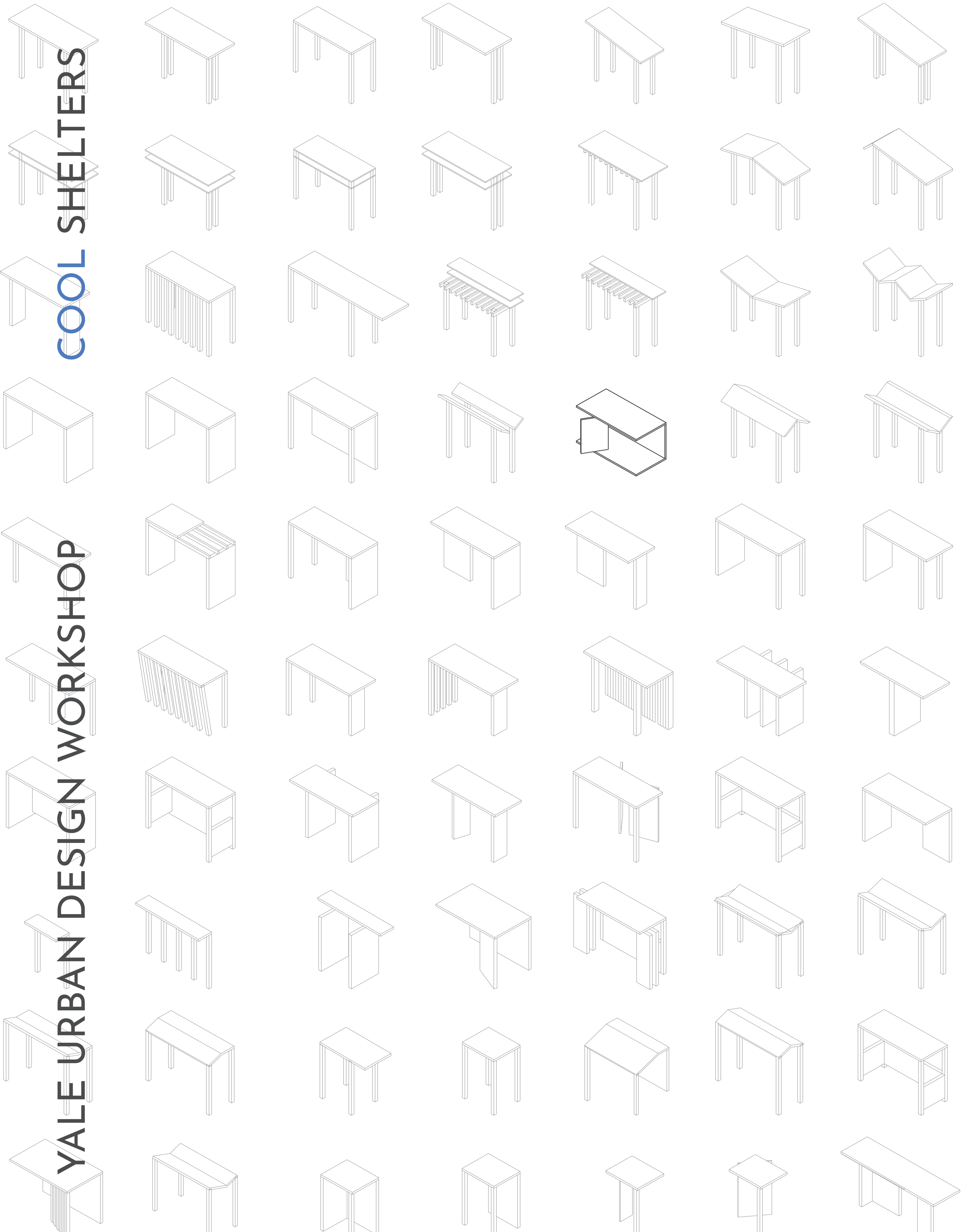

COOL SHELTERS

YALE URBAN DESIGN WORKSHOP

Yale Urban Design Workshop
Yale School of Architecture
P.O. Box 208242
New Haven, CT 06520
udw.yale.edu

COOL SHELTERS

Yale Urban Design Workshop

With support provided by

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YALE URBAN DESIGN WORKSHOP
Center for Urban Design Research
delivery hours: 9:00 am - 5:00 pm, M-F
udw.architecture.yale.edu

About the Project

The Yale Urban Design Workshop is a community design center based at the Yale School of Architecture, providing urban design assistance to communities in Connecticut, New England, and beyond.

Cool Shelters emerged from the Workshop as a year-long interdisciplinary project investigating how transit shelters can be reimagined as climate-adaptive public infrastructure in response to extreme heat. Supported by the Yale Planetary Solutions Impact! Grant, this book synthesizes the team's research, conversations, and design work over the course of the year.

Meet the Team

Amelia Lee *(Yale College '26, B.S. Environmental Studies)is an environmentalist and urbanist passionate about making cities more sustainable, vibrant, and just. Her academic and professional work spans environmental science and policy, urban planning, and transportation advocacy. In Summer 2025, she conducted neighborhood pre-planning research with the Yale Urban Design Workshop.*

Luke Louchheim *(Yale College '27, B.A. Architecture)is a student with professional experience in design and preservation, having worked at architectural practices in Argentina and New York. His academic focus centers on public-facing architecture that produces civic engagement and meaningful interactions between people and place.*

Meghana Ramesh *(Yale School of Architecture '26, M.Arch II) is a licensed architect in India with a Bachelor of Architecture. Her academic work and master's research explore spatial agency and the public use of urban space, with particular attention to how urban infrastructure can support diverse civic life.*

Shannon Lee *(Yale School of the Environment '27, M.E.M.) holds a B.A. in Environmental Policy and Economics from UC San Diego. Before beginning her graduate studies in urban climate resilience, she worked in the waste management industry across both private and public-sector contexts.*

Faculty Advisors

Andrei Harwell, AIA *is an architect, urban designer, Senior Critic at the Yale School of Architecture, and Executive Director of the Yale Urban Design Workshop. His work focuses on the role of architecture and urban design in addressing challenges facing cities, towns, and regions.*

Aicha Woods *is the Urban Program Manager at the Yale School of the Environment. Her work spans urban planning, housing affordability, and climate resilience, drawing on experience across public, nonprofit, and private-sector contexts.*

Matthew Rosen *is an architect, founder of Twenty Three Calvin, instructor at the Yale School of Architecture, and Assistant Director of the Yale Urban Design Workshop. His work explores architecture's aesthetic, methodological, and ethical dimensions, with attention to lived and subjective experience.*

Alan Organschi *is a principal and partner at Gray Organschi Architecture, Professor in the Practice at the Yale School of Architecture, and Director of the Yale Building Lab. His work focuses on biogenic materials, carbon storage, and circular economic strategies in urban building.*


ride.
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transit
LEGEND

Cool Shelters is a mass timber climate-adaptive public transportation shelter, aiming to reclaim urban spaces for people and the planet.

