive architectural landscape study. AI-generated illustration

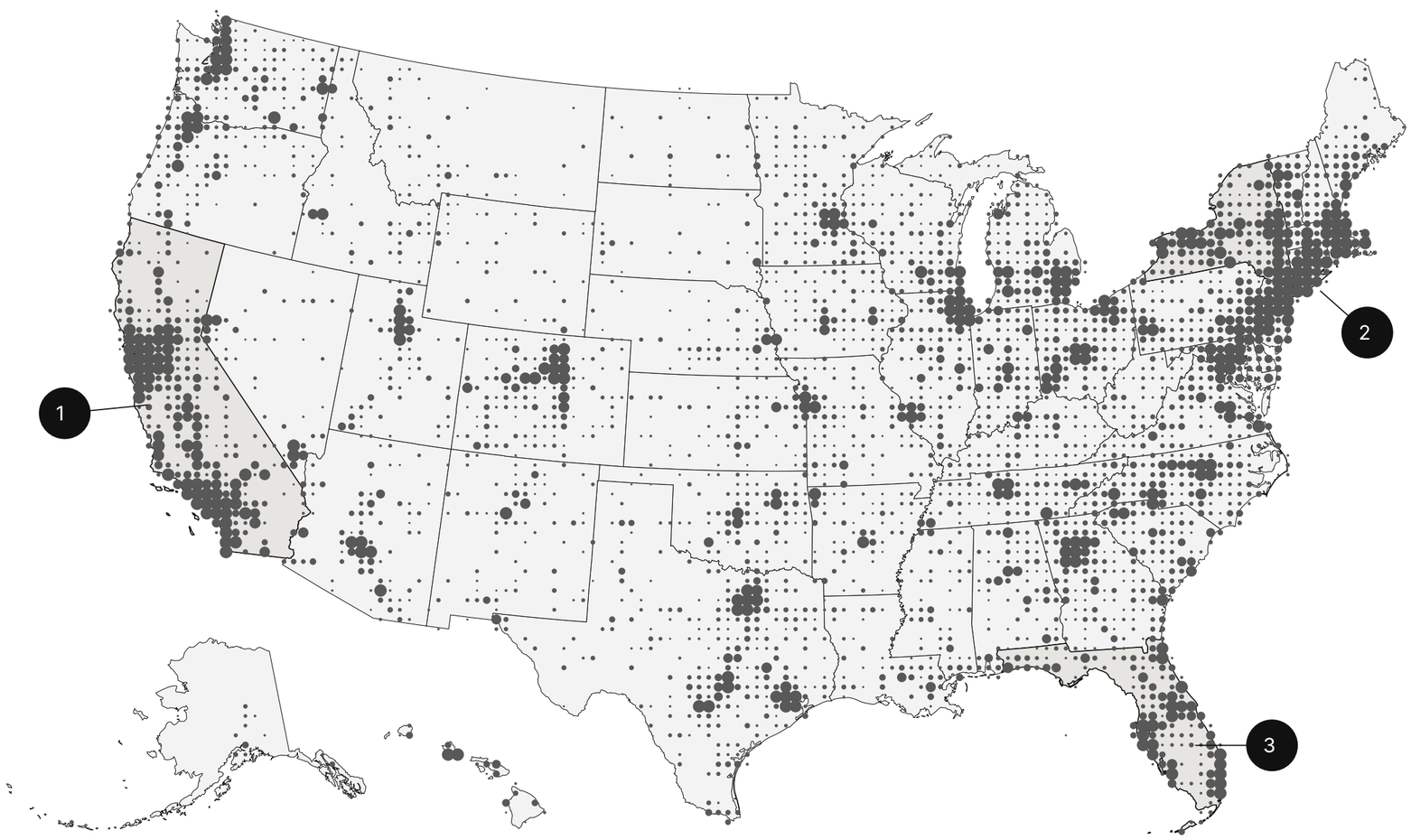
The shift is happening quickly. In 2020 the world bought around three million electric cars; in 2025 it bought more than twenty million.[4] In the United States there were about seven million electric cars and light trucks on the road in 2025, under three in every hundred. The Energy Information Administration expects about 120 million by 2040, close to four in ten.[5] Speed is not the same as certainty. A review of ninety-four studies on electric-car adoption found that what actually persuades people to switch, public charging included, is far less settled than is usually assumed.[6] Behind electrification, automation is arriving too, as driverless taxis carry paying passengers in American cities and freight follows. This thesis treats it as background: with a driver or without one, every electric vehicle has to stop to charge.

For now, most of that charging happens at home. By the Department of Energy's estimate, four of every five charges happen in a driveway or a garage.[7] The convenience has a cost. An electric car driven a typical American distance uses three to four thousand kilowatt-hours of electricity a year, about a third of what an average home already uses.[8] Home charging moves the cost of the transition onto household bills, and it is no option at all for people who live in apartments or keep their car on the street. As the fleet grows, public charging will have to carry more of the load, and the places built for it will shape how millions of people spend part of their week.

MAP 1.1

Where public charging is today

Where the US's 290,019 charging points are · at 88,068 stations · public and private



PUBLIC CHARGING PORTS

01	CA	69,255
02	NY	20,184
03	FL	15,379
04	TX	13,004
05	MA	11,891
06	WA	9,096
07	CO	7,940
08	GA	7,640
09	NJ	6,995
10	IL	6,246
11	PA	5,893
12	NC	5,862
13	MI	5,720
14	MD	5,619
15	VA	5,513
16	OH	5,391
17	CT	4,990
18	AZ	4,774
19	OR	4,349
20	MO	3,316
21	MN	3,275
22	UT	3,208
23	TN	3,143
24	NV	2,838
25	WI	2,438
26	SC	2,237
27	IN	2,230
28	AL	1,754
29	OK	1,665
30	ME	1,628
31	KS	1,423
32	VT	1,353
33	IA	1,301
34	NM	1,271
35	KY	1,202
36	AR	1,115
37	DC	1,087
38	HI	1,040
39	RI	881
40	LA	848
41	NH	834
42	NE	789
43	ID	746
44	DE	718
45	MS	705
46	WV	546
47	MT	481
48	WY	357
49	SD	332
50	ND	283
51	AK	206

Each dot on the map groups nearby charging locations, and its size grows with the number of charging points there. Public means open to any driver, even when the equipment is privately owned; private means workplaces, fleets and apartment blocks that report their chargers. Home chargers are not counted anywhere.

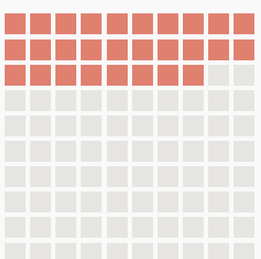
Source: US DOE, Alternative Fuels Data Center, station inventory, 18 Oct 2026

Electrification in three numbers

Figure 1.1

28%

of US greenhouse gas comes from transport



Transport

Source: EPA 1990–2022 (2024) · Note 1

Figure 1.1

20M+

electric cars sold worldwide in 2025

2020 · ≈3 M

2025 · 20 M+

Source: IEA 2025–26 · Note 4

Figure 1.1

4 in 5

charges happen at home

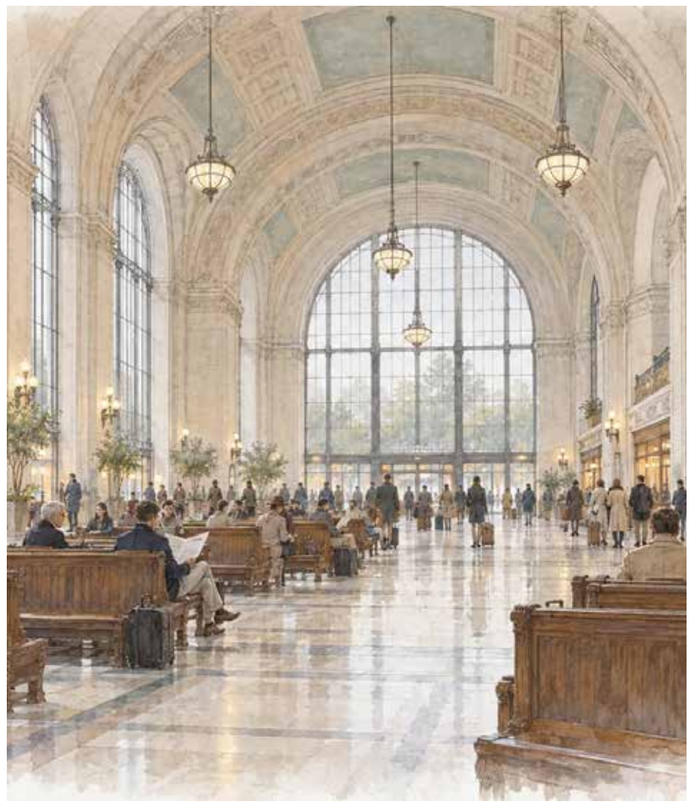
Home · 80%

Public and work · 20%

Home Public and work

Source: US DOE, National EV Charging Network · Note 7

1.2 The Pause Today



The railway built a civic room. An enclosed hall gives people room to sit, meet and wait, with shops and cafés at its edges. Interpretive study inspired by Pennsylvania Station. AI-generated architectural study



The road built a canopy. A canopy shelters fuel islands and a pay booth: a brief vehicle transaction, with no public waiting room. AI-generated architectural study



Charging inherited the forecourt. The stop gets longer, but the layout stays a forecourt. People wait inside cars, lean beside them or sit on the kerb. AI-generated architectural study

The railway understood the pause. The great stations of the late nineteenth and early twentieth centuries were among the grandest civic buildings in their cities: passengers arrived early and waited in halls, concourses and plazas lined with restaurants, shops and newsstands. In New York, McKim, Mead and White borrowed the vaults of a Roman bath for the waiting room of Pennsylvania Station in 1910, and when the station was demolished in 1963 the city lost its great civic room and its preservation movement began.[9] The airport went further and made the terminal a city of waiting.

The road went the other way. For most of the twentieth century its pause was the gas station, which settled early into a formula that hardly changed afterwards: a canopy over the pumps, islands to pull up beside, and a booth to pay at on the way out.[10] It was built for five minutes, and it did that well. Five minutes is long enough to pay and too short for a civic form.

Table 1.1. Every age built a civic building around its stop: what is the charging stop's civic form?

Era & stop	Typical pause	Civic form & public life
Caravanserai	Overnight	Courtyard for shelter, trade and exchange on the Silk Road
Coaching inn	Hours to overnight	Rest, food and news for travellers and the town
Railway station	30–60 minutes	Civic hall and concourse (Penn Station, 1910: a waiting room modelled on Roman baths)
Airport	1–2 hours	The terminal as a self-contained city of waiting
Gas station	5 minutes	Forecourt canopy and payment booth; too short for a civic form
The Powerhouse	20 minutes to overnight, every day	Charging cluster, local energy and neighbourhood civic room open to all

A civic room and a canopy

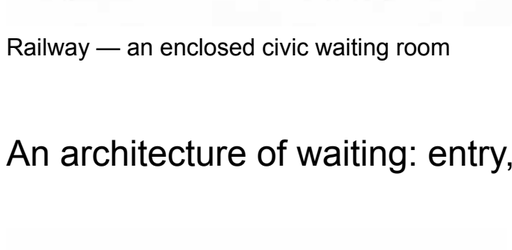


Railway — an enclosed civic waiting room

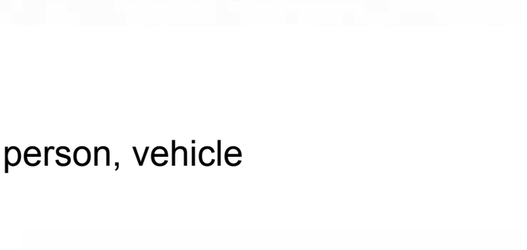


Road — shelter over the vehicle forecourt

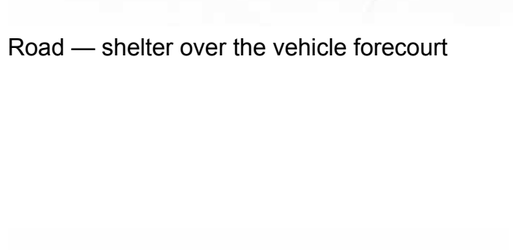
An architecture of waiting: entry, person, vehicle



Caravanserai
One gate; shared court



Coaching inn
Galleries over the coach yard



Early railway station
Building as threshold

Railway concourse
A public interior



Filling station
The vehicle takes the site



Highway service area
A room beside the road



Airport terminal
Waiting as experience



Electric forecourt
A room beside the chargers

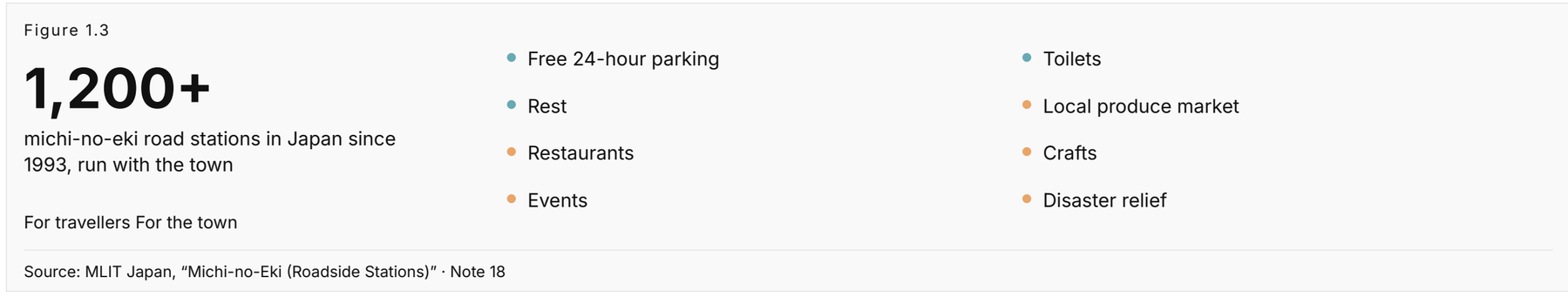
AI-generated interpretive typological studies; not measured reconstructions or a common scale. Ochre marks pedestrian arrival; pale grey marks vehicle territory.

Charging has inherited this form without its reason. The usual response is a few chargers added to the edge of an existing forecourt or car park. The federal standards behind the National Electric Vehicle Infrastructure programme set out power, connectors and uptime, and say nothing about the place around the charger.[11] So drivers sit in their cars beside a row of posts for half an hour. Freight is worse off. Truck parking already ranks as the American trucking industry's second most pressing problem, after the economy, and drivers near the end of their legal hours often keep driving in search of a space.[12] Charging for heavy vehicles is scarcer still, and a recent review of the American market names it, with range and upfront cost, as one of the main obstacles to electric freight.[13] Marc Augé's word for such places fits them well: non-places, used all the time and belonging to no one.[14] The geographer Peter Merriman has argued that the label is too quick. Writing on England's first motorway and its service areas, he shows that such sites are made into places by the people, vehicles and practices that pass through them.[15] The charging stop is not condemned to be a non-place; it has simply never been designed as anything else.

A few places show that the pause can hold more. In England, Gridserve's electric forecourt at Braintree opened in 2020 with a café, a shop and a lounge beside its chargers, a first sign of what a longer stop can support.[16] In Los Angeles, Tesla has built a diner beside a Supercharger. Can Aktuna's study of it describes how such sites borrow from hospitality, leisure and spectacle to make "compulsory waiting" more inhabitable, and finds that drivers respond to the branded spectacle with ambivalence and that experiences like it are unevenly spread.[17] These are commercial answers. The demand they reveal is public. Japan has done it at national scale. Since 1993 its Ministry of Land, Infrastructure, Transport and Tourism has designated more than 1,200 *michi-no-eki*, "road stations", each pairing round-the-clock rest and toilets for travellers with a market for local produce, restaurants, crafts, events and disaster relief, run with the town and its residents.[18] The road station is the closest thing the road has to the railway station's civic room. The Powerhouse asks what that room becomes when the pause is a charge.

Civic road stations

Figure 1.3



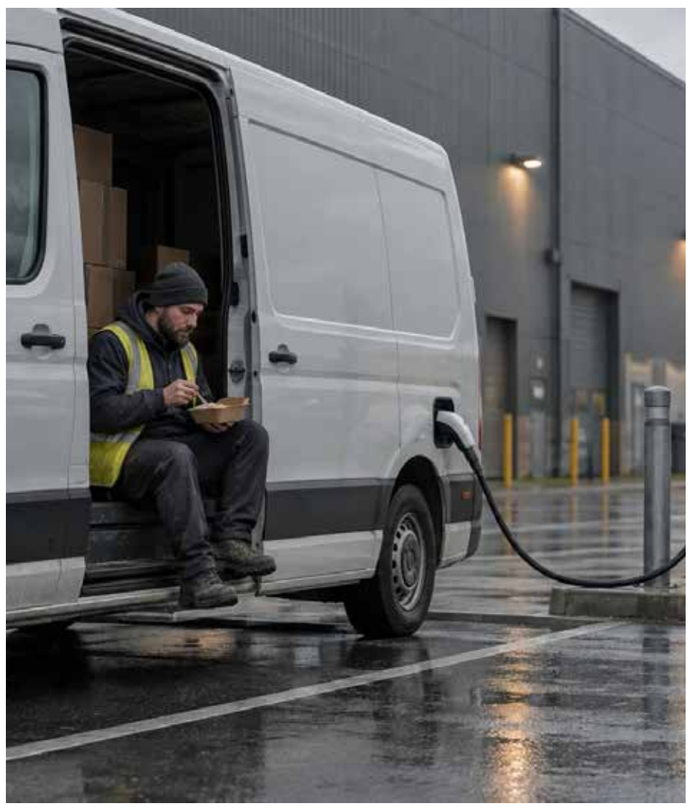
Source: MLIT Japan, "Michi-no-Eki (Roadside Stations)" · Note 18

1.3 What Is a Charge Stop?

A charge stop lasts as long as the battery takes to fill, which depends on the size of the battery and the power of the charger. A fast charger can take a car from low to most of the way full in twenty minutes to an hour. A slower charger of the kind found at homes, workplaces and bus depots takes several hours, and usually runs overnight.[19] Larger vehicles carry larger batteries and stop for longer, so the same pause stretches from a coffee for a car to a night's sleep for a bus.