We see public infrastructure as an essential means to create thoughtful interventions. Intended to replace a parking space, the reimagined bus stop departs from the car-centric nature of cities in favor of pedestrians and public transportation. Through research into existing systems of design, material selection, procurement, installation, and maintenance in Connecticut, with a focus on New Haven, the project establishes a practical design framework and proof-of-concept shelter that integrates heat mitigation, sustainably sourced materials, and place-based adaptation within real public infrastructure constraints.

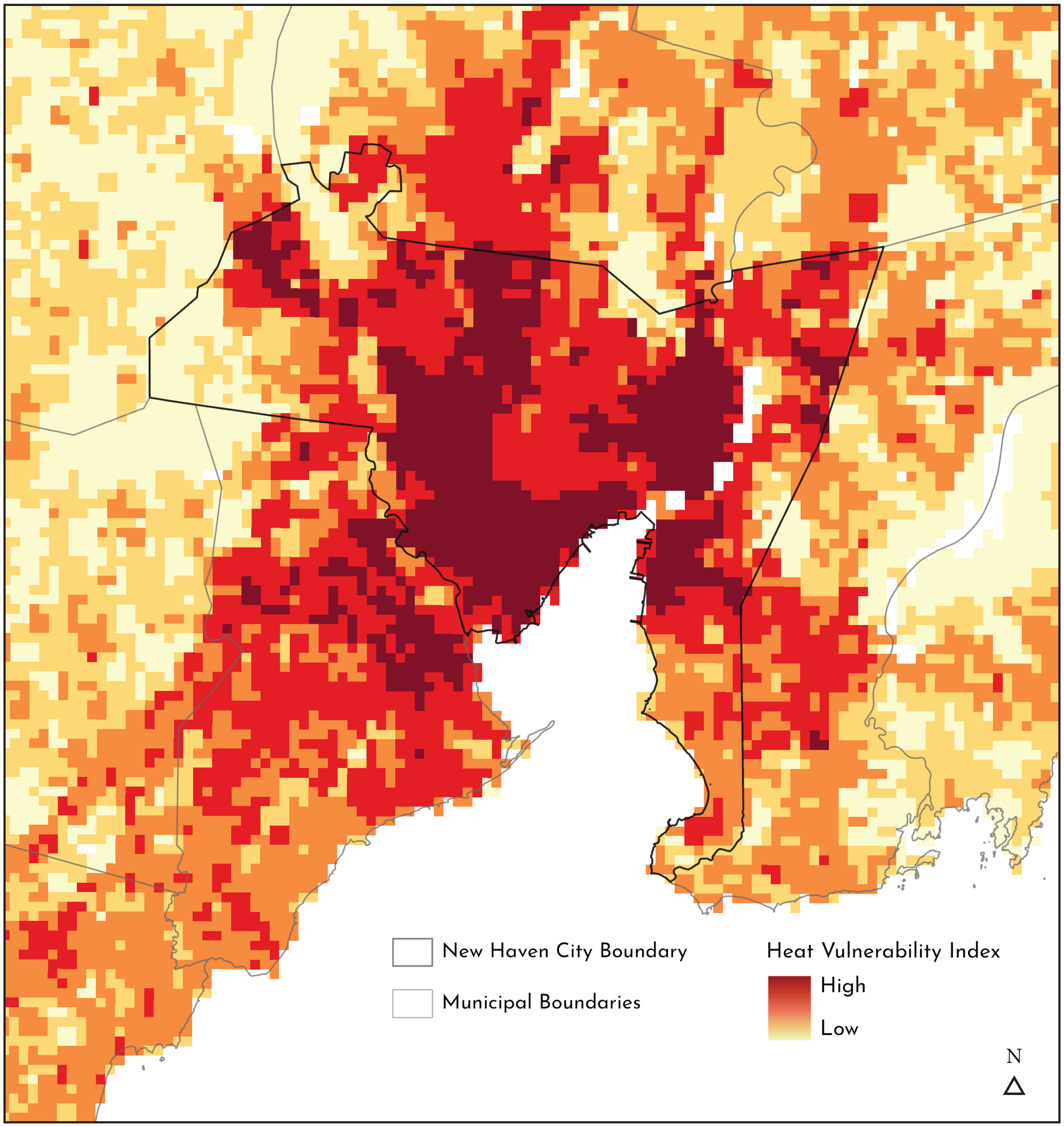
Contents


BUS STOP
ROUTE
O
DOWNTOWN
WINCHESTER AVE - NEWBURY ST
DAILY — DAYTIME & EVENING
COMMUTER
CONNECTION
CT TRANSIT
SUBWAY

Defining the Problem

Extreme heat is increasingly shaping public health and daily mobility in cities, yet the transit infrastructure many residents depend on remains poorly equipped to provide protection from heat exposure. Bus stops represent a critical but overlooked site of climate vulnerability within the public realm.

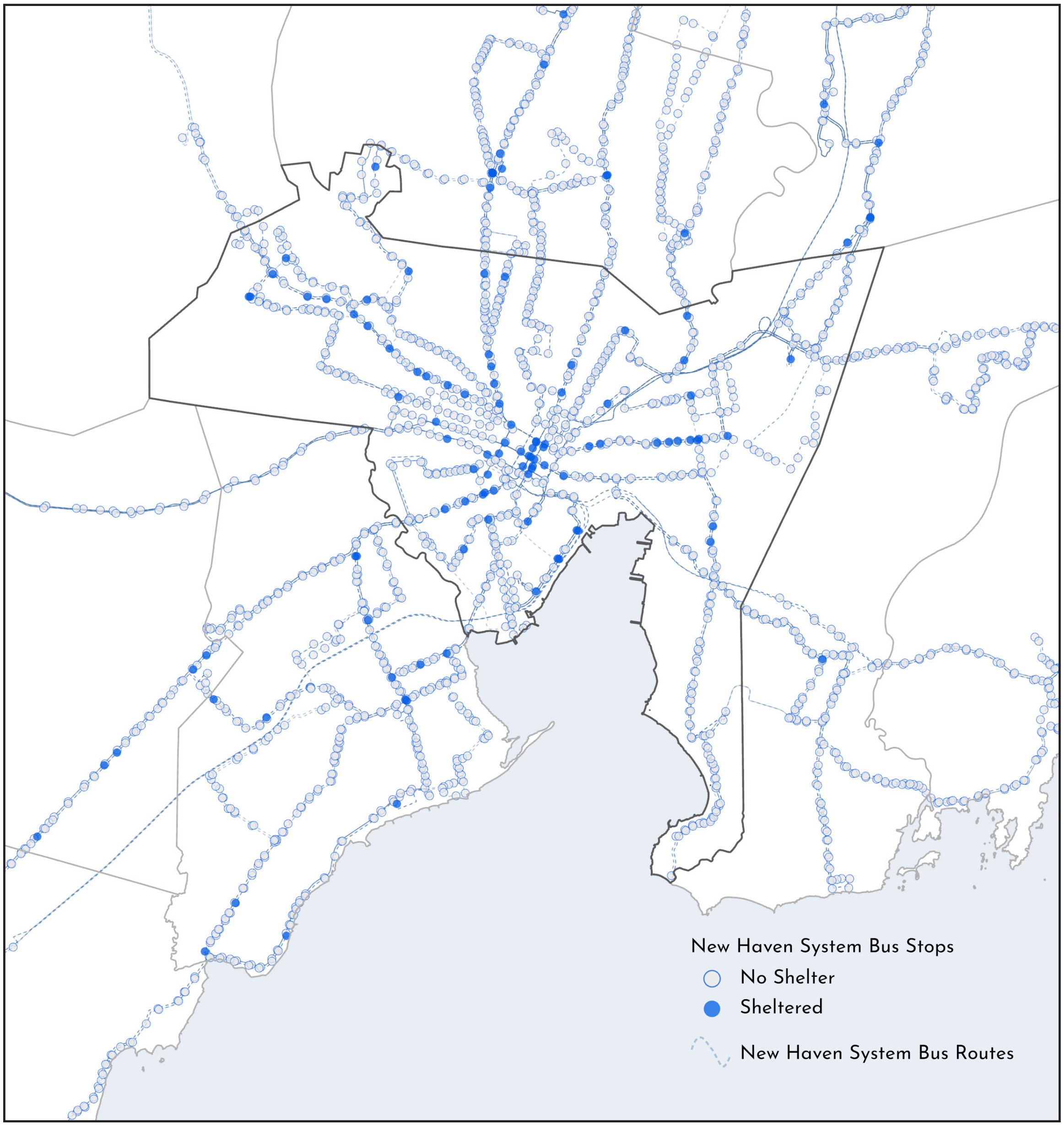
New Haven Heat Vulnerability Map



Heat stress is among the most urgent public health consequences of climate change, with even a 1°F temperature increase associated with a 2.5% rise in mortality risk (Anderson & Bell, 2011). These impacts fall disproportionately on low-income communities and communities of color, where historic disinvestment and environmental inequities compound vulnerability.

In New Haven, Connecticut's Heat Vulnerability Index identifies low-income neighborhoods in the urban core as especially vulnerable, where limited tree canopy and extensive impervious surfaces intensify heat exposure (CIRCA, 2021).

New Haven Bus Network & Shelters



These same heat vulnerable areas are among the city's most transit-dependent, yet shelter infrastructure remains scarce. New Haven's busiest transit corridors overlap substantially with its hottest and most vulnerable neighborhoods, where riders often wait 30 to 45 minutes with little protection from the elements.

Nearly 30% of New Haven households do not own a vehicle, with car-free rates exceeding 50% in some neighborhoods near downtown (US Census Bureau). Despite a reliance on public transportation, only 78 of 891 bus stops in the city (9%) are sheltered, leaving most riders exposed to heat and precipitation while waiting.

Maps synthesized from heat vulnerability data (CIRCA, 2026) and bus stop data (CTDOT, 2025),

Existing Infrastructure Fails Riders

Existing bus stop conditions across New Haven reveal recurring deficiencies in thermal comfort, accessibility, maintenance, and rider amenities.

No shelter

Guerilla bench

No bench

Unmaintained interior

Minimal shade

Ineffective shade

Broken polycarbonate

Structural damage

The Aluminum Shelter, Reconsidered

In 1964, JCDecaux transformed public transit infrastructure with a deceptively simple insight: a sleek aluminum bus shelter, engineered for durability and sized for advertising panels, could be provided to cities at minimal cost to taxpayers (JCDecaux, 2021). Sixty years later, that insight continues to define how bus shelters are built and procured across much of the country and beyond.

Connecticut is no exception. The 2025 Bus Stop Enhancement Program (BSEP) continues this model through state-led procurement of pre-approved shelter systems designed for rapid deployment across the CTtransit network (CTDOT, 2026).

While this approach efficiently expands shelter coverage, it prioritizes ridership thresholds, ADA compliance, and cost over environmental performance. Thermal comfort and heat mitigation remain absent from most formal shelter siting and design criteria.

Rather than accept the bus shelter as a fixed typology, this project asks how transit infrastructure might be redesigned for the climatic realities of contemporary cities.

Where BSEP prioritizes ridership demand, our work prioritizes a different variable: heat vulnerability. In communities already burdened by urban heat island effects and limited access to cooling, bus stops represent both a point of concentrated exposure and an opportunity for targeted intervention. In this sense, the bus shelter can function not merely as transit infrastructure, but as distributed climate infrastructure embedded directly into the public realm.

Design Framework

Our bus shelter design aims to fulfill three primary goals: **heat mitigation, sustainable sourcing, and place-based adaptation**. Driven by our interdisciplinary backgrounds, each goal emerged from a key insight about what equitable, climate responsive infrastructure requires in practice and is explored through a set of interconnected design parameters.

HEAT MITIGATION

Context-specific strategies that deliver thermal comfort in real conditions.

informs material performance and durability

SUSTAINABLE SOURCING

Low-carbon, durable, simple systems that reduce impact across the entire life cycle.

bioregional supply chain, using local materials and manufacturers

MATERIAL RESEARCH

- Engineered Timber (Mass Timber, including CLT, GLT, etc.)
- Aluminum (incl. Perforated)
- Polycarbonate
- Glass
- Recycled materials
- Coatings

structure informs material use

STRUCTURE

- Cantilever
- Slope
- Shear of walls
- Wind resistance

ACTIVE COOLING

Powered/mechanical systems: fans, pumps, misting systems, evaporative "swamp" cooling, sensors, solar-powered controls.

MATERIAL CRITERIA

- Low embodied carbon
- Structurally sound
- Low thermal conductivity
- Reparable, recyclable
- Simple assembly and joinery
- One primary material wherever possible

generous overhangs for shade

PASSIVE COOLING

Low-energy design strategies that reduce heat gain and improve comfort through form, material, shade, and airflow.