Twenty minutes. A coffee beside the car at a highway charging stop. AI-generated illustration



One to two hours. A delivery driver eating lunch on the van step, with nowhere to sit. AI-generated illustration



A night. Electric trucks parked after an overnight legal rest; a driver crosses the lot to the showers. AI-generated illustration

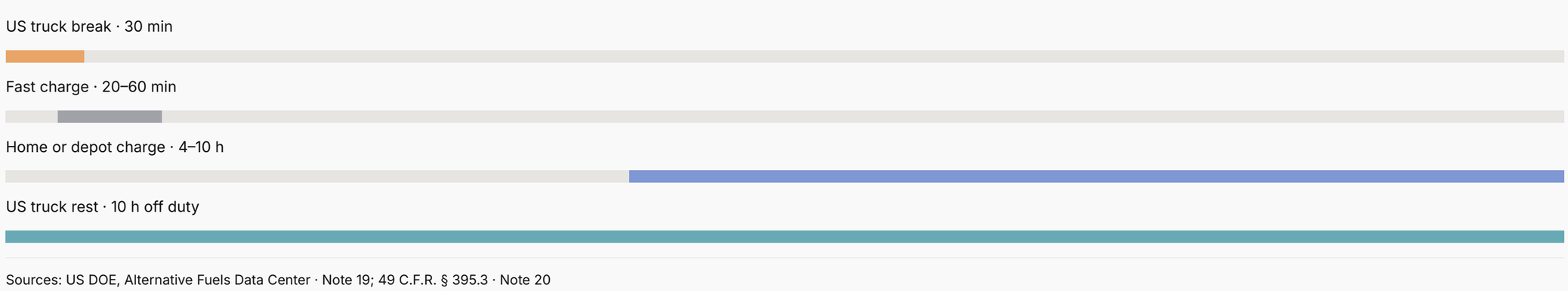
For freight, the stop is set by law as well as by technology. American rules require a truck driver to take thirty minutes off after eight hours at the wheel, and ten hours off duty at the end of a working day.[20] An electric truck can charge during a break its driver already has to take, which turns a regulation into a reason to build.

The length of a charge stop

Figure 1.4

20 min–10 h

stays the Powerhouse plans for: the programme fits the stay

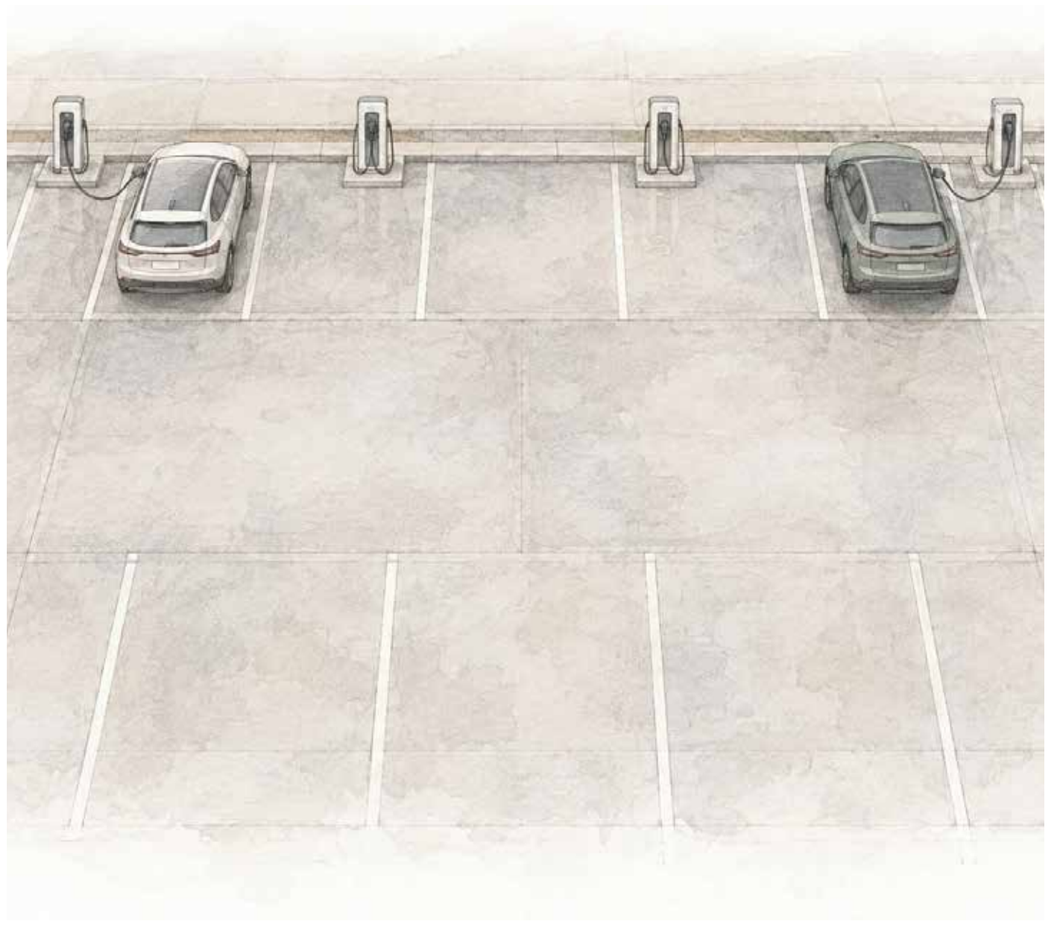


Sources: US DOE, Alternative Fuels Data Center · Note 19; 49 C.F.R. § 395.3 · Note 20

The charge stop is therefore not one stop but many. Cars, trucks, buses, motorcycles, bicycles and e-bikes all need somewhere to charge, and each brings a different person to the site for a different length of time: twenty minutes, an hour or two, a whole night. A gas station could treat every visitor the same, because everyone left within five minutes. A charge stop cannot. Its length is what makes it worth designing, and its range, from twenty minutes to overnight,

is what the Powerhouse plans for.

1.4 Programme Makes the Place



A charger is not a place. A mostly empty parking lot with charging bays along one edge, but no public programme. AI-generated architectural study



Programme makes the place. The same ground gains a two-storey public building: market and clinic below, shared workspace and community rooms above. AI-generated architectural study, speculative

A long pause gives a site time, but not a reason to be there. The Powerhouse takes its ground from parking, the space every vehicle already claims wherever it stops; a typical car stands still for about ninety-five per cent of its life.[21] But a charger set on that ground does not make a place, any more than a bench makes a park. What the ground needs is something to do.

Space alone has been tried. For more than sixty years New York has let developers build taller in return for a plaza or an arcade at street level. When Jerold Kayden's team surveyed 503 of these spaces, they rated about two in every five as marginal: open, public, and empty.[22] William Whyte spent years filming people in plazas like these. They stayed where there was something to do and somewhere to sit, and walked past everywhere else.[23] Ray Oldenburg called the places that hold people between home and work "third places": the café, the barbershop, the corner bar.[24] A 2025 study that monitored young adults' brain activity and stress found that such places restore people about as well as green space does, mainly through the contact they allow with others.[25] Eric Klinenberg's term for the libraries, parks and community rooms that make this contact possible is social infrastructure.[26]

That is the role of the programme at the Powerhouse. It is chosen for each site, from what the people who live, work and travel nearby lack: a gym, a clinic, a library, a market, rooms for drivers. It is what brings people in, whether they arrive with a vehicle to charge or on foot from the street. The charge is what lets them stay. Part of every site is open to anyone, with nothing to buy, so that the Powerhouse reads first as a public building and only second as a place to charge. The line between the two is a

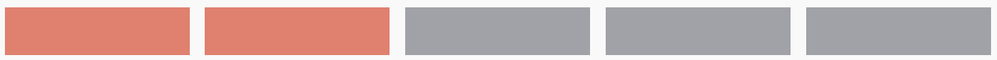
rule a stranger can apply: a programme is a use where the stay is the point, a place you come to be in; retail is a use where the purchase ends the stay. Food is the edge: a café is programme if you can sit without buying.

The limits of space alone

Figure 1.5

2 in 5

of New York's 503 plazas traded for bigger buildings rated marginal: space with no reason to be there



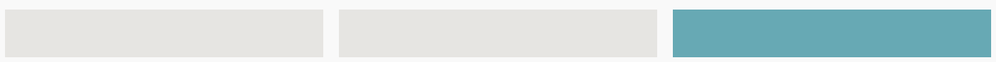
Marginal The rest

Source: Kayden et al., Privately Owned Public Space (2000) · Note 22

Figure 1.5

3rd place

cafés and gathering spaces restore people about as well as green space



Home Work 3rd place

Restorative, mainly through social contact

Sources: Oldenburg (1989) · Note 24; Xu et al. (2025) · Note 25

1.5 The Network Around the Charger

If the programme brings people in, the charger is what holds the network of programmes together. It sits at the centre, and everything around it is arranged by how long people stay. Closest to it is what fits twenty minutes: somewhere to sit, eat, wash and let children play. Further out is what fits an hour or two: a gym, a clinic, a reading room, a place to work. Furthest out, on corridors and at depots, is what fits a night: rooms, showers and a kitchen for drivers. Each ring serves the people charging, and each is open to people who are not.

Stan Allen argued that infrastructure works best as a field: it fixes the services and leaves the uses free to change.[27] The charger works the same way. It brings vehicles to the same place every day, it fixes the time they stay, and it brings energy, made and stored on site, to everything around it. The programmes can change with the neighbourhood while the charger at the centre stays put. On a freight corridor the network might be rooms and showers; in a city, a gym and a workspace; in a town, a clinic and a market. The *michi-no-eki* show the same pattern at a national scale: one standard core of rest and toilets, and around it whatever each town chooses to add.[18]

The network also works between sites. No two Powerhouses carry the same programme, because no two neighbourhoods lack the same things, but every one has a charger at its centre and public space at its edge. Together they make a network across the road system as well as within each site.



Freight corridor. Truck charging bays at early morning, with rooms, showers and a kitchen for drivers behind them. AI-generated architectural study, speculative



City. Chargers at ground level, a gym and workspace above, a public corner plaza. AI-generated illustration, speculative



Town. A market hall and clinic around a courtyard, with a few cars charging along one side. AI-generated architectural study, speculative

Figure 1.6 / The network around the charger

at the centre, with programmes around it arranged by how long people stay



Each ring serves people charging and is open to people who are not · public space at the edge

Sources: the thesis, section 1.5; Allen, “Infrastructural Urbanism” (1999) · Note 27

1.6 The Proposition

The proposition comes out of the sections above. Electric road transport is growing quickly, and its pause is longer than the one the road was built for. Today that pause is spent in non-places. Programme, not space, is what holds

people, and a charger can sit at the centre of a network of programmes chosen for each neighbourhood. Put together, this is the hypothesis: an Electric Vehicle Powerhouse complex will turn charging activities into an opportunity for enhanced civic and community engagement. If the extra time leads only to more retail, the hypothesis fails.



1 charger at the centre, with programmes around it arranged by how long people stay
AI-generated architectural study; not a measured reconstruction or a common scale.

The hypothesis fails if the built site behaves like the big-box lot it is meant to invert: if people stay only as long as their vehicle does, if no one arrives without one, and if the extra time is spent only buying. In the measures of Chapter 4, it fails when the person-clock runs no longer than the vehicle-clock, when fewer than one visitor in five comes on foot, by bicycle or by transit, and when the open layer of the site stands empty while the bays are full.

Three questions test it, and each becomes a chapter. Chapter 2, *The Conditions of the Pause*, asks how long each kind of vehicle stays, from a quick charge to an overnight rest, and what that time allows. Chapter 3, *The Place*, asks what makes people stay and what each neighbourhood lacks. Chapter 4, *A Framework for the Pause*, asks how programme, public space and charging fit together on one site, measured as minutes on site, the share of the site open to all, and the programme it holds. The method is comparative: existing gas stations, service areas, truck stops and charging hubs are read on these three measures, in corridor, city and town settings.

The research starts in New York and widens to the rest of the United States, with precedents from the United

Kingdom, Europe and Japan. It covers every road vehicle and the people nearby who do not charge at all, and every stay from a twenty-minute charge to a driver's overnight rest. Chargers at malls and supermarkets are set aside, because there the shopping draws the charger rather than the other way round. Faster charging does not undo the argument. In 2025 BYD announced a charging system that adds about 400 kilometres of range in five minutes,[28] but the Powerhouse does not depend on a slow charge. It depends on a programme worth staying for.



The proposition. An unresolved circular field suggests charging, public life and open ground; the architectural form remains to be designed. AI-generated architectural study, speculative

1.7 Three Ways of Reading the Pause

The thesis reads the pause in three ways, each matched to one part of the building, and keeps all three short. Sustainable development, meeting the needs of the present without compromising the ability of future generations to meet their own,[29] governs the ground and the energy: the Powerhouse builds on ground vehicles already claim, makes and stores its own power, and lets the energy be seen. The pause itself is read from the person who spends it, on site and with a watch, in the timed counts of William Whyte and of Jan Gehl and Birgitte Svarre that Chapter 4 makes the thesis's instrument. And who the place is for is read from the ground, in Jane Jacobs's terms: a place is safe when people are present and watching, not when they are watched, which is why the Powerhouse plans its night around the people who are there rather than around lighting and cameras.



Sustainability: its ground and energy. A solar roof over the bays, with battery storage behind a screen. AI-generated architectural study, speculative



Phenomenology: the pause itself. A quiet room looking out on the bays, someone reading in the low sun. AI-generated illustration, speculative



Social theory: who the place is for. Shared tables in an open courtyard, visible from the street. AI-generated illustration, speculative

1 Sustainability

Should it exist?

Yes: it builds on ground vehicles already claim, makes its own energy and serves people who cannot charge at home.

Source: The thesis, section 1.7

→

2 Phenomenology

Can the stop become a place?

Yes: the site gathers a pause in a journey into a place people know and belong to.

Source: The thesis, section 1.7

→

3 Social theory

Who is it for?

Everyone: lived by its users rather than planned for vehicles, and safe because people are there.

Source: The thesis, section 1.7

→

The Powerhouse

A place for the pause

A charger at the centre, a network of programmes around it, open to all.

Source: The thesis, section 1.7

Nothing in this chapter is yet argued; it is stated. Each statement is expanded once, in the chapter that owns it: the conditions of the pause in Chapter 2, what makes people stay in Chapter 3, and in Chapter 4 the instrument that turns both into a building on a particular site, and that can accept or reject the site.

CHAPTER 02

The Conditions of the Pause

2.0 Reading the charging landscape

01

Ground & access

Source: The thesis

→

02

Time & demand

Source: The thesis

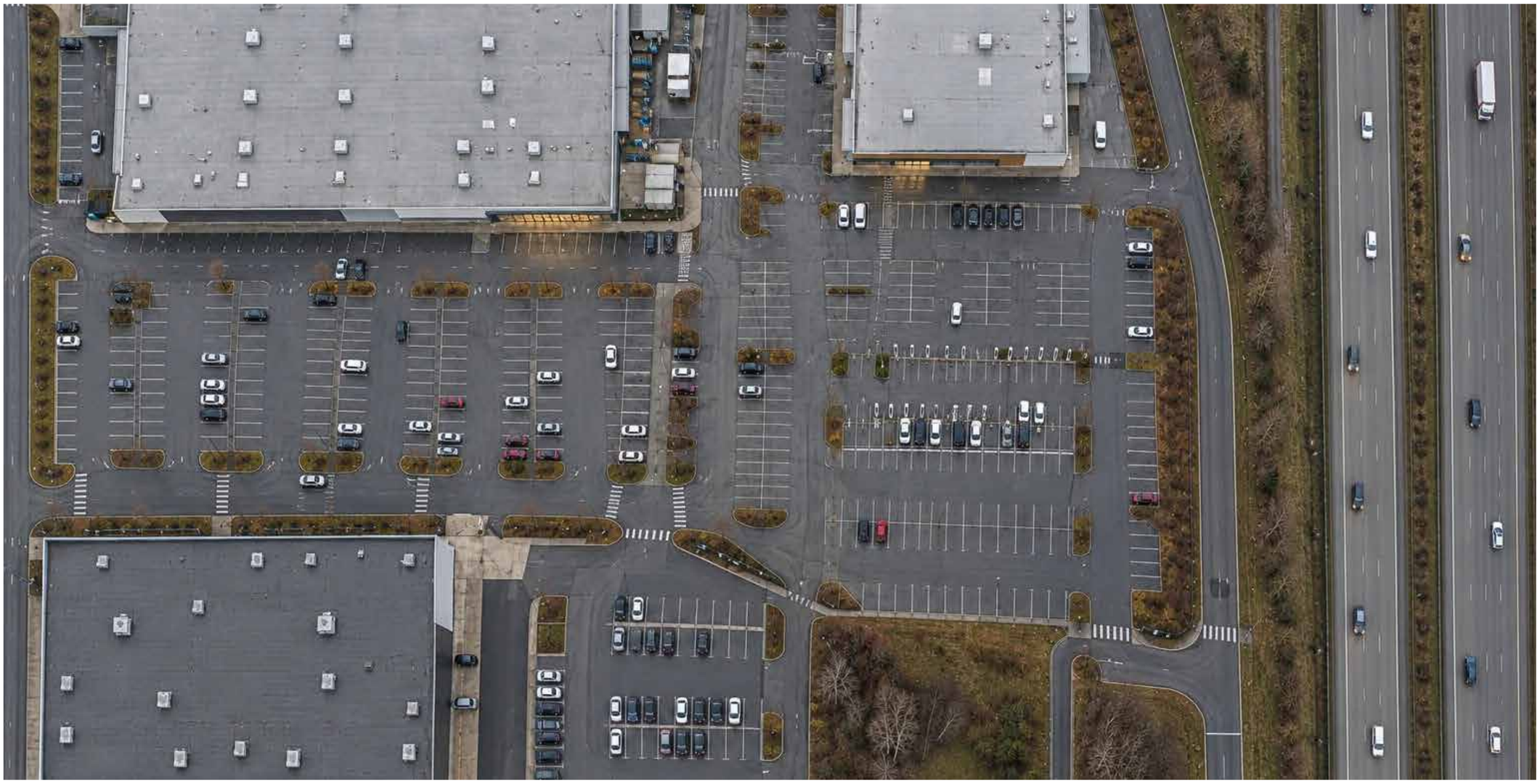
→

03

Rules & adaptation

Source: The thesis

Chapter 1 set out the proposition: the programme brings people in; the charge lets them stay. This chapter reads the conditions of that stay: the ground it happens on, how people charge, the buildings that have held a pause before, the vehicles, the rules and the future. It starts with the network as it stands.