CLT panels provide ample valuable wall space for customization

VARIABLES

CLIMATE

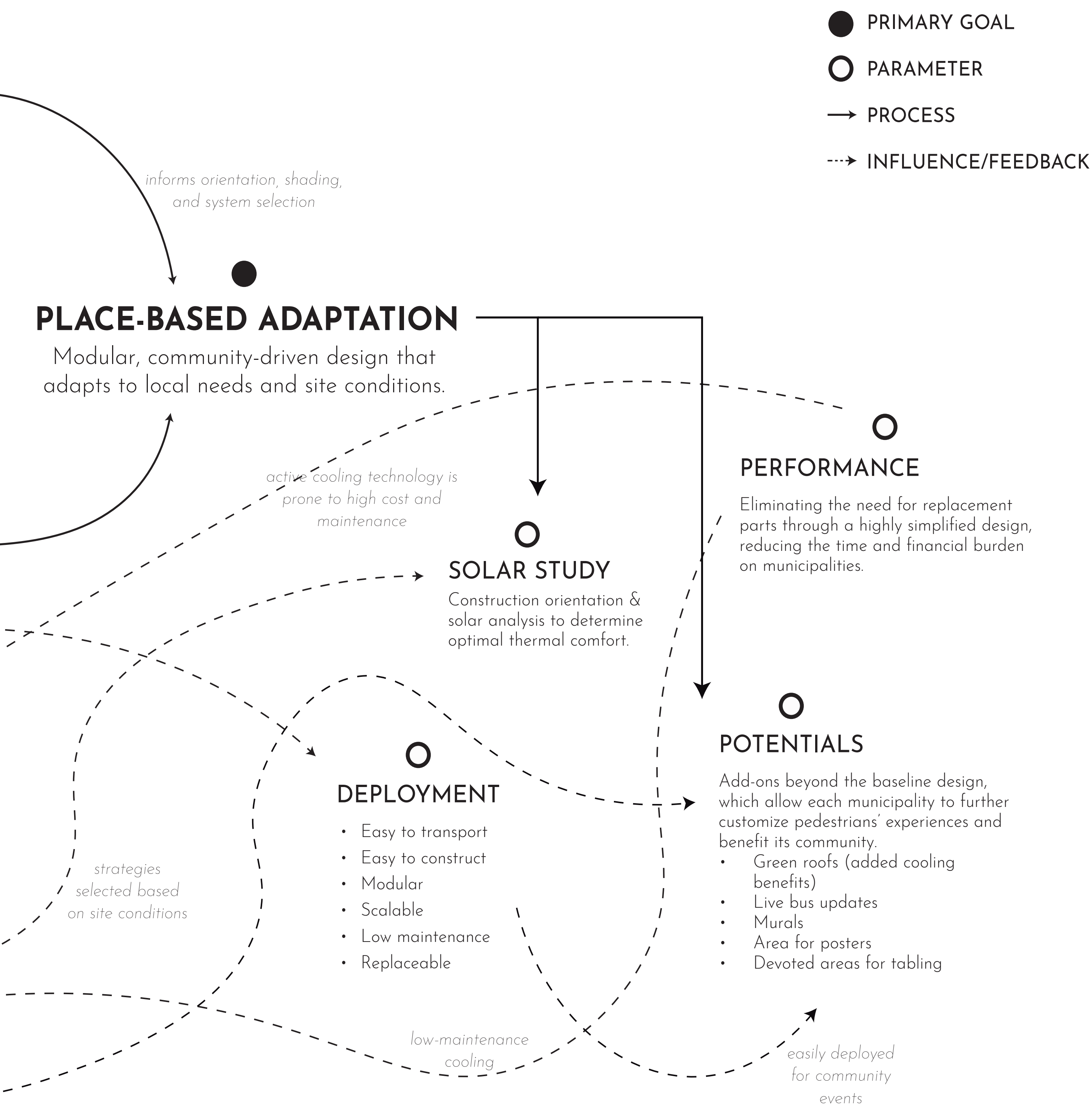
- Temperature
- Humidity
- Sun angle & exposure
- Wind

SITE

- Urbanity
- Surrounding buildings, trees, and other forms

COMMUNITY

- Cultural context
- Demographics
- Safety & access
- Local identity



INDUSTRY

- Proximity to manufacturers
- Scalability
- SKU index
- Replacability
- Supply

POLICY

- Building code
- Transit design gidelines
- Funding prioritization
- Resilience goals
- Local policy

RIDERSHIP

- Accessibility
- Safety
- Use levels
- Wait times
- Transit node

Key Insights

Heat mitigation is context-specific.

Effective cooling cannot be designed in the abstract—it must respond to local climate conditions. New Haven's temperate summers are characterized by high humidity, which renders evaporative cooling ineffective, and by variable wind patterns that make passive ventilation an unreliable strategy. These constraints pushed our team toward cooling approaches that perform consistently regardless of wind direction or moisture content in the air, rather than systems that work well only under ideal conditions.

Sustainable sourcing relies on both material and method.

The carbon footprint of any structure accumulates across the full lifecycle of its materials—from extraction and manufacturing through construction, maintenance, and eventual end-of-life disposal or reuse. Simplicity of design reinforces this commitment: a shelter built from essentially one material is easier to maintain, repair, and recover at end of life, avoiding the complications that arise from composite or mixed-material assemblies. Together, material choice and design restraint ensure that our shelter's environmental responsibility does not stop at the point of production, but extends across the entire life of the structure.