The ground built for standing. A suburban edge from above: far more tarmac than building. AI-generated illustration

A charging network joins electricity supply, charging equipment and vehicles. A station is a location; a port

serves one vehicle at a time. Several connectors on one post do not mean several vehicles can charge at once. “Public” describes who may use a charger, not who owns the land under it: a privately run station can be open to any driver, while a depot or workplace can restrict entry.[1] [2] These distinctions matter as soon as a national count is turned into the size of a building.

In October 2026 the federal Alternative Fuels Data Center listed 290,019 charging ports at 88,068 stations across the United States, public and private; Map 1.1 shows where they are. Of these, 260,991 ports at 82,698 stations are public, a little over three ports per station on average. Most of them are slow. About seven in ten public ports are Level 2, the kind that takes hours; about three in ten, 79,030, are DC fast chargers. Half of those fast ports belong to a single network, Tesla’s. The network is also concentrated: California alone holds about a quarter of all public ports, and California, New York and Florida together hold about two in five.[3]

Figure 2.1a

260,991

public charging ports in the United States, October 2026.

Level 2 · 69%

DC fast · 30%

Source: AFDC, author’s count

Figure 2.1b

2.7×

as many charging ports as in 2020, public and private.

2020

107,561 ports

2023

184,098 ports

2026

290,019 ports

Source: AFDC trends; Oct 2026 inventory

Figure 2.1c

33

electric cars per public charging point, end of 2025.

2020

Fewer than 20

2025

33

Source: IEA, Global EV Outlook 2026

Figure 2.1d

2 in 5

public charging ports are in three states.

California

26.5%

New York

7.7%

Florida

5.9%

Source: AFDC, author’s count

The network has grown quickly. The same database counted 107,561 ports in 2020 and 184,098 in 2023,[4] so today’s total is about 2.7 times what it was five years ago. Fast charging grew fastest: more than 18,000 new fast ports opened in 2025 alone, about 30 per cent more than the year before.[5] Cars have grown faster still. At the end of 2025 there were 33 electric cars for every public charging point in the United States, up from fewer than 20 in 2020.[6] The network is expanding, but the fleet is outrunning it. Set against the 2030 scenario in section 2.2, today’s public fast ports are a little over two-fifths of the modelled need, and today’s public Level 2 ports about one-sixth.

A count of plugs says nothing about the place around them. On average a public station is just over three ports: three vehicle-sized spaces and a post. Nothing in the count says whether there is room for the person who arrives with them. That is the condition this chapter reads, and the one the Powerhouse is meant to change. A gap on a map is not a site. A Powerhouse belongs where a need for charging meets a connection to the road and the electrical grid, and a neighbourhood with a reason to come.

The sections that follow move from that ground to charging practice, then to architectural types, vehicle demand, regulation and the future. New York appears only as a demanding condition within the wider study: one state with about one in thirteen of the nation’s public ports, in a city where half of all car owners park on the street. It is not a site selection. A corridor, a town and a dense city may all need a Powerhouse, but the pause will work differently in each.

2.1 The Ground of the Road

Roads are usually described by movement: lanes, junctions, speeds and travel times. Yet every trip ends with a vehicle standing still, and the ground built for standing is larger than the ground built for moving. Taken together, the roofs, roads and paved lots of the lower forty-eight states cover about 112,610 square kilometres, slightly less than the area of Ohio.[7] Nobody knows how much of that is parking. One national estimate places the number of parking spaces in the United States anywhere between 105 million and 2 billion;[8] the width of the range is itself the finding.

Where the ground has been counted, the numbers are large. Los Angeles County held about 18.6 million parking spaces in 2010, covering some 200 square miles, or 14 per cent of its incorporated land.[9] An inventory of five American cities found 1.6 million spaces in Seattle, 5.2 for every household; 2.2 million in Philadelphia, 3.7 per household; and 27.1 per household in Jackson, Wyoming.[10] Seen from above, paved surfaces cover about 28 per cent of Sacramento, more than its roofs.[11]

Figure 2.2a

≈ Ohio

112,610 km² of roofs, roads and pavement across the lower 48 states.

Source: Elvidge et al. (2004)

Figure 2.2b

14%

of Los Angeles County’s incorporated land is parking: about 18.6 million spaces.

Parking · 14%

Other land · 86%

Source: Chester et al. (2015)

Figure 2.2c

5.2 · 3.7 · 27.1

parking spaces per household in Seattle, Philadelphia and Jackson, Wyoming.

Seattle
1.6 million spaces

Philadelphia
2.2 million spaces

Jackson, WY
27.1 per household

Source: Scharnhorst (2018)

This ground is sized to the vehicle, not to the person in it. It is laid out for turning circles and clearances, used a few minutes or hours at a time, and empty for much of the day, since a typical car stands still about 95 per cent of its life, as Chapter 1 noted. It is also hard ground. It heats in the sun and sheds rainwater quickly, which is why the EPA’s *Green Streets Handbook* treats parking surfaces as places to plant, shade and let water soak in.[12]

The Powerhouse begins on this ground. It is parking in the sense that vehicles already stand there, but the proposal is not a parking lot with a building beside it. The ground is reorganised around a place people can enter. A charger stays reachable by a vehicle; a room, court or garden is reachable without one, and the two routes meet without asking anyone on foot to cross a working charging bay. The US Access Board’s guidance on accessible charging makes the same point at the scale of one person: clear space and an accessible route to the facilities, not only to the plug.[13]



The ground as found. Cracked, unshaded asphalt in summer heat. AI-generated illustration



The ground re-made. The same view with shade, planting, permeable paving and a protected path. AI-generated illustration, speculative

This also suggests where a Powerhouse can stand, without naming a site. The ground already exists wherever vehicles stop: at the curb, in the depot, on the forecourt, at the service area and in the garage. A Powerhouse belongs where that ground meets a need for charging, a connection to the road and the electrical grid, and a neighbourhood with a reason to come. New York shows the opposite extreme to Jackson. It has the least parking per household of the five cities counted,[14] and half of its car owners park on the street.[15] Where ground for standing is this scarce, a shared place to charge matters most.

2.2 Where and How We Charge

Charging is not one activity. At home it happens while someone is doing something else; at work it can fill the working day; at a destination it goes along with a visit. A fast-charging stop interrupts a journey, and depot charging follows a vehicle’s shift. The architecture depends on which of these sets the timetable, and a long connection does not have to mean a long wait beside the car.

Most charging is private. Worldwide, electric-vehicle owners surveyed by the IEA charge at home or at work almost 75 per cent of the time and use public fast chargers about 10 per cent of the time. Public provision is still growing quickly: there were more than seven million public charging points at the end of 2025, after growth of more than a third that year.[16] These are global figures; Chapter 1 gives the American one, four in five charges at home.

There are three kinds of charger: Level 1, Level 2 and DC fast. The US Department of Transportation’s examples for a passenger car run from about 4–10 hours on Level 2 to between 20 minutes and an hour on a fast charger.[17] The real time depends on the car and the session. A charger’s rating is its maximum, and the temperature, how full the battery already is, the car’s own limits and a supply shared with other chargers can all slow it down.



Charging where life happens. A car completing an overnight charge in a home garage, early morning. AI-generated illustration



Nowhere to charge at home. An apartment street in early morning, cars parked kerb to kerb and no chargers. AI-generated illustration

In 2023 the national laboratory modelled what the United States would need in 2030 for 33 million electric cars and light trucks: 25.7 million ports at single-family homes, 570,000 at apartment buildings, 490,000 at workplaces, about 1.07 million public Level 2 ports and 182,000 public fast ports.[18] It is a planning scenario made in 2023, not a count, and it covers light-duty vehicles only; it does not size a bus or freight network.

Figure 2.3c

2030 scenario

US ports modelled for 33 million light-duty EVs.

25.7m	0.57m	0.49m	1.07m	0.182m
Single-family homes	Multifamily homes	Workplaces	Public Level 2	Public fast

Source: DOE / 2023 NREL study; conditional scenario, not current counts

For the Powerhouse this narrows the case. Most vehicles should charge where they already spend time. The opportunity is strongest where a visit that has to happen meets a programme worth having: the city driver with nowhere to charge at home, the traveller far from home, the fleet between shifts. The study also has to count the people who arrive without a vehicle, because counting only those who are plugged in would miss the public use the hypothesis is about.



2030 scenario US ports modelled for 33 million light-duty EVs.
AI-generated architectural study; not a measured reconstruction or a common scale.



2030 scenario US ports modelled for 33 million light-duty EVs.
AI-generated architectural study; not a measured reconstruction or a common scale.



2030 scenario US ports modelled for 33 million light-duty EVs.
AI-generated architectural study; not a measured reconstruction or a common scale.



2030 scenario US ports modelled for 33 million light-duty EVs.
AI-generated architectural study; not a measured reconstruction or a common scale.



2030 scenario US ports modelled for 33 million light-duty EVs.
AI-generated architectural study; not a measured reconstruction or a common scale.

Figure 2.3a

≈75%

Global surveyed EV owners’ charging at home or work.

Private charging · 75%

Other charging · 25%

Source: IEA, Global EV Outlook 2026; reported behaviour, not US port shares

Figure 2.3b

>7 million

Public charging points worldwide at end-2025.

Change

More than one-third growth during 2025

Source: IEA, Global EV Outlook 2026

2.3 An Architecture of Waiting



Caravanserai. One gate and a shared court: courtyard of the Mahyar caravanserai, Iran. Eugène Flandin, 1840; public domain.



Coaching inn. Galleries over the coach yard: the George Inn, Southwark, 1889. Public domain.



Railway terminal. A public concourse: main concourse, Grand Central Terminal, New York, c. 1913. Detroit Publishing Co., Library of Congress; public domain.



Airport terminal. Waiting as experience: TWA Flight Center, New York (Saarinen, 1962). Photograph 2019, Wikimedia Commons; CC0.

Every place of waiting answers the same three questions in plan. How do you enter? Where does the person wait? Where does the vehicle go? The answers have changed with each kind of journey, and reading them side by side shows what the charging stop has inherited and what it has lost.

The oldest answer is the courtyard. A caravanserai was built as a square or rectangular enclosure around an open court, with a single entrance and rooms arranged around the edge.[19] Animals, goods and travellers came through the same gate and shared the same open centre, but the rooms gave each traveller a place out of the way of the traffic. The English coaching inn kept the arrangement and added height. At the George Inn in Southwark, rebuilt in 1677 after a fire, galleries on the upper floors look down onto the yard where coaches once drew in.[20] In both, the vehicle and the person share one ground, and the building wraps around it.

The railway separated them. At Liverpool Road in Manchester, opened in 1830, passengers entered from the street and passed through the station building to reach the trains, so the building became the threshold between the city and the line.[21] By 1913, Grand Central Terminal in New York had turned that threshold into a public room: a concourse between the street and the platforms, open to anyone, where the whole city could cross, meet and wait.[22] The train was out of sight below; the person had the hall.

The road went the other way. In 1913 Pittsburgh got two of the first filling stations built for drivers to pull in to: the Murwin station in June and Gulf’s on Baum Boulevard in December.[23] The type that followed was reduced to its essentials: a canopy over the pumps, an island to stop

beside and a small kiosk. The vehicle took the whole site; the person stayed in the car or stood beside it. The Pennsylvania Turnpike, opened in 1940, grouped fuel, food and rest at service plazas along a controlled-access road,[24] which gave the long-distance driver a building again, but one placed beside the road rather than built around the stop.

Figure 2.4a

Before 1600

Caravanserai.

Plan

One gate; a shared court; rooms around the edge

Source: Encyclopaedia Iranica

Figure 2.4b

1677

George Inn, Southwark.

Plan

Galleries look down on the coach yard

Source: National Trust Heritage Records

Figure 2.4c

1830

Liverpool Road Station, Manchester.

Plan

The building becomes the threshold to the line

Source: Science and Industry Museum

Figure 2.4d

1913

Grand Central Terminal, New York.

Plan

A public concourse between street and platform

Source: Grand Central Terminal

The airport repeated the railway's separation at a larger scale. The TWA Flight Center at New York's Idlewild airport, opened in 1962, made the space between the kerb and the aircraft a single sweeping hall in which waiting was designed as an experience; it is now restored as a hotel, and people still come to sit in it.[25] The most recent case is the electric forecourt. GRIDSERVE's Braintree site, opened in 2020, puts a building with a café and lounge beside its chargers.[26] It brings back a room for the person, but the plan is still the forecourt's: bays in front, building to one side.

The road's latest answer is the **power center**: a block of big-box stores set in a C or a U around one shared parking lot, each store a destination with its own door, the lot in the centre where the caravanserai had its court. It is the one case in which programme was added to parking at scale, and it produced no place at all. The person's route is car to door and door to car; nothing stands between the stores; no one arrives on foot; and nothing in it can be used without buying. It is the control for this thesis: programme and parking together are not enough, and the plan and the kind of programme decide. The Powerhouse is its inversion, and section 4.3 draws the two side by side.

Figure 2.4e

1913

First drive-in filling stations, Pittsburgh.

Plan

Canopy, island and kiosk: the vehicle takes the site

Source: Heinz History Center

Figure 2.4f

1940

Pennsylvania Turnpike service plazas.

Plan

Fuel, food and rest beside the road

Source: Pennsylvania Turnpike Commission

Figure 2.4g

1962

TWA Flight Center, New York.

Plan

One hall from kerb to aircraft; waiting as experience

Source: TWA Hotel

Figure 2.4h

2020

GRIDSERVE Braintree.

Plan

A café and lounge beside the charging bays

Source: GRIDSERVE; operator account

Read together, the cases show three moves that make a place of waiting work. The first is a protected interior, a court, hall or concourse, that is not the vehicle's space. The second is a single, legible threshold where arrival becomes a stay. The third is a room sized to the pause. The gas station kept none of the three, and the charging stop has inherited it. The Powerhouse needs all three: a court that people and vehicles share without crossing each

other's paths, a threshold that turns a charging bay into an arrival, and rooms sized to twenty minutes, an hour or two, and a night. One plan move follows from all three and answers the question the forecourt never did: the charging bay is a stall on the edge of the court. The vehicle noses up to the court as a horse once did to the caravanserai wall; the person steps from it into the court; the drive runs behind the bays. The vehicle is present in the place, seen and charging, and its route never enters it.

Figure 2.5a

Interior

A protected court, hall or concourse that is not the vehicle's space.

Powerhouse

A court people and vehicles share without crossing paths

Source: Section 2.3, from the cases above

Figure 2.5b

Threshold

A single, legible point where arrival becomes a stay.

Powerhouse

The charging bay becomes an arrival

Source: Section 2.3, from the cases above

Figure 2.5c

Room

A room sized to the pause.

Powerhouse

Rooms for 20 minutes, an hour or two, and a night

Source: Section 2.3, from the cases above

Figure 2.4a / Before 1600



Caravanserai
One gate; shared court; rooms at the edge

AI study · Context: Encyclopaedia Iranica

Figure 2.4b / 1677



George Inn, Southwark
Galleries overlook the coach yard

AI study · Context: National Trust

Figure 2.4c / 1830



Liverpool Road Station, Manchester
The building as threshold to the line

AI study · Context: Science and Industry Museum

Figure 2.4d / 1913



Grand Central Terminal, New York
A public concourse

AI study · Context: Grand Central Terminal

Figure 2.4e / 1913



Drive-in filling stations, Pittsburgh
The vehicle takes the site

AI study · Context: Heinz History Center

Figure 2.4f / 1940



Pennsylvania Turnpike service plazas
Fuel, food and rest beside the road

AI study · Context: Pennsylvania Turnpike Commission

Figure 2.4g / 1962



TWA Flight Center, New York
Waiting as experience

AI study · Context: TWA Hotel

Figure 2.4h / 2020



GRIDSERVE Braintree
A room beside the charging bays

AI study · Context: GRIDSERVE

The drawings that follow this section use the same layers for every case: approach, vehicle threshold, pedestrian threshold, waiting space and route back. The dates identify cases; they do not claim that one type grew out of another.

The comparison also cannot settle cause and effect on its own: people may stay longer because a place is good, rather than the place being good because people had time. The site study in later chapters tests that with observation.

2.4 Vehicles, Time and Demand

A charge stop has to be read at the scale of the vehicle. A bicycle and a truck may both stay for several hours, but they need very different space, energy and access. Battery size alone does not set the length of the stop: a small battery on a slow charger can take hours, and a large one may take only what the next leg needs.



Every vehicle, a different pause. E-bike, motorcycle, car, van, bus and truck plugged in side by side. AI-generated architectural study

Table 2.1 compares named vehicles, each under its own charging conditions, so its rows cannot be ranked against one another. Bosch gives about 4.5 hours for its PowerTube 500 e-bike battery on the 4 A Standard Charger.[27] The manual for the 2020 Zero SR/F motorcycle gives under five hours for its ZF14.4 pack in mild conditions; it is an older model, used here as an example.[28] The Department of Transportation's car examples rest on their own battery and charging assumptions.

The arithmetic is simple once the energy and the average power are stated. Ford's extended-range E-Transit van has an 89 kWh usable battery.[29] Charging it from 10 to 80 per cent adds 62.3 kWh: about 37 minutes at an average of 100 kW, or about 5.7 hours at 11 kW. These are calculations, not a measured charging curve, but they show why a charge time has to start from the energy added and the average power, rather than the whole battery and the

charger’s peak rating.

Larger vehicles follow the same arithmetic. New Flyer gives a full depot charge of 4.9 hours for a 660 kWh bus,[30] and Volvo gives 80 per cent in about 90 minutes for its 565 kWh VNR Electric truck at up to 250 kW.[31] Both are manufacturers’ figures for particular equipment; together they show how widely the stop can vary.

Table 2.1. Vehicle size and charging time: model-specific examples.

Vehicle	Battery example	Charging condition	Published or calculated time	Basis
Electric bicycle	Bosch PowerTube 500; 0.5 kWh	4 A Standard Charger	≈4.5 h to full	Manufacturer example
Motorcycle	Zero SR/F ZF14.4; historical 2020 model	Model-specific onboard charging	Under 5 h to full in mild conditions	Owner’s manual; configuration matters
Passenger car	60 kWh illustrative BEV	Level 2 / DC fast	4–10 h / 20–60 min	DOT examples; see source assumptions
Van	Ford E-Transit extended range; 89 kWh usable	11 kW average / 100 kW average, assumed	≈5.7 h / 37 min, 10–80%	Author calculation, not tested charge time
City bus	New Flyer CHARGE NG; 660 kWh example	Manufacturer’s depot setup	≈4.9 h to full	Manufacturer estimate for stated setup
Heavy truck	Volvo VNR Electric; 565 kWh example	Up to 250 kW	80% in ≈90 min	Manufacturer claim; start SOC unspecified

The three stays from Chapter 1 still frame the design: twenty minutes, an hour or two, and a night. They are reference cases, and real sessions will fall between them.

For each one the design asks what a person can reach, use and leave comfortably in the time, and keeps the way back to the vehicle short.

Figure 2.6a

20 min

A brief visit.

Ask

What can someone reach and use comfortably?

Source: Thesis planning reference, not a measured average

Figure 2.6b

1–2 h

Time for a programme.

Ask

Can the activity outlast the technical charge?

Source: Thesis planning reference, not a measured average

Figure 2.6c

A night

A distinct rest condition.

Ask

How do privacy, safety and overnight access work?

Source: Thesis planning reference, not a measured average

Growth changes how many visits a site serves more than how long each one lasts. Section 2.2 gives one scale for cars in 2030. For heavier vehicles, the IEA’s Current Policies Scenario puts electric trucks at about a fifth of global truck sales in 2035 and about a tenth of the trucks on the road.[32] Neither figure says how many chargers one site needs; each Powerhouse will still need its own study of catchment, vehicle schedules and grid connection.

The site study will keep two clocks: how long the vehicle is plugged in, and how long the person stays, from arrival to departure. It will also note whether people leave the site while their vehicle charges. A longer stay counts only if comfort, access and a free programme explain it.

2.5 The Rules of the Stop

Some pauses are set by law, not by the battery. In the United States a truck driver may drive up to eleven hours after ten consecutive hours off duty, and must take a thirty-minute break after eight hours of driving. Time on duty but not driving can count as that break, and there are exceptions and sleeper-berth rules.[33] A charging session is not a required rest in itself, but it can fall within one.

European rules are different. Within their scope, a driver takes a forty-five-minute break after four and a half hours of driving and a regular daily rest of eleven hours, which

can be split or shortened in defined ways.[34] These rules set the driver's working day, not the vehicle's charging. The design opportunity is to let the two coincide where they can, while keeping a place to rest that does not depend on the plug.



The rules of the stop. A driver resting in the cab in early morning, the truck charging outside. AI-generated illustration

Charging funded under the federal NEVI rules (23 C.F.R. Part 680) has requirements of its own. A corridor fast-charging station must have at least four ports, each able to deliver up to 150 kW at the same time, and must be open to the public around the clock.[35] Each port must also be working more than 97 per cent of the year, by the rule's own calculation.[36] The rules apply to funded projects within their scope; they do not cover every private charger or promise any particular charging time.

Accessibility is a second layer. The US Access Board's guidance separates what the law already requires from further design recommendations. An accessible route, usable controls and a clear transfer space have to work together with the route into the building, and no canopy column, cable or vehicle overhang should block that route. The exact requirements depend on the site and are checked once a site is chosen.

Figure 2.7a

30 min

US property-driver interruption after 8 cumulative driving hours.

Qualify

On-duty/non-driving time can count; exceptions apply

Source: FMCSA, Summary of Hours of Service Regulations

Figure 2.7b

4 × 150 kW

Baseline for applicable corridor-serving NEVI stations.

Deliver

Meet simultaneous vehicle requests up to 150 kW per port

Source: 23 C.F.R. § 680.106; scope matters

Figure 2.7c

>97%

Annual charging-port uptime under the federal rule.

Distinguish

Equipment reliability is not a guarantee of useful public space

Source: 23 C.F.R. § 680.116(b)

Land-use permission is a third. New York City's City of Yes for Carbon Neutrality amendment, adopted in 2023, changed the zoning rules to make room for energy infrastructure.[37] It does not permit every programme around a charger everywhere. A clinic, a café or overnight rooms may each need their own approvals, occupancy class and fire strategy. The final design has to show permission for the whole building, because no "civic station" category exists yet.

Table 2.2. Regulation and its architectural consequence.

Scope	Baseline rule	Design implication
US property-carrying driver	30 min interruption after 8 cumulative driving hours; qualifying on-duty/non-driving time can count	A break can overlap charging, but connecting a truck does not by itself establish compliance
US daily rest	Generally 10 consecutive hours off before the 11-hour driving limit; exceptions and sleeper rules apply	An overnight programme is a distinct case from a quick-charge stop
EU drivers within the regulation's scope	Normally 45 min after 4.5 h driving; regular daily rest 11 h, with permitted reductions and splits	Do not transfer US thresholds to European precedents
Applicable corridor-serving NEVI station	At least four DC fast ports; each meets vehicle requests up to 150 kW simultaneously; public access 24/7	Electrical capacity, bay geometry and accessible approach must be designed together
Local building and land-use rules	Charger permission does not automatically permit a café, clinic, library or overnight rooms	Check each use, access, fire strategy and occupancy on the eventual site

In the comparison, these rules are recorded for each site. If one site gives more ground to the public than another, the reason may be zoning, ownership or access rules rather than the length of the charge. Recording them keeps the study from crediting charging time with an outcome that another rule produced.

2.6 The Literal Powerhouse

Charging is getting faster, and it is getting heavier. In March 2025 SAE published J3271, the Megawatt Charging System for trucks and buses, whose connectors can deliver up to 3.75 megawatts.[38] For cars, BYD's one-megawatt system, mentioned in Chapter 1, adds about 400 kilometres of range in five minutes. A vehicle's stop will shorten. The power a site must deliver will not. The National Renewable Energy Laboratory expects that charging sites for heavy trucks will need upwards of 20 megawatts.[39] The stop gets shorter while the building behind it gets bigger.

The energy also starts to pause on its own. Battery swapping replaces a vehicle's battery in minutes instead of charging it in place. By February 2026 NIO had built 3,790 swap stations and completed 100 million swaps.[40] The driver leaves almost at once, but the battery left behind stays on site for hours while it recharges. The stop moves from the person to the energy. The constant of the Powerhouse is the energy's dwell, not the driver's: a

site that must deliver twenty megawatts needs a building whatever the car does.



The literal powerhouse. Solar roof, battery room, charging bays and public rooms in one architectural study.
AI-generated architectural study, speculative



Lights on when the grid fails. The neighbourhood dark in a power cut; the Powerhouse lit and full of people.
AI-generated illustration, speculative

This is where the Powerhouse earns its name. A charging site can hold energy as well as pass it on. With batteries on site, a fast-charging station can draw a steady, smaller supply from the grid and release it at speed when vehicles arrive. Appropriately sized battery-buffered systems can cut the grid capacity a station needs by about 50 to 80 per cent, and can keep chargers running through a power cut; the federal guidance gives the example of a station operating for up to ten hours without the grid.[41] Add generation on the site's roofs and canopies, and the building becomes a small power plant for its neighbourhood: storing energy, smoothing demand and keeping the lights on when the network fails. The store earns as well as serves. A battery that buys power when it is cheap and sells it back when the grid is short earns from the grid whether or not a single driver arrives, and that income is what keeps the open ground and the public rooms running when charging does not pay. In the Powerhouse the energy layer funds the public layer; the charging layer is the one allowed to fail.

The architecture follows from three layers that change at different speeds. The energy layer (connection, storage and generation) needs to be reachable and replaceable, because batteries and power electronics wear out and improve far faster than buildings. The charging layer (bays, cables and chargers) will change with each generation of vehicle and standard. The public layer (rooms, courts and routes) should last for decades. Federal fleet guidance already asks operators to plan charging from vehicle schedules, battery sizes and dwell times rather than from the charger alone;[42] the Powerhouse applies the same logic to the building, keeping the long-lived public rooms independent of the short-lived equipment.

Faster charging does not empty the building. Some pauses are set by people, not batteries: a truck driver still needs thirty minutes off after eight hours of driving, and ten hours off at the end of the day.[43] A visit to a clinic, a reading room or a community event lasts as long as it lasts. The three stays from Chapter 1 still hold: twenty minutes, an hour or two, and a night. What changes is the overlap. The programme brings people in; the charge lets them stay, and as the charge shortens, the programme carries more

of the reason to be there. People who arrive without a vehicle use the building in the same way.

Figure 2.8a

3.75 MW

per connector under the Megawatt Charging System for trucks (SAE J3271, 2025).

Source: NREL

Figure 2.8b

20 MW+

the power heavy-truck charging sites may need.

Source: NREL

Figure 2.8c

100 million

battery swaps at 3,790 NIO stations by February 2026: the battery waits while the driver leaves.

Source: NIO (2026)

Figure 2.8d

50–80%

less grid capacity needed by a fast-charging station with on-site batteries.

Source: Joint Office / NREL

Figure 2.9a

Energy

Connection, storage and generation.

Changes

Most often: batteries and power electronics wear out and improve

Source: Thesis design principle

Figure 2.9b

Charging

Bays, cables and chargers.

Changes

With each generation of vehicle and standard

Source: Thesis design principle

Figure 2.9c

Public rooms

Rooms, courts and routes.

Changes

Least: built to last for decades

Source: Thesis design principle

These are the conditions of the pause. The ground already exists wherever vehicles stand. Charging is moving from homes to public sites, and growing. Every age has built a place for its pause, and today's pause is set by vehicles, rules and the speed of the charger. As that speed rises, the site's role as a store and source of power grows. Chapter 3 turns from the conditions to the place itself: what people need, what makes them stay, and how a public room can be recognised as one.

CHAPTER 03

The Place of the Pause

3.0 A New Kind of Station

A railway station is never only a platform. Grand Central Terminal in New York is open to the public from early morning until two at night, and it holds restaurants, a food hall, a market and shops around the concourse where trains are never seen.[1] The airport has gone further. When Jewel opened at Singapore's Changi Airport in 2019, its planners expected forty to fifty million visitors in the first year, most of them residents rather than travellers, coming for a forest valley and a waterfall seven storeys tall.[2] [3]

John Kasarda describes the airport that grows a city of programmes around itself as the aerotropolis.[4] In both cases the transport function brings people to a building, and a network of other programmes turns that building into a destination.

Figure 3.1a

5:15–2:00

Grand Central Terminal is open to the public almost round the clock.

Holds

Restaurants, a food hall, a market and shops

Source: Grand Central Terminal

Figure 3.1b

40–50 million

visitors expected in Jewel Changi's first year, 60 per cent of them residents.

Holds

A forest valley and a seven-storey waterfall

Source: New York Times (2019)

Figure 3.1c

Powerhouse

A charger at the centre, and a network of programmes around it.

Holds

What the place lacks, sorted in Table 3.1

Source: The thesis

Planning research has a name for this double role. In Luca Bertolini's node–place model, a station area is at once a **node**, a point in the transport network, and a **place**, a part of the city with its own activities.[5] Where the two are in proportion the area is balanced. Where transport outweighs everything else, the model calls it an **unbalanced node**: a location "where the transport systems are relatively more developed than the urban activities."[6] Almost every charging site built today is an unbalanced node. It is a strong point in the energy and road network, often fast and well connected, and almost nothing as a place. The model is borrowed here as a way of seeing rather than as a measure: a charging site is a node in the energy and road networks, not in a passenger network, and its public has to be made rather than captured. Where the city setting makes the node multimodal, with buses, bicycles and people on foot as well as cars, the borrowing comes closest to Bertolini's own.

Figure 3.2a

Unbalanced node

A charging site today: strong in the transport and energy network, almost nothing as a place.

Node

Strong

Place

Weak

Source: After Bertolini (1999); Chorus and Bertolini (2011)

→

Figure 3.2b

Add programme

Programmes from Table 3.1, chosen for what the place lacks, raise its place value.

How

Section 3.6, Table 3.1

Source: The thesis

→

Figure 3.2c

Balanced

The Powerhouse: the charge makes it a node; the programme makes it a place.

Node

Strong

Place

Strong

Source: After Bertolini (1999)

The Powerhouse is proposed as the architecture that balances it. The charge makes it a node; the programme makes it a place. Section 2.3 traced how places of waiting worked in plan; this chapter asks what they hold. A station and an airport hold a mix: rooms for a few minutes, rooms for an hour, rooms for a night, some open to everyone and some run by an operator. A charging site has the movement and the time, but so far none of the mix. What the Powerhouse holds depends on the place: on what the people who live, work and travel nearby lack, on what keeps them comfortable while they stay, and on what would make the building worth visiting without a vehicle to charge.

3.1 What People Need

Infrastructure is usually counted in pipes, cables and roads, but it also includes the places where people meet. Eric Klinenberg calls these places social infrastructure: libraries, parks, playgrounds, community rooms and even barbershops, the settings that decide whether strangers cross paths and come to rely on each other.[7] His study of the 1995 Chicago heat wave found that neighbourhoods with similar demographics and the same heat suffered very different death tolls, and that those with active streets, shops, organisations and gathering places lost fewer people, because neighbours knew to check on one another.[8]



A new kind of station. A public hall with a food hall, market and benches, where the charging bays are seen through one glazed edge and most people have no vehicle to charge. AI-generated illustration, speculative AI-generated architectural study; not a measured reconstruction or a common scale.



The same connection, more public life The road and charging connection stay; a public court and useful rooms strengthen the place.
AI-generated architectural study; not a measured reconstruction or a common scale.

The need is larger than a heat wave. In 2023 the US Surgeon General declared an epidemic of loneliness and isolation, reporting that about half of American adults experience loneliness.[9] Ray Oldenburg argued that third places, the café and the corner shop between home and work, were disappearing from American life, and with them the casual contact that holds a neighbourhood together.[10] A third place needs regulars, and a charging site has them by its nature: fleet drivers on shift patterns, residents who cannot charge at home, truck drivers on the routes the law makes them rest on. They return daily, which is a claim a charger can make and a park cannot.

What people need from a public place can be named. Stephen Carr and his co-authors identify five needs that people bring to public space: **comfort**, **relaxation**, **passive engagement** with the scene around them, **active engagement** with other people, and **discovery**.[11] William Whyte’s films showed the same needs at work: people sit where there is somewhere to sit, stay where there is food, shade and something to watch, and walk past everywhere else.[12] For a Powerhouse the five needs translate into provision. Comfort means toilets, drinking water, shade

and shelter. Relaxation means seating away from the bays. Passive engagement means a view of the life of the place. Active engagement means rooms to meet, eat, play and work. Discovery means a programme that changes: a market day, an exhibition, an event. Jan Gehl and Birgitte Svarre's methods of counting who stays, where and for how long give the study a way to check whether the provisions work.[13]

Figure 3.3a

1 in 2

US adults report experiencing loneliness.

Report loneliness · 50%

Do not · 50%

Source: US Surgeon General (2023)

Figure 3.3b

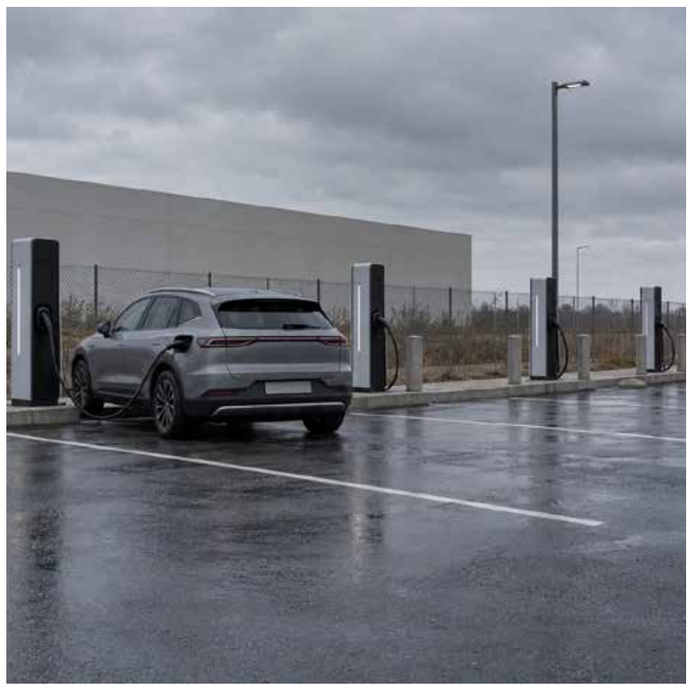
The basics

What every Powerhouse provides before any programme.

Provide

Toilets · drinking water · shade · seating · food · play

Source: After Whyte (1980); the thesis



Nothing to sit on. A charging lot beside the highway: one person on the kerb, no bench, no shade, no toilet. AI-generated illustration
AI-generated architectural study; not a measured reconstruction or a common scale.



Five needs, provided. A shaded plaza beside the bays: seats, water, toilets, food, play and something to watch. AI-generated architectural study, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.



Five needs, five provisions What each need people bring to a public place becomes in a Powerhouse.
AI-generated architectural study; not a measured reconstruction or a common scale.

3.2 A Place Without the Plug

Chapter 2 measured the pause by the charge. This section takes the opposite case: a Powerhouse that works even when no one is charging. If the building depended entirely on the length of a charge, faster chargers would empty it. The test in this section is not independence from the charger but survival of its shortening: a programme people use for its own sake keeps the building full as the charge gets faster, which Chapter 2 showed it will.

Research on station areas shows how much this matters. A study of high-speed rail stations in China's Yangtze River Delta found that station areas are shifting from a "transit place" to an "ultimate destination", yet their planning neglects the non-travelling pedestrians who come for commerce, services, recreation and walking, and that it is these visitors who bring business and public life to a station area.[14] The same is true of a charging site. The people who come without a vehicle to charge are the ones who make it a place.

Japan's roadside stations show the model at national scale. Since 1993 its Ministry of Land, Infrastructure, Transport and Tourism has designated *michi-no-eki* that combine free parking, toilets and rest for travellers with information and a facility for the local area: a market for local produce, a restaurant, a craft workshop or a community hall, run with the host municipality.[15] There are now about 1,230 of them, and 79 have been designated as disaster-prevention stations with backup power, water and open ground for relief.[16] Residents use them as everyday places, not only travellers.