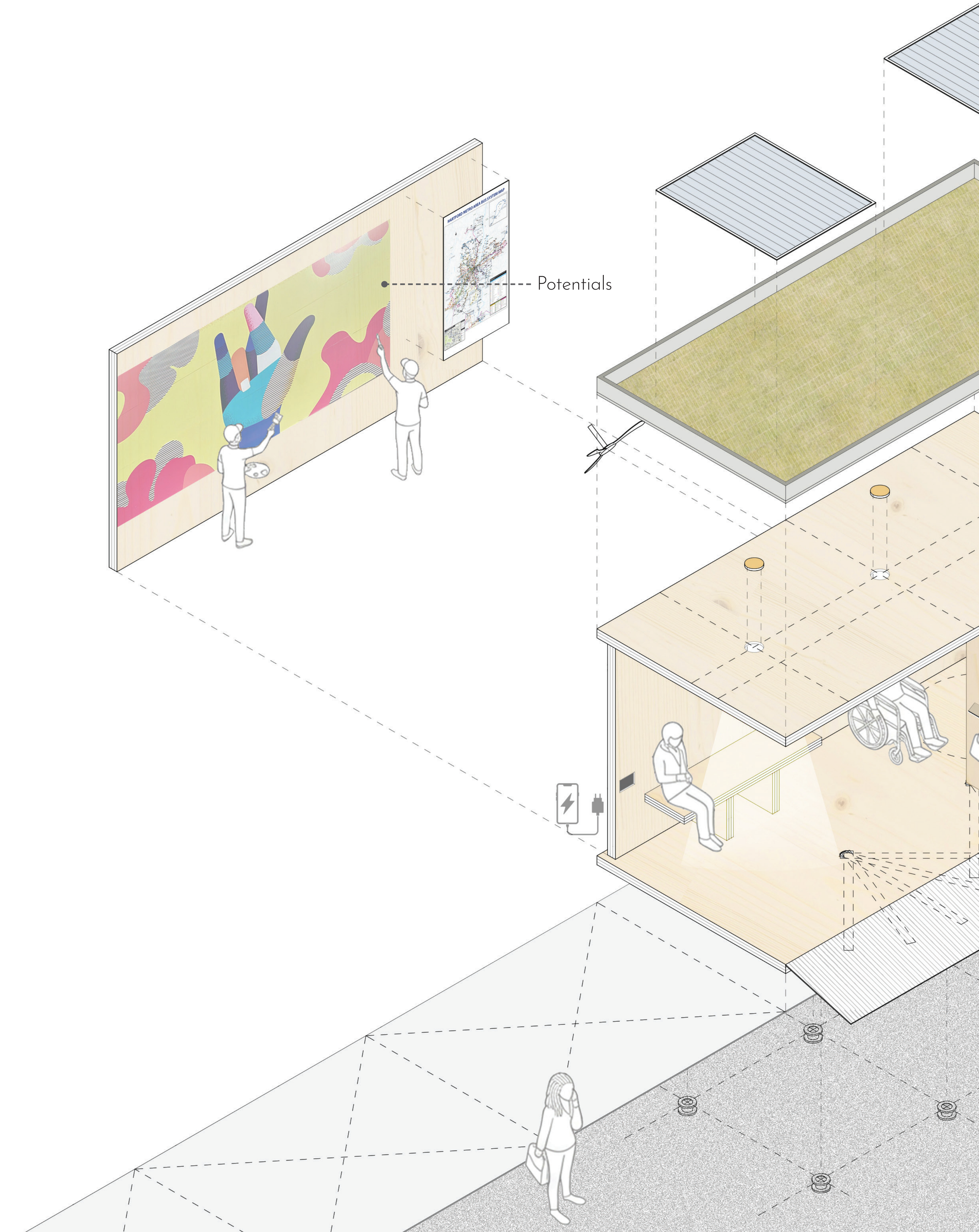
Place-based adaptation transforms generic infrastructure into placemaking.

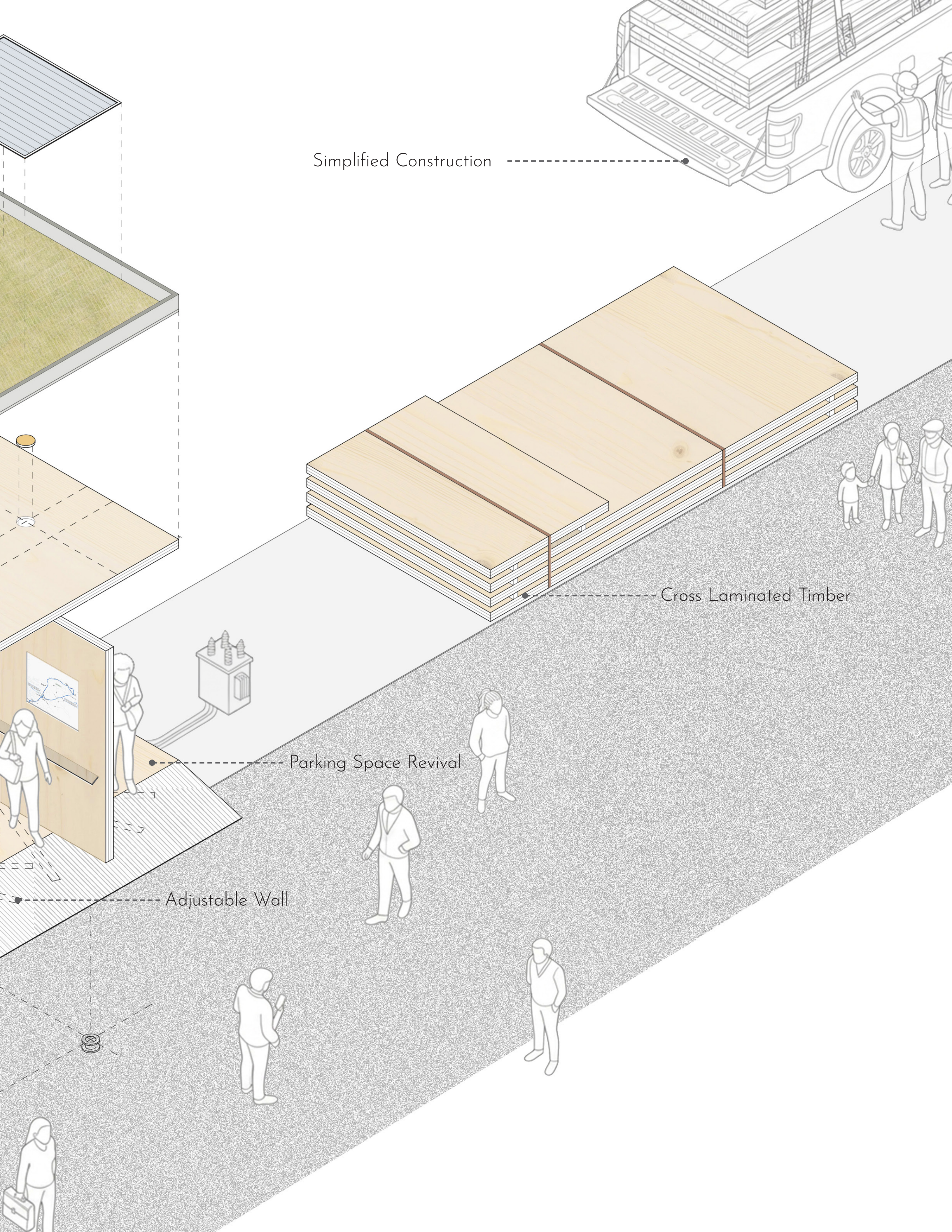
No two neighborhoods are alike, and a shelter designed as a rigid, one-size-fits-all object will inevitably serve some communities better than others. Our design prioritizes modularity, with a baseline design that is adaptable upon installation to more closely fulfill user needs. Customizations further allow local communities to select additional elements that reflect their preferences.