Figure 3.4a

1,230

michi-no-eki road stations in Japan, run with their towns.

Disaster stations

79, with backup power, water and open ground

Source: Japan News / Yomiuri (2025)

Figure 3.4b

No plug needed

Programmes that stay busy without a single charging session.

For example

Toilets · plaza · playground · market · clinic · childcare · shelter

Source: Section 3.2; Table 3.1

The same test sorts the Powerhouse's programme. Some uses stay busy all day without a single charging session: toilets, a covered plaza, a playground, a market or grocery, a parcel room, a laundromat, a clinic, a pharmacy, childcare and a cooling or emergency shelter. Others depend more on the people the charge brings: a waiting lounge, a café, rooms for drivers. A Powerhouse needs enough of the first kind that it would still be a place if every vehicle left. That is the building's insurance against section 2.6, not its reason to exist; the reason remains the stop that the charger and the law make certain.

3.3 An Icon for the Transition

People adopt new infrastructure more readily when it belongs to a place they care about. A review of research on renewable energy across Europe found that local acceptance turns less on the technology than on landscape character, attachment to place and trust in the process, and that a plant seen as a technical object dropped into a landscape is resisted most.[17] Charging is the visible part of the energy transition for most people, and today it looks like a row of posts in a car park.

Architecture can change that, and the thesis's answer is not the icon Charles Jencks describes, a form so singular that it becomes a city's emblem and whose power lies in enigma,[18] though the Guggenheim Museum Bilbao still drew 1,305,003 visitors in 2025 on that strength.[19] A type that must be built a thousand times cannot be singular. What it can have is what every repeated type has had: a recognisable figure. The gas station had its canopy, the turnpike its plaza roof, the *michi-no-eki* its sign. The Powerhouse's figure is the energy roof, the canopy that generates, shades and is seen from the road. Bjarke Ingels Group's CopenHill in Copenhagen shows the ambition at its largest: a 41,000-square-metre waste-to-energy plant

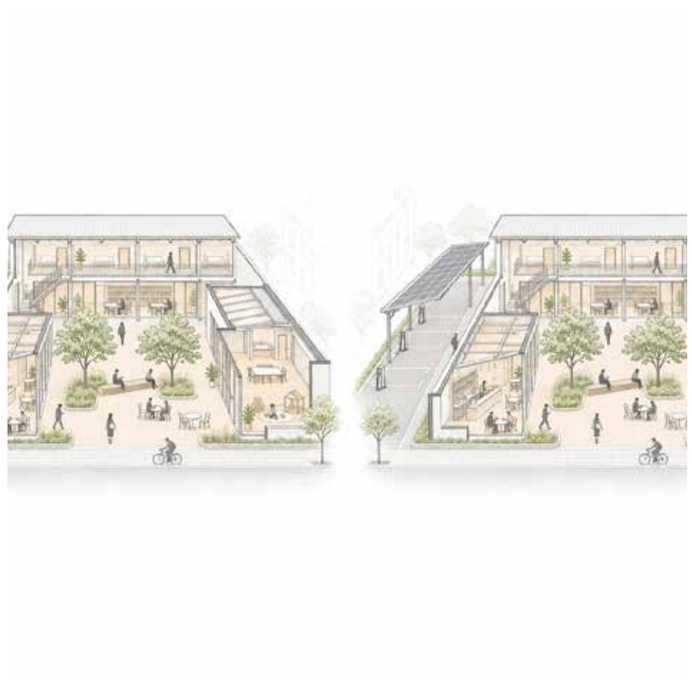
whose roof is a public ski slope and hiking trail, with an 85-metre climbing wall on its façade.[20] [21] People come to ski or climb and leave knowing how their city’s energy is made.



Michi-no-eki. A Japanese roadside station: parking and rest for travellers, a market and a hall for the town. AI-generated illustration
AI-generated architectural study; not a measured reconstruction or a common scale.



Market day, no plug. The bays stand empty while the plaza, market, clinic and playground are full. AI-generated architectural study, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.



The no-plug test The catalogue sorted by whether a programme would still be busy if every vehicle left.
AI-generated architectural study; not a measured reconstruction or a common scale.

The icon also has a critic. Leslie Sklair argues that today’s iconic buildings mostly serve private interests and consumption, whereas monumental architecture in the past “often had a strong public component.”[22] The Powerhouse takes that critique as its brief. It is meant to be an icon of the transition in that sense: a figure people recognise, visit and are proud of, repeated along the road, with the public component restored: its structure, roof and light make the energy visible, and its open ground and public rooms make it a place anyone can use. An icon without a public programme is a brand; with one, it is a civic building.

Figure 3.5a

1,305,003

visitors to the Guggenheim Museum Bilbao in 2025.

Source: Guggenheim Museum Bilbao

Figure 3.5b

41,000 m²

CopenHill: a waste-to-energy plant whose roof is a public ski slope and trail.

Façade

An 85-metre climbing wall

Source: BIG; VisitCopenhagen



A row of posts. The visible face of the transition: charging posts in the corner of a car park. AI-generated illustration
AI-generated architectural study; not a measured reconstruction or a common scale.



An icon with a public programme. A building whose structure, roof and light make the energy visible, with open ground in front. AI-generated architectural study, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.

3.4 From Dark Lot to Green Ground

Most charging today happens on dark, hard ground. Conventional pavement absorbs the sun: in an Arizona pilot study cited by the EPA, asphalt reached 152°F (67°C) at mid-day, while cool pavements stayed 10 to 16°F cooler.[23] Paved surfaces and buildings hold that heat and release it into the evening, which is what makes cities hotter than their surroundings.[24] A driver waiting beside a charger on a summer afternoon is waiting on one of the hottest surfaces in the city.

Figure 3.6

152°F

Asphalt at mid-day in an Arizona pilot study; cool pavements stayed 10 to 16°F cooler.

Asphalt	Cool pavement
152°F (67°C) at mid-day	10 to 16°F cooler

Source: US EPA, Using Cool Pavements to Reduce Heat Islands

The parking lot does not have to be like this. Eran Ben-Joseph’s study of its design and culture shows that parking lots can be aesthetically pleasing, environmentally and architecturally responsible, and used for something other than car storage.[25] Green ground changes the experience most. The World Health Organization’s review of urban

green space links it with better mental and physical health, lower stress, more physical activity and more social contact, as well as relief from heat, noise and air pollution.[26] The EPA's *Green Streets Handbook*, introduced in 2.1, treats parking surfaces as places to plant, shade and let rain soak in.[27]

The Powerhouse turns the ground it stands on into a community park. Trees and canopies shade the bays and the routes between them; planted ground takes the rain; lawns, gardens and a playground sit where people wait. CopenHill's roof shows that an energy building can carry a park; the Powerhouse brings the park down to the ground people arrive on. The architecture makes the building's sustainability visible: shade, water and planting are things people feel. A place that is cool, green and comfortable is one people choose to stay in. The ground works as well as it grows. The same roof that shades the bays generates: a canopy of about five by five metres over one bay peaks near five kilowatts and gives twenty to twenty-five kilowatt-hours on a good day, about a third of one car's charge, so the roof alone cannot make charging free; the roof, the battery store of 2.6 and the grid together can offset it, and the first twenty minutes can be given. On a freight corridor the green is the canopy and the swale, and the ground under the trucks is hardstanding with a roof; the trees and the lawn belong to the city and the town.

3.5 Open, With Rooms That Close

A public building does not have to be open in every part at every hour. Keller Easterling argues that the rules built into infrastructure, its gates, payment systems and access controls, decide who may enter long before any law is invoked.[28] A charging station that can only be entered by car and unlocked with an app has already decided who it is for.



Dark lot. Asphalt at noon, a driver waiting in the car, nowhere else to wait. AI-generated illustration
AI-generated architectural study; not a measured reconstruction or a common scale.



Green ground. The same bays between trees and canopies, on ground that takes the rain. AI-generated architectural study, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.



From dark lot to green ground The same bays on two grounds: asphalt in full sun, and planted ground under trees and canopies.
AI-generated architectural study; not a measured reconstruction or a common scale.

The Powerhouse sets its rules in layers. Its ground, routes, plaza, shade, seating, toilets and water are open

to everyone, with nothing to buy and no vehicle needed. Some rooms keep set hours: a reading room, a community hall, a market. Others are run by an operator for the people they serve: a clinic, a gym, childcare, rooms for drivers on their required rest. These rooms are permanent parts of the building with their own entrances and hours, and closing them does not close the public ground around them.

Figure 3.7a

Open

Ground, routes, plaza, shade, seating, toilets and water.

Who

Everyone; nothing to buy, no vehicle needed

Source: Section 3.5

Figure 3.7b

Set hours

A reading room, a community hall, a market.

Who

Everyone, while open

Source: Section 3.5

Figure 3.7c

Operator

A clinic, a gym, childcare, rooms for drivers.

Who

The people each room serves

Source: Section 3.5

This gradient lets the Powerhouse be both open and safe to run. The public layer is what makes it a civic building; the operated rooms are what make it useful every day; the charger serves both. The design question is where each layer sits, and the answer is a U rather than a ring: the open ground is a court that touches the street on one side and the bays on another, the scheduled rooms wrap the rest, and the operated rooms keep their own doors. At two in the morning the U is open on the street side and lit, with the washroom, an automated kiosk, seats and the drivers' rooms on that edge, so that the open layer can be reached on foot while every room is shut, and so that someone is there. Who keeps each layer is part of the plan: the open layer is public and is paid for by the energy layer (2.6); the scheduled rooms are leased at a town's or a community's rent; the operated rooms are leased commercially.

3.6 What a Powerhouse Can Hold

The sections above lead to a catalogue rather than a single brief. Table 3.1 sets out programmes a Powerhouse can hold, sorted three ways: by the length of stay they suit (the three stays from Chapter 1), by the setting where they are most likely to be needed (a freight corridor, a city, a town), and by access (open to all, set hours, or run by an operator). No site needs all of them. A corridor site might hold toilets, a food hall, showers and rooms for drivers; a city site a reading room, a gym and a workspace; a town site a clinic, a market and a hall.

Table 3.1. A catalogue of programmes: what a Powerhouse can hold, by length of stay, setting and access.

Programme	20 min	1–2 h	A night	Corridor	City	Town	Access	Runs it
Toilets and drinking water	●	●	●	●	●	●	Open	Public
Covered plaza and seating	●	●		●	●	●	Open	Public
Children's playground	●	●			●	●	Open	Public
Community garden and lawn		●			●	●	Open	Public
Cooling and emergency shelter			●	●	●	●	Open when needed	Public
Automated kiosk	●	●	●	●	●	●	Open	Public

Programme	20 min	1–2 h	A night	Corridor	City	Town	Access	Runs it
Waiting lounge	●	●		●	●		Open	Public
Café	●	●		●	●	●	Set hours	Town or community lease
Food hall	●	●	●	●	●		Set hours	Town or community lease
Grocery or convenience store	●			●	●	●	Set hours	Town or community lease
Parcel and post room	●				●	●	Set hours	Town or community lease
Bike hub	●	●			●	●	Set hours	Town or community lease
Laundromat		●		●	●		Set hours	Town or community lease
Library reading room		●			●	●	Set hours	Town or community lease
Community hall		●			●	●	Set hours	Town or community lease
Market hall		●				●	Set hours	Town or community lease
Repair workshop and tool library		●			●	●	Set hours	Town or community lease
Gym		●			●	●	Operator	Commercial lease
Co-working space		●			●		Operator	Commercial lease
Health clinic and pharmacy		●			●	●	Operator	Commercial lease
Childcare		●			●	●	Operator	Commercial lease
Showers	●	●	●	●			Operator	Commercial lease
Drivers’ rooms			●	●			Operator	Commercial lease

Author’s classification. The list began from forty programmes recurring across charging networks, federal guidance, driver surveys and precedents; an AI model (Jev, by TypeSafe) assisted the first sorting, and the author reviewed every entry. Programmes unrelated to the pause, such as pet services and car washes, are left out.

The catalogue is the tool that balances the node. Each programme added from the table raises the place value of a site that the charger has already made a strong node, until the two are in proportion. Chapter 4 turns the catalogue into a framework: it asks what a particular place lacks, chooses from the table, and arranges the choices around the charger, using the three moves from section 2.3 and the access layers above. The Powerhouse is not a fixed building repeated along the road. It is a type that takes its programme from the place. The table also says who runs each programme, because who pays for the open layer at two in the morning is part of the catalogue, not an afterthought.



Eleven at night. The open ground lit and in use; the hall and market shut; the operated rooms keeping their own hours. AI-generated illustration, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.



Open, with rooms that close The three layers in plan, and their hours: the open ground at the centre never closes.
AI-generated architectural study; not a measured reconstruction or a common scale.



One type, three forms The corridor, city and town Powerhouse as three programme arrangements.
AI-generated architectural study; not a measured reconstruction or a common scale.



Twenty-three programmes, three ways Table 3.1 counted by stay, by setting and by access.
AI-generated architectural study; not a measured reconstruction or a common scale.

CHAPTER 04

A Framework for the Pause

4.0 From Catalogue to Building

Chapters 1 to 3 argued. Chapter 1 stated the proposition, Chapter 2 the conditions of the pause and Chapter 3 what a Powerhouse can hold. This chapter does not say those things again. It turns them into an instrument: five sheets that a person can fill in, in order, for a site they have never seen, and that can say no as well as yes.

The five sheets are these. Read the site, with counts that have units and thresholds. Name its setting, and with it which of two things, the charge or the programme, brings people there. Arrange the building by six plan rules, each with its tiebreak. Run the day, so that the plan says who is on site at every hour in that setting rather than in an easier one. Test it, against the failure stated in 1.6 and the three measures with their conditions. The sheets are worked here on the three settings; Graduate Thesis 01 fills them in on two real sites, and Thesis 02 builds one.

A framework that fixes nothing cannot be wrong. This one fixes the sheets, the tiebreaks and the failure, and leaves the site and the form to the design.

4.1 Reading the Site

A site is read twice, as a node and as a place, in the terms Luca Bertolini used for station areas,[1] borrowed as in 3.0 as a way of seeing. The node sheet has five counts. People within a fifteen-minute walk who cannot charge at home, from the share of households without off-street parking. Electric vehicles per public charging point in the catchment, against the national figure of 33 (2.0). Freight: whether a route with required driver rests, or a depot, lies within reach. Road access: whether the site can be entered and left without a turn across traffic. And the grid: the capacity of the feeder, in kilowatts, with the storage of 2.6 counted where the feeder falls short.

Figure 4.1a

Read

The site as a node and as a place.

Source: Section 4.1

→

Figure 4.1b

Recognise

Its setting: corridor, city or town.

Source: Section 4.2

→

Figure 4.1c

Arrange

Charger, programmes and public ground, by six rules.

Source: Section 4.3

→

Figure 4.1d

Plan the day

Who is on site at every hour.

Source: Section 4.4

→

Figure 4.1e

Measure

Minutes on site, share open to all, programme on site.

Source: Section 4.5

The place sheet has three. What the neighbourhood already has and lacks of Carlos Moreno’s six everyday functions, living, working, supplying, caring, learning and enjoying, within a short walk or ride,[2] counted as the facilities present within 800 metres. Which of the five needs of 3.1 the nearest public space meets. And how a person can arrive without a vehicle: on foot, by bicycle, by bus, each as a route that exists or does not.

The two sheets together give the site its position in the vocabulary of Chorus and Bertolini: unbalanced node, unbalanced place, balanced, stressed or dependent,[3] and each position has its response. The typical charging site is an unbalanced node and the main case: add programme. A lively neighbourhood with no charging is an unbalanced place: bring the charger in at the place’s scale. A balanced site needs a light touch; a stressed one a

compact Powerhouse woven into what exists. The reading also rejects. A lot at the end of an industrial road, two kilometres from any home, on a small feeder, with no bus and no sidewalk, scores nothing on the place sheet and little on the node sheet: it is not a Powerhouse site, and the right answer there is a plug. A main street with a strong place and a weak feeder gets a slow-charging Powerhouse at the town's scale, or none. A framework that can give those two answers is a framework.



Node and place. A Powerhouse between the road network on one side and a neighbourhood on the other. AI-generated illustration, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.



Five steps, and where they come from Each step draws on sections of Chapters 1 to 3; the result is one building, tested against the same steps.
AI-generated architectural study; not a measured reconstruction or a common scale.

Figure 4.2a

Unbalanced node

Strong in the network, weak as a place: the typical charging site.

Response

Add programme

Source: After Chorus and Bertolini (2011)

Figure 4.2b

Unbalanced place

A lively neighbourhood with no charging.

Response

Bring the charger in, at the place's scale

Source: After Chorus and Bertolini (2011)

Figure 4.2c

Balanced

Node and place in proportion.

Response

A light touch

Source: After Chorus and Bertolini (2011)

Figure 4.2d

Stressed

At its limits as both node and place.

Response

A compact Powerhouse woven into what exists

Source: After Chorus and Bertolini (2011)

Figure 4.2e

Dependent

Weak as both node and place.

Response

Not a Powerhouse site

Source: After Chorus and Bertolini (2011)



Reading a site. A road, a rail line, a substation, an old garage and a neighbourhood meeting at one corner, and no charger yet. Any site; the reading comes first. AI-generated illustration
AI-generated architectural study; not a measured reconstruction or a common scale.



The same connection, more public life The road and charging connection stay; a public court and useful rooms strengthen the place.
AI-generated architectural study; not a measured reconstruction or a common scale.

4.2 Three Settings

The same type takes three forms, and the sheet's second question decides which: what brings people here, the charge or the programme. On a freight corridor the stop is compulsory, set by the battery and by law, so the charge brings people and the programme makes the stop bearable. In a city the people nearby come for the clinic, the gym and the reading room, and the driver with no driveway is one user among many, so the programme brings people and the charge is one of its services. A town sits between, and leads with the programme. The Powerhouse is the type that holds both ends of that trade; Table 4.1 sets out the three forms.

On a **freight corridor** the node is strong and the place is thin. Trucks stop for required breaks and overnight rests; drivers need sleep, showers, food and safety more than anything else. The precedent is the highway service plaza, from the Pennsylvania Turnpike of 1940 traced in 2.3, which grouped fuel, food and rest beside the road. The corridor Powerhouse adds what the plaza lacked: a building organised around the stop rather than placed beside it, and rooms for a night.

In a **city** both node and place are strong, and ground is scarce. Here the Powerhouse works as a mobility hub, where charging meets the other ways people move. Bremen has dedicated street space to shared mobility since 2003, when its mobil.punkt stations became the first on-street car-sharing stations in Germany.[4] Crossrail Place in London shows how far a transport building can go: a new railway station at Canary Wharf topped by shops and a public roof garden under a 310-metre timber roof.[5] The city Powerhouse is compact and layered, with charging below and public rooms and planting above.

In a **town** the node is modest and the place needs most. A town may lack a clinic, a market or a hall, and the people who come may be local rather than passing through. The precedent is Japan's *michi-no-eki*, studied in 3.2: a roadside stop run with the town, holding a market, a restaurant and a hall, and serving as a disaster base. The town Powerhouse leads with that civic programme and treats charging as one of its services.



City. Compact and stacked: charging below, public rooms above, a roof garden. AI-generated architectural study, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.



Town. A civic hall with a market, clinic and hall, and charging alongside. AI-generated architectural study, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.



One type, three forms The corridor, city and town Powerhouse as three programme arrangements.
AI-generated architectural study; not a measured reconstruction or a common scale.

Table 4.1. Three settings: one type, three forms.

	Freight corridor	City	Town
Node–place reading	Strong node, weak place	Strong node, strong place (often stressed)	Modest node, place in need
What brings people	The charge: a stop the battery and the law require	The programme; the charge is one of its services	The programme, with charging as a service
Who arrives	Truck and van drivers, long-distance travellers	Residents without home charging, ride-hail and delivery drivers, people on foot, by bike and transit	Local residents, visitors, people passing through
Main stays	20 min · a night	20 min · 1–2 h	1–2 h
Lead programme (Table 3.1)	Toilets, food hall, showers, drivers’ rooms	Reading room, gym, co-working, childcare, bike hub	Clinic and pharmacy, market hall, community hall
Precedent	Highway service plazas (2.3)	mobil.punkt, Bremen; Crossrail Place, London	Michi-no-eki, Japan (3.2)
Form	Spread along the road; rooms for rest set back from the bays	Compact and stacked; a public roof	A civic hall with charging alongside

4.3 Arranging the Powerhouse

Once the site and setting are read, the plan follows six rules, each with its tiebreak. **Rings by stay.** The charger sits at the centre and the rooms are placed by how long people stay (1.5): what fits twenty minutes nearest, an hour or two beyond, a night at the edge. Stay places a room; access only labels it, so a cooling shelter and a drivers’ room sit in the same ring and differ in their door. **The stall on the court.** The three moves of 2.3, a protected interior, a legible threshold and a room sized to the pause, come down to one plan move: the bay is a stall on the edge of the court, the vehicle noses up to it, the person steps into the court, and the drive runs behind. **Two routes.** Vehicles reach the bays by the loop behind them; people reach the court and the rooms by a route of their own from the street (2.1); the two meet only at the stall. **The U.** The open ground touches the street on one side and the bays on another, and the set-hours and operated rooms wrap the rest (3.5), so that the open layer is reachable at any hour and the night services sit on its open edge. **Energy funds the public layer.** The three layers of 2.6 change at their own speeds, and the store earns from the grid; that income keeps the open layer running, and the charging layer is the

one allowed to fail. **Working ground.** The roof generates and shades, the ground takes the rain, and the trees belong to the city and the town; on the corridor the ground under the trucks is hardstanding with a canopy (3.4).



Freight corridor. Spread along the road: truck bays at the front, rooms for a night set back. AI-generated architectural study, speculative AI-generated architectural study; not a measured reconstruction or a common scale.

Figure 4.3a

Rings

The charger at the centre; programmes in rings by length of stay.

From

Section 1.5

Source: Rule 1

Figure 4.3b

Three moves

A protected interior, a legible threshold, a room sized to the pause.

From

Section 2.3

Source: Rule 2

Figure 4.3c

Two routes

Vehicles reach the chargers, people reach the rooms; the routes never cross.

From

Section 2.1

Source: Rule 3

These rules give the type its consistency, and the test of a rule is that breaking it makes the building something else. A lot at the centre makes it a power center; a building beside the bays makes it a forecourt; rooms the energy does not fund make it a mall. Figure 4.3h sets the arrangement against its opposite, the power center of 2.3: there the lot is at the centre and the stores at the edge, and the only way in is by car; here the court is at the centre, the bays are at its edge, and the way in on foot is a route of its own.

Figure 4.3d

Access layers

Open ground at the centre, set-hours rooms around it, operated rooms that can close.

From

Section 3.5

Source: Rule 4

Figure 4.3e

Lifespan layers

Energy replaced most often, charging re-equipped, public rooms built to last.

From

Section 2.6

Source: Rule 5

Figure 4.3f

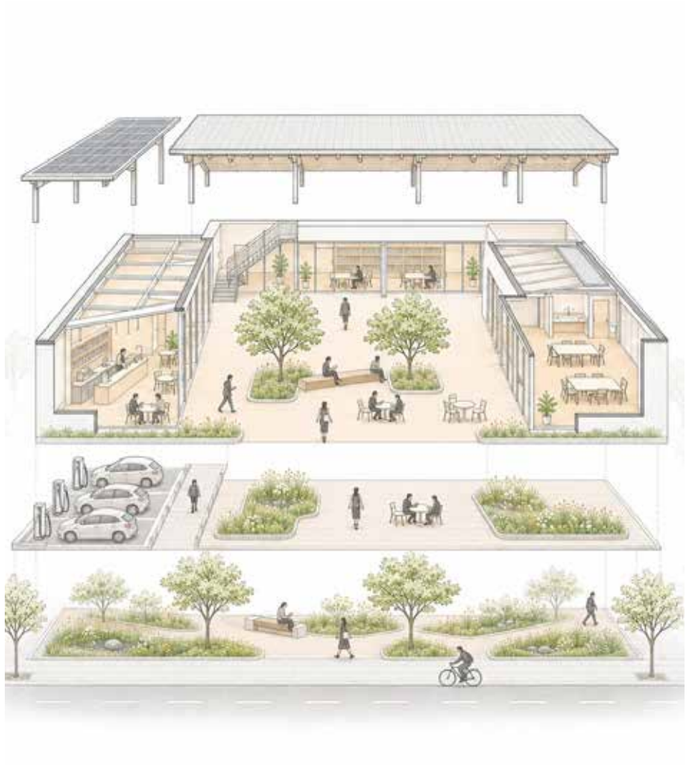
Green ground

Planted, shaded and permeable; rain into the soil, not off the tarmac.

From

Section 3.4

Source: Rule 6



The rules, lifted apart. Ground, bays, rooms and roof as the layers of one building. AI-generated architectural programme diagram, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.



Six spatial rules Duration, the court-edge stall, separate routes, the open U, replaceable systems and green ground.
AI-generated architectural study; not a measured reconstruction or a common scale.



The power center, inverted The big-box block and the Powerhouse as two plans: what sits at the centre, what sits at the edge, and how a person arrives.
AI-generated architectural study; not a measured reconstruction or a common scale.

4.4 Across the Day and Night

A building organised around a single use is empty for much of the day. Kevin Lynch urged designers to treat time as a material of the city as real as space,[6] and Henri Lefebvre showed how urban life is made from overlapping daily rhythms.[7] A Powerhouse is planned across the full twenty-four hours, and planned for its own setting rather than for the mixed site that makes the argument easiest (Table 4.2).

The rhythm also keeps the place safe. Jane Jacobs argued that streets are safe when people are present and watching, not when they are watched.[8] On a corridor the night has drivers on their required rest; in a city it has night-shift workers and fleets between shifts; in a town it may have no one, and the sheet should say so. A lit washroom, an automated kiosk, two bays and nobody is an honest row, and the open edge of the U is what makes the place safe to return to in the morning.

Table 4.2. One building across the day.

Time	Freight corridor	City	Town
06:00–12:00	Drivers leaving after rest; trucks on a first break showers, food hall, kiosk	Commuters, delivery and fleet drivers starting shifts café, market set-up, childcare, bike hub	Residents, parents, the market café, market hall, clinic opens
12:00–18:00	Thirty-minute breaks; a few travellers food hall, lounge, showers	Residents, schoolchildren after school, visitors clinic, reading room, workshops, playground, gym	Residents; people passing through clinic and pharmacy, hall, playground, market
18:00–24:00	Drivers arriving for the night; a few cars food hall, drivers' rooms, the lit court	Returning commuters, evening visitors food hall, community hall, events, gym	Residents, evening events hall, café, the planted ground
00:00–06:00	Drivers on required rest; fleets drivers' rooms, showers, lit waiting room, kiosk	Night-shift workers; fleets between shifts waiting room, kiosk, showers	Often no one washroom, automated kiosk, two bays, the lit open edge of the U



Seven in the morning. Commuters, fleet drivers and the market being set up. AI-generated illustration, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.



Two in the morning. Drivers on their rest, a night-shift worker, a lit and open waiting room. AI-generated illustration, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.



One building across the day Who is on site in each quarter of the day, and which rooms are open; the open layer runs through.
AI-generated architectural study; not a measured reconstruction or a common scale.

4.5 Measuring the Pause

Chapter 1 promised three measures and section 1.6 stated the failure. The framework makes both operational, for existing sites and for the design.

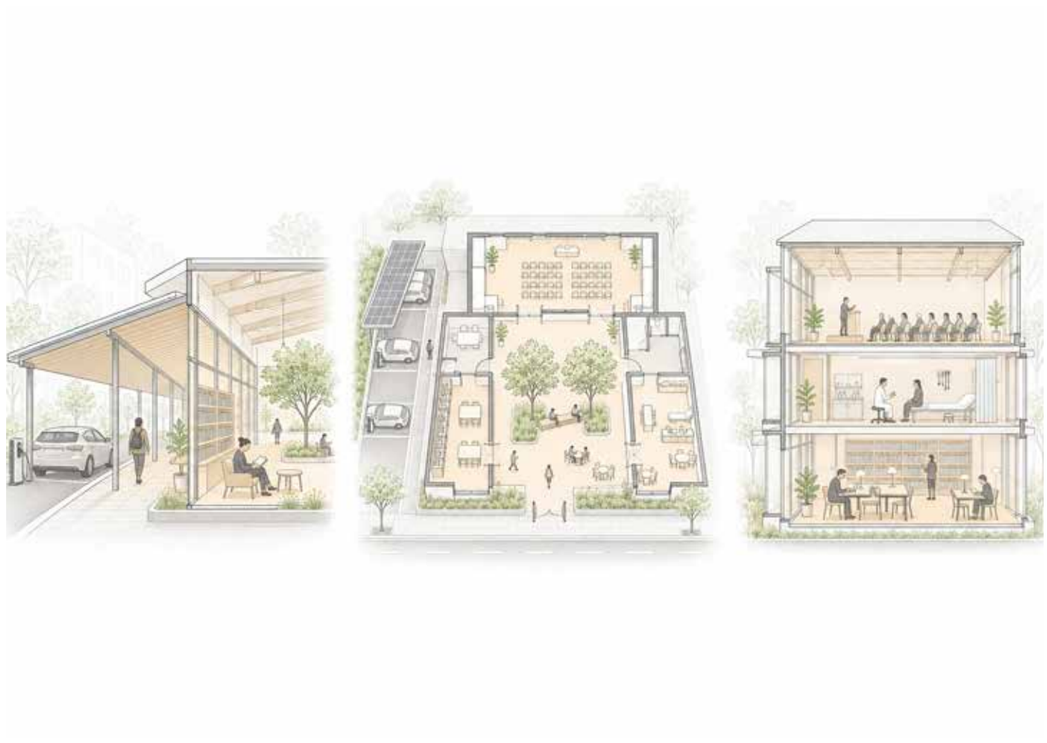
Minutes on site. Two clocks, as in 2.4: how long the vehicle is plugged in, and how long the person stays, from arrival to departure. The hypothesis fails when the second runs no longer than the first. A longer stay counts only if comfort, access and a free programme explain it, which the counts below are there to show.

Share of the site open to all. The site plan is divided into the three access layers, and the measure is the share anyone can use with nothing to buy and no vehicle, with a condition a parking lot fails and a court passes: open, and shaded or roofed, and with somewhere to sit, and reachable on foot without crossing a drive. A bare lot scores nothing and the power center near nothing; this is what separates the Powerhouse from a forecourt with a shop and from a plaza open in name only, of the kind Kayden's survey found marginal (1.4).

Programme on site. The measure counts the programmes from Table 3.1 that are present and used: a clinic with a queue, a hall with an event a week, a room open when the sheet says it is. It counts how many of them meet a need the place sheet found, and how many work without the plug. If the extra time leads only to more retail, the hypothesis fails (1.6).



A timed count. Who is where, doing what, from above: people gather where there is shade and a seat. AI-generated architectural study, speculative
AI-generated architectural study; not a measured reconstruction or a common scale.



Three measures, drawn Observe time on site, space open to all and programmes in use.
AI-generated architectural study; not a measured reconstruction or a common scale.

Figure 4.4a

Minutes on site

Two clocks: the vehicle plugged in, the person on site.

Working when

People stay for the place, and arrive without a vehicle

Source: Sections 2.4, 4.5

Figure 4.4b

Share open to all

Site area anyone can use, with nothing to buy and no vehicle needed.

Working when

The open layer leads the plan

Source: Sections 3.5, 4.5

Figure 4.4c

Programme on site

Programmes from Table 3.1 that meet a local need and work without charging.

Fails if

The extra time leads only to more retail

Source: Sections 1.6, 4.5

The measures are taken by observation, using the timed counts of William Whyte and of Jan Gehl and Birgitte Svarre: who is present, where, doing what and for how long, at set times across the day.[9] Before Thesis 01 begins, three existing sites are counted, one in each setting, a highway service plaza with chargers, a city fast-charging hub and a town lot with chargers, for three days each, with every half hour mapped, arrivals counted by mode and the two clocks taken for thirty vehicles a site. Operators' session data gives the vehicle-clock where it can be had; nothing but standing there gives the person's. The count is the baseline the failure test needs, and the first time the thesis will have measured rather than argued.

4.6 From Framework to Building

The framework ends in a set of principles for the design that follows (Figure 4.5). They describe the building's character, not its final form: a node and a place in balance, with the charge and the programme trading places by setting; a charger at the centre with rooms in rings by stay; a court with the bays as stalls on its edge, open to

the street as a U; a roof that makes the energy visible and shades the ground beneath; an energy store that earns, and pays for the open layer; working ground; and a recognisable figure, repeated along the road, that people are proud of because it is theirs to use.



One Powerhouse. The principles in one building: a public court, an energy roof, green ground, an icon that is theirs to use. AI-generated illustration, speculative AI-generated architectural study; not a measured reconstruction or a common scale.

Figure 4.5a

Node and place

The charge makes it a node; the programme makes it a place.

Source: Principle 1

Figure 4.5b

Charger at the centre

Programmes in rings around it.

Source: Principle 2

Figure 4.5c

A public court

Protected from the vehicle routes, open to anyone.

Source: Principle 3

Figure 4.5d

A roof for energy

Generation and shade made visible.

Source: Principle 4

Figure 4.5e

Green ground

Planted and permeable.

Source: Principle 5

Figure 4.5f

A public icon

Recognised and used by the people around it; its layers change at their own speeds.

Source: Principles 6–7

One building cannot show that a type repeats. Graduate Thesis 01 therefore reads two sites in two settings with the sheets of this chapter, one to be built and one only to be read, and Thesis 02 builds the first. Two readings show that the framework repeats; one building shows what a Powerhouse looks like. That is the claim the thesis can keep.

CHAPTER 01

Notes

1. US Environmental Protection Agency, “Fast Facts on Transportation Greenhouse Gas Emissions,” based on *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990–2022* (Washington, DC: EPA, 2024).

2. US Department of Energy, Vehicle Technologies Office, “Fact of the Week #1360: A Typical EV Is 87%–91% Efficient Compared to 30% for a Conventional Gasoline Vehicle,” September 16, 2024.

3. Stephen P. Holland, Erin T. Mansur, Nicholas Z. Muller, and Andrew J. Yates, “Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors,” *American Economic Review* 106, no. 12 (2016): 3700–3729.

4. International Energy Agency, *Global EV Outlook 2025* and *Global EV Outlook 2026* (Paris: IEA, 2025 and 2026).

5. US Energy Information Administration, *Annual Energy Outlook 2026*, Table 39, “Light-Duty Vehicle Sales by Technology Type,” and light-duty vehicle stock projections (Washington, DC: EIA, 2026). Shares are of cars and light trucks.

6. Michael Wicki, Gracia Brückmann, Franziska Quoss, and Thomas Bernauer, “What Do We Really Know about the Acceptance of Battery Electric Vehicles? – Turns Out, Not Much,” *Transport Reviews* 43, no. 1 (2023): 62–87.

7. US Department of Energy, “National EV Charging Network,” https://www.energy.gov/topics/national-ev-charging-network.

8. US Energy Information Administration, household electricity consumption, 2022; US DOE and EPA, fueleconomy.gov; author’s estimate.

9. Carroll L. V. Meeks, *The Railroad Station: An Architectural History* (New Haven: Yale University Press, 1956).

10. John A. Jakle and Keith A. Sculle, *The Gas Station in America* (Baltimore: Johns Hopkins University Press, 1994); Daniel I. Vieyra, *“Fill ’er Up”: An Architectural History of America’s Gas Stations* (New York: Macmillan, 1979).

11. Federal Highway Administration, “National Electric Vehicle Infrastructure Standards and Requirements,” 23 C.F.R. pt. 680 (2023).

12. Nana Duah, Steven Jiang, Om Prakash Yadav, Hieu Trung Nguyen, and Nastasha Earle-Young, “Navigating the Truck Parking Challenge: A Comprehensive Review of Strategies, Emerging Technologies, and Future Directions,” *Transportation Research Interdisciplinary Perspectives* 34 (2025): 101740.

13. Anne-Marie Anderson and Richard J. Kish, “The Costs and Benefits of Electric Trucks: A Synopsis of the U.S. Trucking Market,” *Sustainability* 17 (2025): 2097.