MINUTES
14 & 42
14 & 42
14 & 42
14 & 42
4 & 42
4 & 42
4 & 42
2:22

The Design

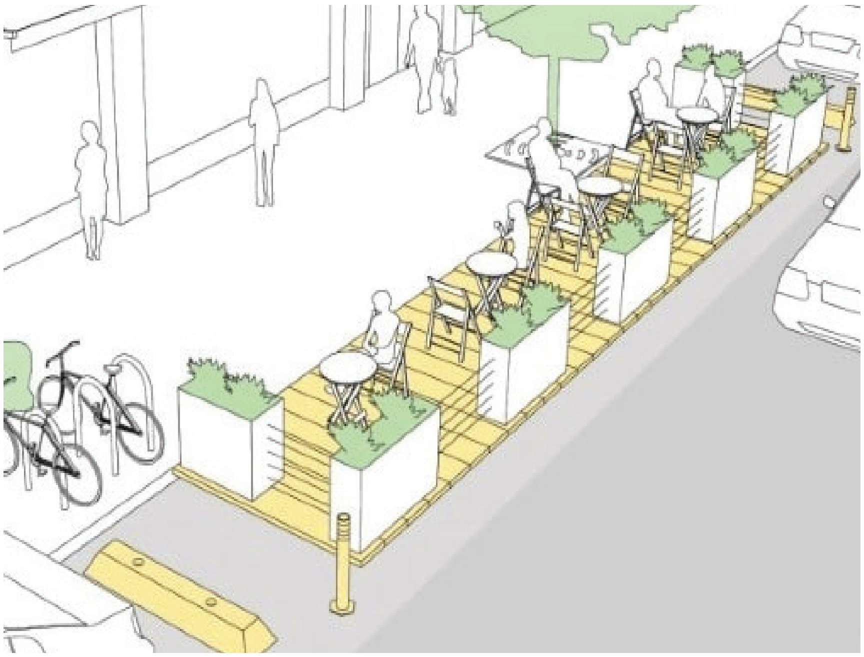
Cool Shelters reimagines the bus stop as a climate-adaptive public space by replacing parking spots with mass timber shelters that prioritize user comfort. The design features an adjustable wall, minimal parts, ease of construction, and potentials for enhancement and multi-usability, offering a practical, sustainable framework tailored to New Haven and beyond.


Potentials


Simplified Construction
Cross Laminated Timber
Parking Space Revival
Adjustable Wall

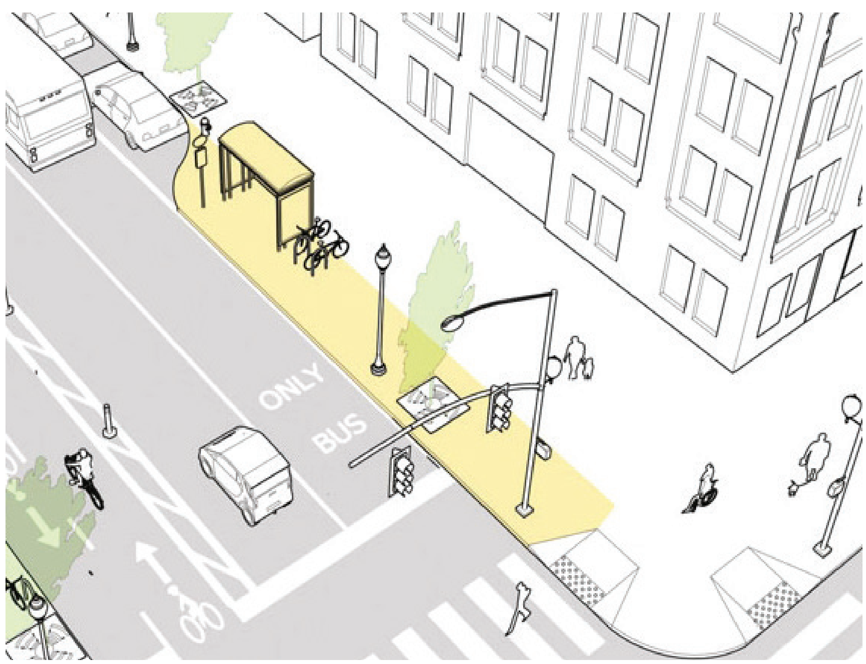
Parking Space Revival

The shelter is designed to replace a parking space, breaking the cycle of carbon lock-in—whereby the built environment perpetuates a high-carbon, car-centric culture (Seto et al., 2016). The parklets that proliferated during the COVID-19 pandemic and bus bulbs established a precedent for reimagining parking spaces as opportunities for placemaking and community connection. Siting shelters in converted parking spaces rather than on narrow sidewalks reclaims street space for the public, a particularly meaningful intervention in neighborhoods with low rates of personal vehicle ownership.



Dining parklets convert curbside parking spaces into outdoor restaurant seating (Image: NACTO, 2013a.)

Bus bulbs are curb extensions that align the bus stop with the parking lane (Image: NACTO, 2013b).

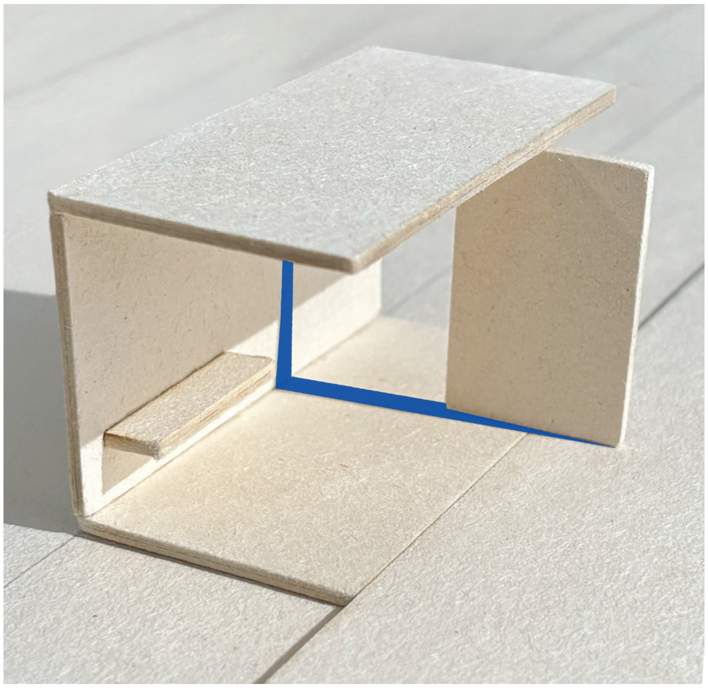


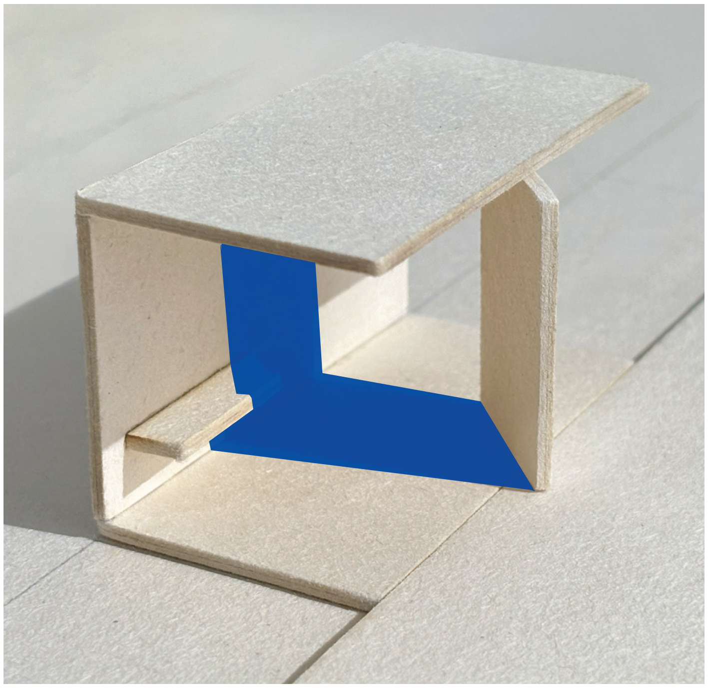
Given their standard sizing, ubiquitous presence, and absence of streetscape elements, we've identified parking spots, identified in white in the images above, as an ideal site in which to envision new bus shelters. The shelter serves a dual purpose of providing visual and audial protection from roadways. Paired with generous shading that covers the immediate sidewalk, the result is a cooling oasis.

The Adjustable Wall

Shade is the primary driver of thermal comfort in the bus shelter, but it is not limited to overhead coverage—it is directional. A roof alone misses some of the most critical hours of solar exposure. By introducing an angled wall, the design intercepts low-angle sunlight from the side, particularly in the late afternoon when thermal stress peaks. This element blocks sun during afternoon hours, extends shade deeper into the waiting zone, and reduces exposure to heat reflected from the street.

Rather than a fixed, one-size-fits-all solution, **the shelter is conceived as a site-responsive system.** The wall is rotated and adjusted along the length of the structure at the time of installation, allowing it to respond to street orientation, the sun path during peak summer conditions, and the surrounding context, including adjacent buildings and existing shade from trees. Correspondingly, the bench and lean wall can be shifted around the structure to optimize comfort.

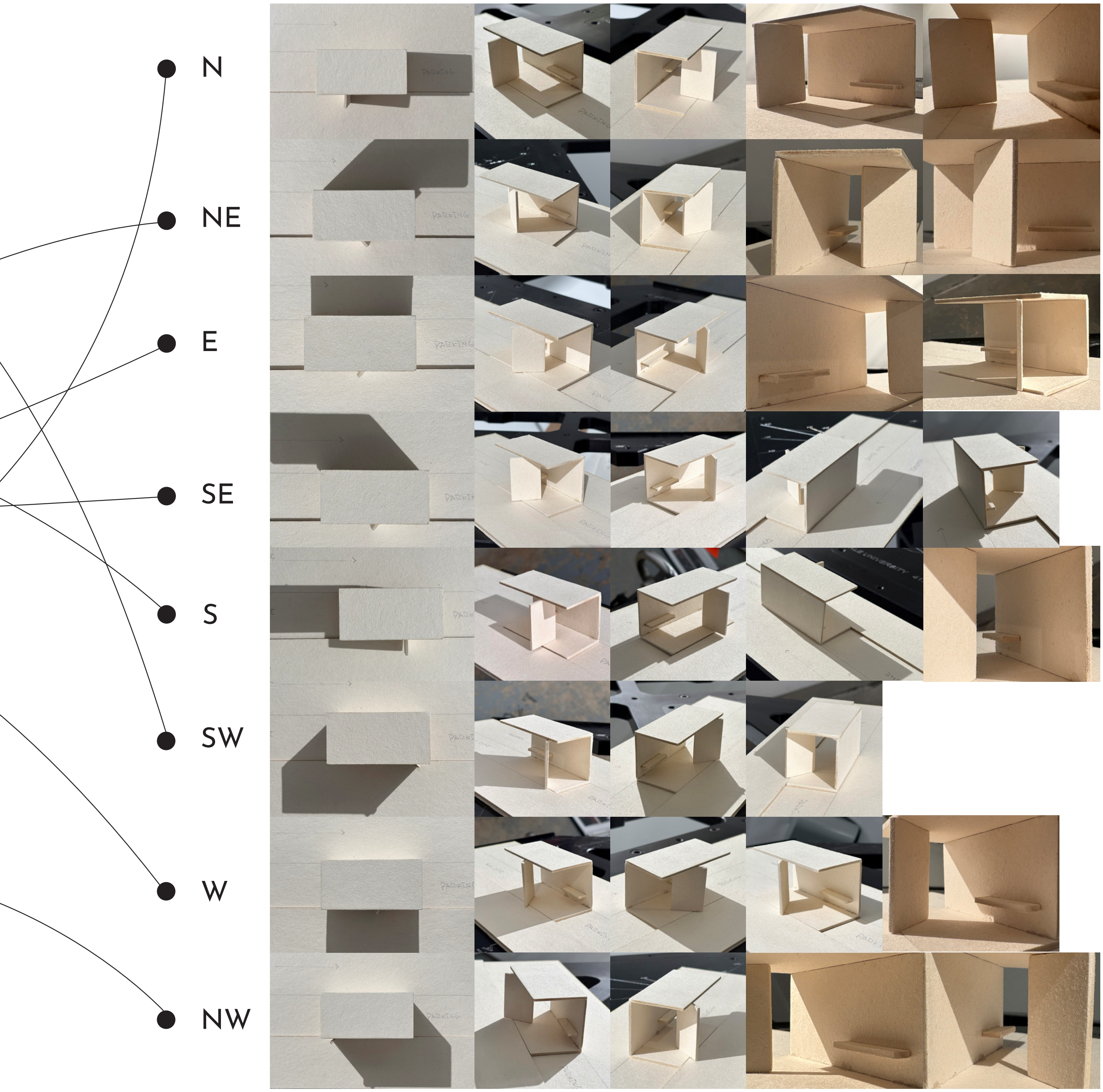




Cool Shelters sees each installation as a place-based process. Shown in the model above, shade is maximized by the simple act of angling a wall. Depending on the street orientation and direction of the sun, the wall can be adjusted at installation to maximize shade throughout the day.

Wall placement becomes the primary way in which each shelter forms its own identity, with orientation determined by local environmental and spatial conditions. What begins as a practical decision becomes an opportunity for a simple, standardized system to establish character through place-based adaption.

For ease of installation, all compass points, corresponding to the direction that the back wall faces, are inscribed on the base plate as a pedagogical tool. Those installing the shelter only need a compass to decide the wall's optimal orientation, positioning it on either third of the shelter's length at a maximum angle of 45 degrees.