14. Marc Augé, *Non-Places: Introduction to an Anthropology of Supermodernity*, trans. John Howe (London: Verso, 1995).

15. Peter Merriman, “Driving Places: Marc Augé, Non-places, and the Geographies of England’s M1 Motorway,” *Theory, Culture & Society* 21, no. 4/5 (2004): 145–167. Source. Accessed October 25, 2026.

16. GRIDSERVE, “GRIDSERVE Opens UK’s First Electric Forecourt,” December 2020, https://www.gridserve.com/gridserve-opens-uks-first-electric-forecourt/.

17. Can Aktuna, “Experiential Charging Hubs as Tourism Micro-Destinations: A Mobilities-Oriented Netnography of Tesla’s Hollywood Diner–Supercharger,” *Mobilities* (2026): 1–18. Abstract via SCAD Libraries (EBSCO).

18. Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan, “Michi-no-Eki (Roadside Stations),” programme launched 1993.

19. US Department of Energy, Alternative Fuels Data Center, “Developing Infrastructure to Charge Electric Vehicles,” https://afdc.energy.gov/fuels/electricity-infrastructure.

20. Federal Motor Carrier Safety Administration, “Maximum Driving Time for Property-Carrying Vehicles,” 49 C.F.R. § 395.3.

21. Donald Shoup, *The High Cost of Free Parking* (Chicago: Planners Press, 2005).

22. Jerold S. Kayden, New York City Department of City Planning, and Municipal Art Society of New York, *Privately Owned Public Space: The New York City Experience* (New York: John Wiley and Sons, 2000).

23. William H. Whyte, *The Social Life of Small Urban Spaces* (Washington, DC: Conservation Foundation, 1980).

24. Ray Oldenburg, *The Great Good Place* (New York: Paragon House, 1989).

25. Leiqing Xu, Dancheng Meng, Shin Bin Tan, Jiahua Li, et al., “Neurological Benefits of Third Places for Young Adults in Healthy Urban Environments,” *Frontiers of Architectural Research* 14, no. 5 (2025), https://doi.org/10.1016/j.foar.2025.01.008.

26. Eric Klinenberg, *Palaces for the People: How Social Infrastructure Can Help Fight Inequality, Polarization, and the Decline of Civic Life* (New York: Crown, 2018).

27. Stan Allen, “Infrastructural Urbanism,” in *Points + Lines: Diagrams and Projects for the City* (New York: Princeton Architectural Press, 1999), 46–57.

28. Reuters, “BYD Unveils New Super-Charging EV Tech, to Build Charging Network in China,” March 17, 2025, https://www.reuters.com/business/autos-transportation/chinas-byd-unveils-faster-charging-ev-platform-aims-build-over-4000-charging-2025-03-17/.

29. World Commission on Environment and Development, *Our Common Future* (Oxford: Oxford University Press, 1987), 43.

CHAPTER 02

Notes

1. US Department of Energy, Alternative Fuels Data Center, “Electric Vehicle Charging Stations.” Source. Accessed October 24, 2026.

2. US Department of Energy, Alternative Fuels Data Center, “Charging Electric Vehicles in Public.” Source. Accessed October 24, 2026.

3. US Department of Energy, Alternative Fuels Data Center, Station Locator inventory, 18 October 2026; author’s counts of ports, stations, charger levels, network and state. Source. Accessed October 25, 2026.

4. US Department of Energy, Alternative Fuels Data Center, “Electric Vehicle Charging Infrastructure Trends”: US public and private charging ports, 2011–2023. Source. Accessed October 25, 2026.

5. Paren, *U.S. EV Fast Charging 2025 Report* (2026): 18,041 new DC fast-charging ports in 2025, about 30 per cent more than in 2024. Industry report. Source. Accessed October 25, 2026.

6. International Energy Agency, “Electric Vehicle Charging,” in *Global EV Outlook 2026* (Paris: IEA, 2026): 33 electric light-duty vehicles per public charging point in the United States at the end of 2025, up from fewer than 20 in 2020. Source. Accessed October 25, 2026.

7. Christopher D. Elvidge et al., “U.S. Constructed Area Approaches the Size of Ohio,” *Eos,*

*Transactions of the American Geophysical Unio*n 85, no. 24 (2004): 233–234. Impervious surface of the 48 states and Washington, DC: 112,610 km²; Ohio: 116,534 km². Source. Accessed October 25, 2026.

8. Mikhail Chester, Arpad Horvath, and Samer Madanat, "Parking Infrastructure: Energy, Emissions, and Automobile Life-Cycle Environmental Accounting," *Environmental Research Letter*s 5, no. 3 (2010): 034001. Source. Accessed October 25, 2026.

9. Mikhail Chester, Andrew Fraser, Juan Matute, Carolyn Flower, and Ram Pendyala, "Parking Infrastructure: A Constraint on or Opportunity for Urban Redevelopment? A Study of Los Angeles County Parking Supply and Growth," *Journal of the American Planning Associatio*n 81, no. 4 (2015): 268–286. Source. Accessed October 25, 2026.

10. Eric Scharnhorst, *Quantified Parking: Comprehensive Parking Inventories for Five U.S. Citie*s (Washington, DC: Research Institute for Housing America, Mortgage Bankers Association, 2018). Source. Accessed October 25, 2026.

11. Hashem Akbari, L. Shea Rose, and Haider Taha, "Analyzing the Land Cover of an Urban Environment Using High-Resolution Orthophotos," *Landscape and Urban Planning* 63, no. 1 (2003): 1–14. Sacramento: vegetation about 36 per cent, roofs about 20 per cent, paved surfaces about 28 per cent. Source. Accessed October 25, 2026.

12. US Environmental Protection Agency, *Green Streets Handbook* (2021). Source. Accessed October 24, 2026.

13. US Access Board, "Design Recommendations for Accessible Electric Vehicle Charging Stations," updated July 17, 2023. Technical assistance; distinguish recommendations from applicable ADA/ABA requirements. Source. Accessed October 24, 2026.

14. Scharnhorst, *Quantified Parking*: New York's parking costs about $6,570 per household to replace, against about $118,000 in Seattle.

15. New York City Department of Transportation, "NYC DOT Launches Expansion of Curbside Electric Vehicle Charging Across Five Boroughs, Solicits Public Feedback on Locations," press release, August 4, 2026. Source. Accessed October 25, 2026.

16. International Energy Agency, "Electric Vehicle Charging," in *Global EV Outlook 2026* (Paris: IEA, 2026). Source. Accessed October 24, 2026.

17. US Department of Transportation, "Charger Types and Speeds," *Charging Forward: A Toolkit for Planning and Funding Rural Electric Mobility Infrastructur*e. Source. Accessed October 24, 2026.

18. US Department of Energy, "EVGrid Assist: Charts and Figures," reporting the 2023 NREL 2030 National Charging Network study. Conditional scenario for 33 million light-duty EVs; not a current forecast. Source. Accessed October 24, 2026.

19. Encyclopaedia Iranica, "Caravansary." Source. Accessed October 25, 2026.

20. National Trust, Heritage Records, "The George Inn, No. 77 Borough High Street, Southwark," record MNA147890: timber-frame and brick inn rebuilt in 1677 after the Southwark fire. Source. Accessed October 25, 2026.

21. Science and Industry Museum, *Revolution Manchester: Mov*e, large-print guide (2023), Liverpool Road Station, 1830. Source. Accessed October 24, 2026.

22. Grand Central Terminal, "About," opening date February 2, 1913. Source. Accessed October 24, 2026.

23. Heinz History Center, "Was the World's First Gas Station in Pittsburgh? It's Complicated," blog. Source. Accessed October 25, 2026.

24. Pennsylvania Turnpike Commission, "Turnpike History" and service-plaza historical account, 1940. Source. Accessed October 24, 2026.

25. TWA Hotel, "Overview": the 1962 TWA Flight Center at JFK Airport, restored as a hotel. Source. Accessed October 25, 2026.

26. GRIDSERVE, "GRIDSERVE Opens UK's First Electric Forecourt," December 2020. Operator's account. Source. Accessed October 24, 2026.

27. Bosch eBike Systems, "4 A Standard Charger EU (BCS220)," PowerTube 500 charging time, approximately 4.5 hours. Source. Accessed October 24, 2026.

28. Zero Motorcycles, *2020 Zero SR/F Owner's Manua*l, ZF14.4 charging guidance. Historical model example. Source. Accessed October 24, 2026.

29. Ford Pro, "New Extended Range E-Transit," April 23, 2024, 89 kWh usable battery. Source. Accessed October 24, 2026.

30. New Flyer, "Xcelsior CHARGE NG," vehicle and charging specifications, 660 kWh example. Source. Accessed October 24, 2026.

31. Volvo Trucks, "Volvo Trucks Launches Electric Truck with Longer Range," January 14, 2022, VNR Electric, 565 kWh example. Source. Accessed October 24, 2026.

32. International Energy Agency, "Outlook for Electric Mobility," *Global EV Outlook 2026*, Current Policies Scenario. Source. Accessed October 24, 2026.

33. Federal Motor Carrier Safety Administration, "Summary of Hours of Service Regulations," property-carrying drivers; 49 C.F.R. § 395.3. Source. Accessed October 24, 2026.

34. European Commission, "Driving Time and Rest Periods," summarising Regulation (EC) No 561/2006, as amended. Source. Accessed October 24, 2026.

35. National Electric Vehicle Infrastructure Standards and Requirements, 23 C.F.R. § 680.106(b), (d), (e). Read within the applicability of Part 680. Source. Accessed October 24, 2026.

36. National Electric Vehicle Infrastructure Standards and Requirements, 23 C.F.R. § 680.116(b), minimum annual uptime greater than 97 percent, subject to the regulation's calculation. Source. Accessed October 24, 2026.

37. New York City Department of City Planning, "City of Yes for Carbon Neutrality (N 230113 ZRY)," adopted December 6, 2023. An example of zoning reform, not confirmation of a thesis site or individual project approval. Source. Accessed October 24, 2026.

38. SAE International, *SAE J3271: Megawatt Charging System for Electric Vehicle*s, Technical Information Report (March 2025); National Renewable Energy Laboratory, "The Dawn of Electric Trucking Calls for High-Power Charging," 2025 (published under the laboratory's new name, NLR), on connectors of up to 3.75 MW. Source. Accessed October 25, 2026.

39. National Renewable Energy Laboratory, "The Dawn of Electric Trucking Calls for High-Power Charging," 2025, citing NREL technical report 82092 (2023), https://www.nrel.gov/docs/fy23osti/82092.pdf. Source. Accessed October 25, 2026.

40. NIO, "NIO Achieves 100 Million Battery Swaps," press release, February 6, 2026. Source. Accessed October 25, 2026.

41. Joint Office of Energy and Transportation, "Battery Energy Storage for Electric Vehicle Charging Stations," help sheet reporting National Renewable Energy Laboratory analysis. Source. Accessed October 25, 2026.

42. US Department of Energy, Federal Energy Management Program, "Smart Charge Management Implementation for Federal Fleets." Source. Accessed October 24, 2026.

43. Federal Motor Carrier Safety Administration, "Summary of Hours of Service Regulations"; 49 C.F.R. § 395.3. See note 33.

CHAPTER 03

Notes

1. Grand Central Terminal, "Shop & Dine": open to the public daily, 5:15 a.m. to 2:00 a.m. Source. Accessed October 25, 2026.

2. "At Singapore's Changi Airport, a New Jewel Shines," *New York Time*s, April 11, 2019: officials expected 40 to 50 million visitors in the first year, 60 per cent of them residents. Source. Accessed October 25, 2026.

3. Jewel Changi Airport, “Rain Vortex”: water falling seven storeys at the centre of Jewel. Source. Accessed October 25, 2026.

4. John D. Kasarda, “Welcome to Aerotropolis, the City of the Future,” *New Perspectives Quarterly* 32, no. 3 (July 2015). SCAD Libraries catalog.

5. Luca Bertolini, “Spatial Development Patterns and Public Transport: The Application of an Analytical Model in the Netherlands,” *Planning Practice & Research* 14, no. 2 (1999): 199–210. Source. Accessed October 25, 2026.

6. Paul Chorus and Luca Bertolini, “An Application of the Node-Place Model to Explore the Spatial Development Dynamics of Station Areas in Tokyo,” *Journal of Transport and Land Use* 4, no. 1 (2011): 45–58. Source. Accessed October 25, 2026.

7. Eric Klinenberg, *Palaces for the People: How Social Infrastructure Can Help Fight Inequality, Polarization, and the Decline of Civic Life* (New York: Crown, 2018).

8. Eric Klinenberg, *Heat Wave: A Social Autopsy of Disaster in Chicago* (Chicago: University of Chicago Press, 2002).

9. Office of the US Surgeon General, *Our Epidemic of Loneliness and Isolation: The U.S. Surgeon General’s Advisory on the Healing Effects of Social Connection and Community* (Washington, DC: HHS, 2023). Source. Accessed October 25, 2026.

10. Ray Oldenburg, *The Great Good Place* (New York: Paragon House, 1989).

11. Stephen Carr, Mark Francis, Leanne G. Rivlin, and Andrew M. Stone, *Public Space* (Cambridge: Cambridge University Press, 1992), chap. 4, “Needs in Public Space.”

12. William H. Whyte, *The Social Life of Small Urban Spaces* (Washington, DC: Conservation Foundation, 1980).

13. Jan Gehl and Birgitte Svarre, *How to Study Public Life* (Washington, DC: Island Press, 2013).

14. Chenyang Zhang, Beixiang Shi, and Junyan Yang, “Simulation Study of Non-Traveling Pedestrian Traffic in High-Speed Railway Station Areas: A Case Study of the Yangtze River Delta,” *Frontiers of Architectural Research* 14 (2025): 714–725. Source. Accessed October 25, 2026.

15. Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan, “Michi-no-Eki (Roadside Stations),” programme launched 1993.

16. “Japan Expands Roadside Stations to Serve as Disaster Response Hubs,” *Japan News* (Yomiuri Shimbun), August 17, 2025: 1,230 stations, 79 designated as disaster-prevention roadside stations. Source. Accessed October 25, 2026.

17. Marco Segreto, Lucas Principe, Alexandra Desormeaux, Marco Torre, Laura Tomassetti, Patrizio Tratzi, Valerio Paolini, and Francesco Petracchini, “Trends in Social Acceptance of Renewable Energy Across Europe: A Literature Review,” *International Journal of Environmental Research and Public Health* 17, no. 24 (2020): 9161. Source. Accessed October 25, 2026.

18. Charles Jencks, *The Iconic Building* (New York: Rizzoli, 2005).

19. Guggenheim Museum Bilbao, “1,305,003 People Visited the Guggenheim Museum Bilbao in 2025,” press release. Source. Accessed October 25, 2026.

20. “Planta de energía CopenHill = CopenHill Power Plant, Copenhagen, Denmark: BIG Bjarke Ingels Group,” *Arquitectura Viva* 230 (2020); Bjarke Ingels Group, “CopenHill”: 41,000 m². Source. Accessed October 25, 2026.

21. VisitCopenhagen, “CopenHill”: the world’s highest climbing wall, 85 metres. Source. Accessed October 25, 2026.

22. Leslie Sklair, *The Icon Project: Architecture, Cities, and Capitalist Globalization* (New York: Oxford University Press, 2017). Source. Accessed October 25, 2026.

23. US Environmental Protection Agency, “Using Cool Pavements to Reduce Heat Islands.” Source. Accessed October 25, 2026.

24. US Environmental Protection Agency, “What Are Heat Islands?” Source. Accessed October 25, 2026.

25. Eran Ben-Joseph, *ReThinking a Lot: The Design and Culture of Parking* (Cambridge, MA: MIT Press, 2012). Source. Accessed October 25, 2026.

26. World Health Organization Regional Office for Europe, *Urban Green Spaces and Health: A Review of Evidence* (Copenhagen: WHO Europe, 2016). Source. Accessed October 25, 2026.

27. US Environmental Protection Agency, *Green Streets Handbook* (2021). See Chapter 2. Source. Accessed October 25, 2026.

28. Keller Easterling, *Extrastatecraft: The Power of Infrastructure Space* (London: Verso, 2014).

CHAPTER 04

Notes

1. Luca Bertolini, “Spatial Development Patterns and Public Transport: The Application of an Analytical Model in the Netherlands,” *Planning Practice & Research* 14, no. 2 (1999): 199–210. Source. Accessed October 25, 2026.

2. Carlos Moreno, Zaheer Allam, Didier Chabaud, Catherine Gall, and Florent Pratlong, “Introducing the ‘15-Minute City’: Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities,” *Smart Cities* 4, no. 1 (2021): 93–111. Source. Accessed October 25, 2026.

3. Paul Chorus and Luca Bertolini, “An Application of the Node-Place Model to Explore the Spatial Development Dynamics of Station Areas in Tokyo,” *Journal of Transport and Land Use* 4, no. 1 (2011): 45–58. Source. Accessed October 25, 2026.

4. Eurocities, “Bremen’s Fight for Car Sharing”: in 2003 Bremen launched the first on-street car-sharing stations in Germany, the mobil.punkt. Source. Accessed October 25, 2026.

5. Foster + Partners, “Launch of Crossrail Place Retail and Roof Garden, Canary Wharf” (2015); “Video: Building Foster + Partners’ Crossrail Place Roof Garden,” *Architects’ Journal*, on the 310-metre ETFE and timber lattice roof. Source. Accessed October 25, 2026.

6. Kevin Lynch, *What Time Is This Place?* (Cambridge, MA: MIT Press, 1972).

7. Henri Lefebvre, *Rhythmanalysis: Space, Time and Everyday Life*, trans. Stuart Elden and Gerald Moore (London: Continuum, 2004).

8. Jane Jacobs, *The Death and Life of Great American Cities* (New York: Random House, 1961), 35–54.

9. William H. Whyte, *The Social Life of Small Urban Spaces* (Washington, DC: Conservation Foundation, 1980); Jan Gehl and Birgitte Svarre, *How to Study Public Life* (Washington, DC: Island Press, 2013).

Bibliography

Akbari, Hashem, L. Shea Rose, and Haider Taha. “Analyzing the Land Cover of an Urban Environment Using High-Resolution Orthophotos.” *Landscape and Urban Planning* 63, no. 1 (2003): 1–14. https://heatisland.lbl.gov/publications/analyzing-land-cover-urban.

Aktuna, Can. “Experiential Charging Hubs as Tourism Micro-Destinations: A Mobilities-Oriented Netnography of Tesla’s Hollywood Diner–Supercharger.” *Mobilities* (2026): 1–18.

Allen, Stan. “Infrastructural Urbanism.” In *Points + Lines: Diagrams and Projects for the City*, 46–57. New York: Princeton Architectural Press, 1999.

Anderson, Anne-Marie, and Richard J. Kish. “The Costs and Benefits of Electric Trucks: A Synopsis of the U.S. Trucking Market.” *Sustainability* 17, no. 5 (2025): 2097.

“At Singapore’s Changi Airport, a New Jewel Shines.” *New York Times*, April 11, 2019. https://www.nytimes.com/2019/04/11/travel/singapores-changi-airport-jewel.html.

Augé, Marc. *Non-Places: Introduction to an Anthropology of Supermodernity*. Translated by John Howe. London: Verso, 1995.

Ben-Joseph, Eran. *ReThinking a Lot: The Design and Culture of Parking*. Cambridge, MA: MIT Press, 2012.

Bertolini, Luca. “Spatial Development Patterns and Public Transport: The Application of an Analytical Model in the Netherlands.” *Planning Practice & Research* 14, no. 2 (1999): 199–210. https://doi.org/10.1080/02697459915724.

Bjarke Ingels Group (BIG). “CopenHill.” https://big.dk/projects/copenhill-2391.

Carr, Stephen, Mark Francis, Leanne G. Rivlin, and Andrew M. Stone. *Public Space*. Cambridge: Cambridge University Press, 1992.

Chester, Mikhail, Andrew Fraser, Juan Matute, Carolyn Flower, and Ram Pendyala. “Parking Infrastructure: A Constraint on or Opportunity for Urban Redevelopment? A Study of Los Angeles County Parking Supply and Growth.” *Journal of the American Planning Association* 81, no. 4 (2015): 268–286. https://www.tandfonline.com/doi/abs/10.1080/01944363.2015.1092879.

Chester, Mikhail, Arpad Horvath, and Samer Madanat. “Parking Infrastructure: Energy, Emissions, and Automobile Life-Cycle Environmental Accounting.” *Environmental Research Letters* 5, no. 3 (2010): 034001. https://iopscience.iop.org/article/10.1088/1748-9326/5/3/034001.

Chorus, Paul, and Luca Bertolini. “An Application of the Node-Place Model to Explore the Spatial Development Dynamics of Station Areas in Tokyo.” *Journal of Transport and Land Use* 4, no. 1 (2011): 45–58. https://doi.org/10.5198/jtlu.v4i1.145.

Duah, Nana, Steven Jiang, Om Prakash Yadav, Hieu Trung Nguyen, and Nastasha Earle-Young. “Navigating the Truck Parking Challenge: A Comprehensive Review of Strategies, Emerging Technologies, and Future Directions.” *Transportation Research Interdisciplinary Perspectives* 34 (2025): 101740.

Easterling, Keller. *Extrastatecraft: The Power of Infrastructure Space*. London: Verso, 2014.

Elvidge, Christopher D., et al. “U.S. Constructed Area Approaches the Size of Ohio.” *Eos, Transactions of the American Geophysical Union* 85, no. 24 (2004): 233–234. https://journalistsresource.org/wp-content/uploads/2012/11/Elvidge_EOS.pdf.

Encyclopaedia Iranica. “Caravansary.” https://www.iranicaonline.org/articles/caravansary/.

Eurocities. “Bremen’s Fight for Car Sharing.” https://eurocities.eu/stories/bremens-fight-for-car-sharing/.

European Parliament and Council of the European Union. Regulation (EC) No 561/2006 on the harmonisation of certain social legislation relating to road transport. *Official Journal of the European Union* L 102 (2006).

Federal Highway Administration. “National Electric Vehicle Infrastructure Standards and Requirements.” 23 C.F.R. pt. 680 (2023).

Foster + Partners. “Launch of Crossrail Place Retail and Roof Garden, Canary Wharf.” 2015. https://www.fosterandpartners.com/news/launch-of-crossrail-place-retail-and-roof-garden-canary-wharf.

Gehl, Jan, and Birgitte Svarre. *How to Study Public Life*. Washington, DC: Island Press, 2013.

Grand Central Terminal. “Shop & Dine.” https://grandcentralterminal.com/shop-and-dine/.

GRIDSERVE. “GRIDSERVE Opens UK’s First Electric Forecourt.” December 2020. https://www.gridserve.com/gridserve-opens-uks-first-electric-forecourt/.

Guggenheim Museum Bilbao. “1,305,003 People Visited the Guggenheim Museum Bilbao in 2025.” Press release. https://www.guggenheim-bilbao.eus/en/press-room/press-releases/1305003-people-visited-the-guggenheim-museum-bilbao-in-2025.

Heinz History Center. “Was the World’s First Gas Station in Pittsburgh? It’s Complicated.” Blog. https://www.heinzhistorycenter.org/blog/was-the-worlds-first-gas-station-in-pittsburgh-its-complicated/.

Holland, Stephen P., Erin T. Mansur, Nicholas Z. Muller, and Andrew J. Yates. “Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors.” *American Economic Review* 106, no. 12 (2016): 3700–3729.

International Energy Agency. *Global EV Outlook 2025*. Paris: IEA, 2025.

International Energy Agency. *Global EV Outlook 2026*. Paris: IEA, 2026.

Jacobs, Jane. *The Death and Life of Great American Cities*. New York: Random House, 1961.

Jakle, John A., and Keith A. Sculle. *The Gas Station in America*. Baltimore: Johns Hopkins University Press, 1994.

“Japan Expands Roadside Stations to Serve as Disaster Response Hubs.” *Japan News* (Yomiuri Shimbun), August 17, 2025. https://japannews.yomiuri.co.jp/original/perspectives/20250817-275283/.

Jencks, Charles. *The Iconic Building*. New York: Rizzoli, 2005.

Jewel Changi Airport. “Rain Vortex.” https://www.jewelchangiairport.com/en/attractions/rain-vortex.html.

Joint Office of Energy and Transportation. “Battery Energy Storage for Electric Vehicle Charging Stations.” Help sheet. https://driveelectric.gov/files/battery-buffered-help-sheet.pdf.

Kasarda, John D. “Welcome to Aerotropolis, the City of the Future.” *New Perspectives Quarterly* 32, no. 3 (2015).

Kayden, Jerold S., New York City Department of City Planning, and Municipal Art Society of New York. *Privately Owned Public Space: The New York City Experience*. New York: John Wiley & Sons, 2000.

Klinenberg, Eric. *Heat Wave: A Social Autopsy of Disaster in Chicago*. Chicago: University of Chicago Press, 2002.

Klinenberg, Eric. *Palaces for the People: How Social Infrastructure Can Help Fight Inequality, Polarization, and the Decline of Civic Life*. New York: Crown, 2018.

Lefebvre, Henri. *Rhythmanalysis: Space, Time and Everyday Life*. Translated by Stuart Elden and Gerald Moore. London: Continuum, 2004.

Lynch, Kevin. *What Time Is This Place?* Cambridge, MA: MIT Press, 1972.

Meeks, Carroll L. V. *The Railroad Station: An Architectural History*. New Haven: Yale University Press, 1956.

Merriman, Peter. “Driving Places: Marc Augé, Non-places, and the Geographies of England’s M1 Motorway.” *Theory, Culture & Society* 21, no. 4/5 (2004): 145–167. https://doi.org/10.1177/0263276404046065.

Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan. “Michi-no-Eki (Roadside Stations).” Programme launched 1993.

Moreno, Carlos, Zaheer Allam, Didier Chabaud, Catherine Gall, and Florent Pratlong. “Introducing the ‘15-Minute City’: Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities.” *Smart Cities* 4, no. 1 (2021): 93–111.

National Renewable Energy Laboratory. “The Dawn of Electric Trucking Calls for High-Power Charging.” Feature, 2025. https://www.nlr.gov/news/feature/2025/the-dawn-of-electric-trucking-calls-for-high-power-charging.

National Trust. Heritage Records. “The George Inn, No. 77 Borough High Street, Southwark.” Record MNA147890. https://heritagerecords.nationaltrust.org.uk/HBSMR/MonRecord.aspx?uid=MNA147890.

New York City Department of Transportation. “NYC DOT Launches Expansion of Curbside Electric Vehicle Charging Across Five Boroughs, Solicits Public Feedback on Locations.” Press release, August 4, 2026. https://www.nyc.gov/html/dot/html/pr2026/expansion-of-curbside-electric-vehicle-charging.shtml.

NIO. “NIO Achieves 100 Million Battery Swaps.” Press release, February 6, 2026. https://www.nio.com/news/20260206001.

Office of the US Surgeon General. *Our Epidemic of Loneliness and Isolation*. Washington, DC: HHS, 2023. https://www.hhs.gov/sites/default/files/surgeon-general-social-connection-advisory.pdf.

Oldenburg, Ray. *The Great Good Place*. New York: Paragon House, 1989.

Paren. *U.S. EV Fast Charging 2025 Report*. 2026. https://www.paren.app/reports/state-of-the-industry-report-us-ev-fast-charging-full-year-2025.

“Planta de energía CopenHill = CopenHill Power Plant, Copenhagen, Denmark: BIG Bjarke Ingels Group.” *Arquitectura Viva* 230 (2020).

Reuters. “BYD Unveils New Super-Charging EV Tech, to Build Charging Network in China.” March 17, 2025.

SAE International. *SAE J3271: Megawatt Charging System for Electric Vehicles*. Technical Information Report, March 2025.

Scharnhorst, Eric. *Quantified Parking: Comprehensive Parking Inventories for Five U.S. Cities*. Washington, DC: Research Institute for Housing America, Mortgage Bankers Association, 2018. https://www.mba.org/docs/default-source/research---riha-reports/18806-research-riha-parking-report.pdf.

Segreto, Marco, Lucas Principe, Alexandra Desormeaux, Marco Torre, Laura Tomassetti, Patrizio Tratzi, Valerio Paolini, and Francesco Petracchini. “Trends in Social Acceptance of Renewable Energy Across Europe: A Literature Review.” *International Journal of Environmental Research and Public Health* 17, no. 24 (2020): 9161. https://doi.org/10.3390/ijerph17249161.

Shoup, Donald. *The High Cost of Free Parking*. Chicago: Planners Press, 2005.

Sklair, Leslie. *The Icon Project: Architecture, Cities, and Capitalist Globalization*. New York: Oxford University Press, 2017. https://doi.org/10.1093/oso/9780190464189.001.0001.

TWA Hotel. “Overview.” https://www.twahotel.com/hotel.

U.S. Department of Energy, Alternative Fuels Data Center. “Developing Infrastructure to Charge Electric Vehicles.” https://afdc.energy.gov/fuels/electricity-infrastructure.

U.S. Department of Energy, Alternative Fuels Data Center. “Electric Vehicle Charging Infrastructure Trends.” https://afdc.energy.gov/fuels/electricity-infrastructure-trends.

U.S. Department of Energy, Alternative Fuels Data Center. Station Locator inventory, 18 October 2026. https://afdc.energy.gov/stations.

U.S. Department of Energy, Vehicle Technologies Office. “Fact of the Week #1360: A Typical EV Is 87%–91% Efficient Compared to 30% for a Conventional Gasoline Vehicle.” September 16, 2024.

U.S. Energy Information Administration. *Annual Energy Outlook 2025: Electric Power and Transport Projections*. Washington, DC: EIA, 2025.

U.S. Environmental Protection Agency. *Fast Facts on Transportation Greenhouse Gas Emissions, Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2023*. Washington, DC: EPA, 2024.

U.S. Environmental Protection Agency. “Using Cool Pavements to Reduce Heat Islands.” https://www.epa.gov/heatislands/using-cool-pavements-reduce-heat-islands.

U.S. Environmental Protection Agency. “What Are Heat Islands?” https://www.epa.gov/heatislands/what-are-heat-islands.

U.S. Federal Motor Carrier Safety Administration. Maximum Driving Time for Property-Carrying Vehicles. 49 C.F.R. § 395.3.

Vieyra, Daniel I. *“Fill ’er Up”: An Architectural History of America’s Gas Stations*. New York: Macmillan, 1979.

VisitCopenhagen. “CopenHill.” https://www.visitcopenhagen.com/copenhagen/planning/copenhill-gdk1088237.

Whyte, William H. *The Social Life of Small Urban Spaces*. Washington, DC: Conservation Foundation, 1980.

Wicki, Michael, Gracia Brückmann, Franziska Quoss, and Thomas Bernauer. “What Do We Really Know about the Acceptance of Battery Electric Vehicles? – Turns Out, Not Much.” *Transport Reviews* 43, no. 1 (2023): 62–87.

World Commission on Environment and Development. *Our Common Future*. Oxford: Oxford University Press, 1987.

World Health Organization Regional Office for Europe. *Urban Green Spaces and Health: A Review of Evidence*. Copenhagen: WHO Europe, 2016. https://www.who.int/europe/publications/i/item/WHO-EURO-2016-3352-43111-60341.

Xu, Leiqing, Dancheng Meng, Shin Bin Tan, Jiahua Li, et al. “Neurological Benefits of Third Places for Young Adults in Healthy Urban Environments.” *Frontiers of Architectural Research* 14, no. 5 (2025). https://doi.org/10.1016/j.foar.2025.01.008.

US Department of Energy, Alternative Fuels Data Center, “Electric Vehicle Charging Stations.” https://afdc.energy.gov/fuels/electricity-stations.

US Department of Energy, Alternative Fuels Data Center, “Charging Electric Vehicles in Public.” https://afdc.energy.gov/fuels/electricity-charging-public.

US Environmental Protection Agency, *Green Streets Handbook* (2021). https://www.epa.gov/nps/green-streets-handbook.

US Access Board, “Design Recommendations for Accessible Electric Vehicle Charging Stations,” updated July 17, 2023. Technical assistance; distinguish recommendations from applicable ADA/ABA requirements. https://www.access-board.gov/tad/ev/.

International Energy Agency, “Electric Vehicle Charging,” in *Global EV Outlook 2026* (Paris: IEA, 2026). https://www.iea.org/reports/global-ev-outlook-2026/electric-vehicle-charging-chap-6-and-10.

US Department of Transportation, “Charger Types and Speeds,” *Charging Forward: A Toolkit for Planning and Funding Rural Electric Mobility Infrastructure*. https://www.transportation.gov/rural/ev/toolkit/ev-basics/charging-speeds.

US Department of Energy, “EVGrid Assist: Charts and Figures,” reporting the 2023 NREL 2030 National Charging Network study. Conditional scenario for 33 million light-duty EVs; not a current forecast. https://www.energy.gov/cmei/vehicles/evgrid-assist-charts-and-figures.

Science and Industry Museum, *Revolution Manchester: Move*, large-print guide (2023), Liverpool Road Station, 1830. https://www.scienceandindustrymuseum.org.uk/sites/default/files/2023-07/2703_REV_MAN_Move-LPG_DIGITAL_AW-compressed.pdf.

Grand Central Terminal, “About,” opening date February 2, 1913. https://grandcentralterminal.com/about/.

Pennsylvania Turnpike Commission, “Turnpike History” and service-plaza historical account, 1940. https://www.paturnpike.com/about-us/turnpike-history.

Bosch eBike Systems, “4 A Standard Charger EU (BCS220),” PowerTube 500 charging time, approximately 4.5 hours. https://shop.bosch-ebike.com/de/EUR/_4_a_standard_charger_eu_%28bcs220%29/p/2100068.

Zero Motorcycles, *2020 Zero SR/F Owner’s Manual*, ZF14.4 charging guidance. Historical model example. https://media.zeromotorcycles.com/resources/owners-manuals/2020/2020-Zero-Owners-Manual-SRF.pdf.

Ford Pro, “New Extended Range E-Transit,” April 23, 2024, 89 kWh usable battery. https://www.fordpresse.be/content/documents/news/2024/2024_04_23_e_transit_4p_en.pdf.

New Flyer, “Xcelsior CHARGE NG,” vehicle and charging specifications, 660 kWh example. https://www.newflyer.com/bus/xcelsior-charge-ng/.

Volvo Trucks, “Volvo Trucks Launches Electric Truck with Longer Range,” January 14, 2022, VNR Electric, 565 kWh example. https://www.volvotrucks.com/en-en/news-stories/press-releases/2022/jan/volvo-trucks-launches-electric-truck-with-longer-range.html.

International Energy Agency, “Outlook for Electric Mobility,” *Global EV Outlook 2026*, Current Policies Scenario. https://www.iea.org/reports/global-ev-outlook-2026/outlook-for-electric-mobility-chap-9-11.

Federal Motor Carrier Safety Administration, “Summary of Hours of Service Regulations,”

property-carrying drivers; 49 C.F.R. § 395.3. https://www.fmcsa.dot.gov/regulations/hours-service/summary-hours-service-regulations.

European Commission, “Driving Time and Rest Periods,” summarising Regulation (EC) No 561/2006, as amended. https://transport.ec.europa.eu/transport-modes/road/social-provisions/driving-time-and-rest-periods_en.

National Electric Vehicle Infrastructure Standards and Requirements, 23 C.F.R. § 680.106(b), (d), (e). Read within the applicability of Part 680. https://www.ecfr.gov/current/title-23/chapter-I/subchapter-G/part-680/section-680.106.

National Electric Vehicle Infrastructure Standards and Requirements, 23 C.F.R. § 680.116(b), minimum annual uptime greater than 97 percent, subject to the regulation’s calculation. https://www.ecfr.gov/current/title-23/chapter-I/subchapter-G/part-680/section-680.116.

New York City Department of City Planning, “City of Yes for Carbon Neutrality (N 230113 ZRY),” adopted December 6, 2023. An example of zoning reform, not confirmation of a thesis site or individual project approval. https://zoningresolution.planning.nyc.gov/recently-adopted/city-yes-carbon-neutrality-n-230113-zry.

US Department of Energy, Federal Energy Management Program, “Smart Charge Management Implementation for Federal Fleets.” https://www.energy.gov/cmei/femp/smart-charge-management-implementation-federal-fleets.

Zhang, Chenyang, Beixiang Shi, and Junyan Yang. “Simulation Study of Non-Traveling Pedestrian Traffic in High-Speed Railway Station Areas: A Case Study of the Yangtze River Delta.” *Frontiers of Architectural Research* 14 (2025): 714–725. https://doi.org/10.1016/j.foar.2024.09.006.