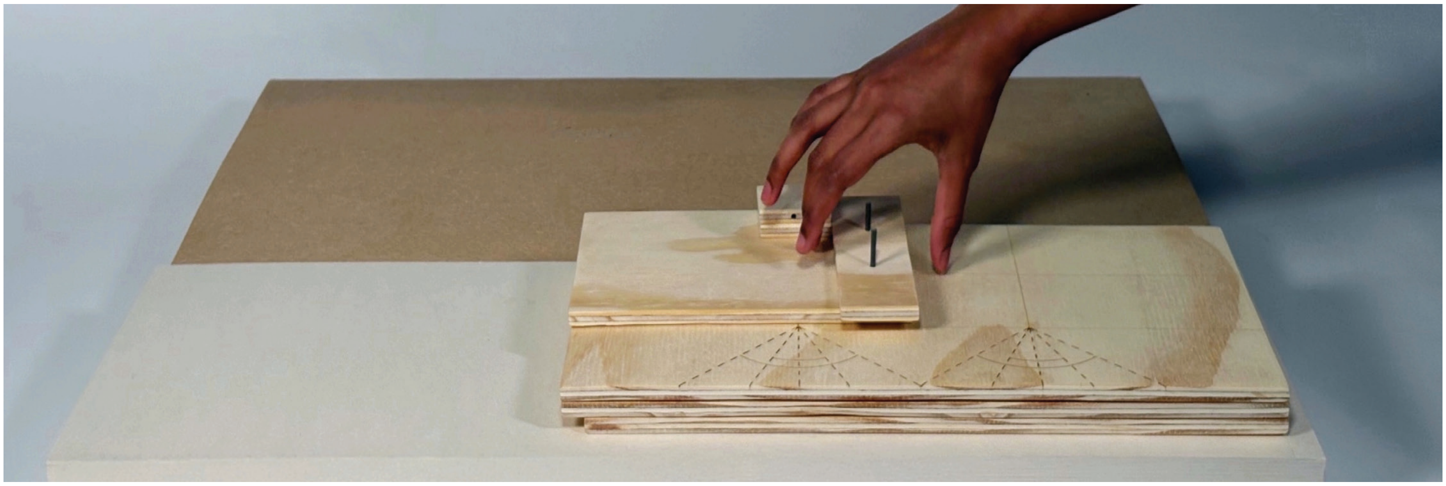


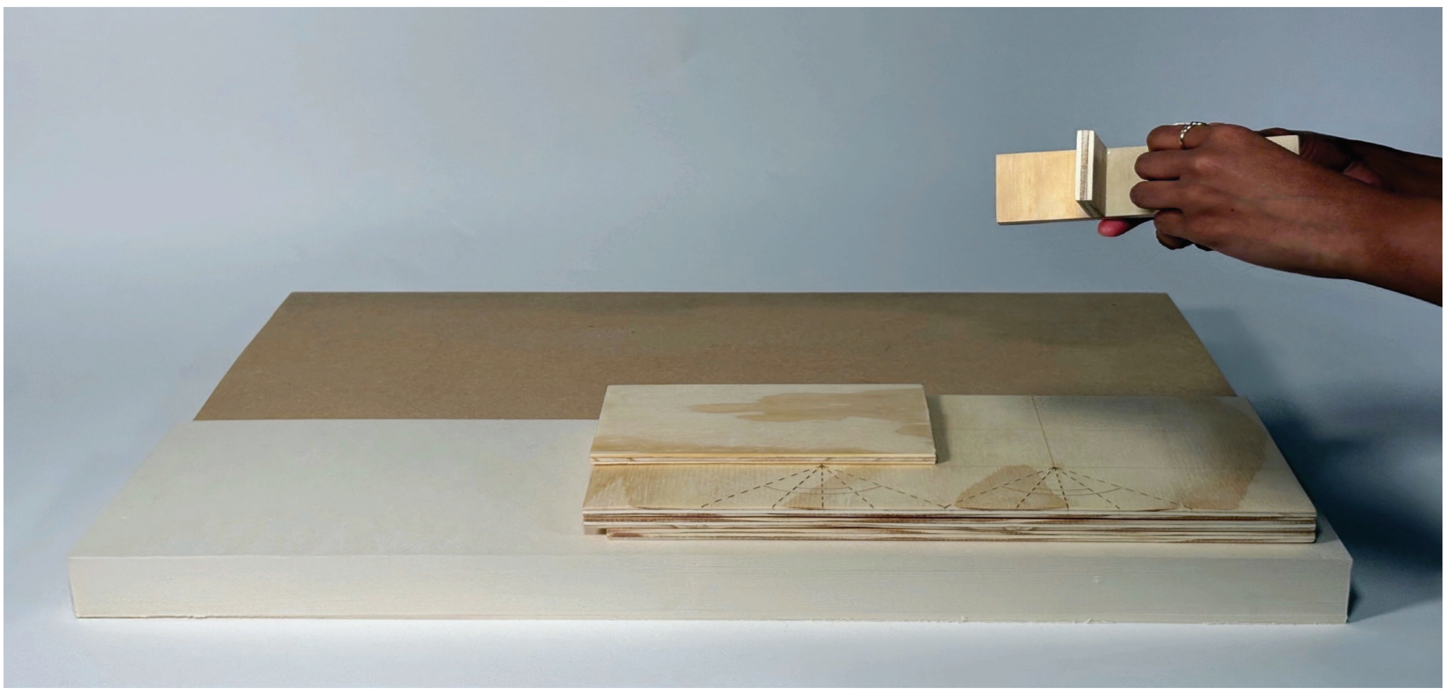
Sun studies, both to investigate the wall's functional (left photos) and aesthetic (right photos) capabilties, were completed at every orientation, giving priority to alleviating times of high heat stress and ridership.

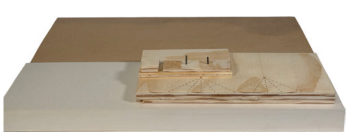
Simplified Construction

Cool Shelters are engineered as a flatpack system, optimized for straightforward manufacturing and rapid on-site assembly. Informed by interviews with municipal stakeholders and bus shelter producers, minimizing waste and logistical simplicity arises from fitting within the constraints posed by CLT. The design relies on proportions, rather than literal dimensions, resulting in easy adaptability between changes in production standards of CLT manufacturers. The base wall, roof, and floor are equal-sized panels with lengths double their widths, requiring only lateral cuts, as CLT is typically fabricated at the same width as a parking space. The adjustable wall is derived from one third of a panel, with the bench fabricated from the remaining offcut. The steel curb plate is offered as an optional component, as most jurisdictions already maintain curb plates for standard operations. **The flatpack weighs ~3 tons(6,112 lbs), which is below the weight limit for a small commercial flat back delivery truck.**

The flatpack system arrives ready for quick assembly on site. Additionally, and depending on the municipality's preferences, the shelter could arrive pre-assembled directly from the manufacturer. In either case, placement is simple: adjustable pedestals support the CLT floor plate, which secures both walls. Resting above the asphalt, this design eliminates the need to drill into the street and install foundations.







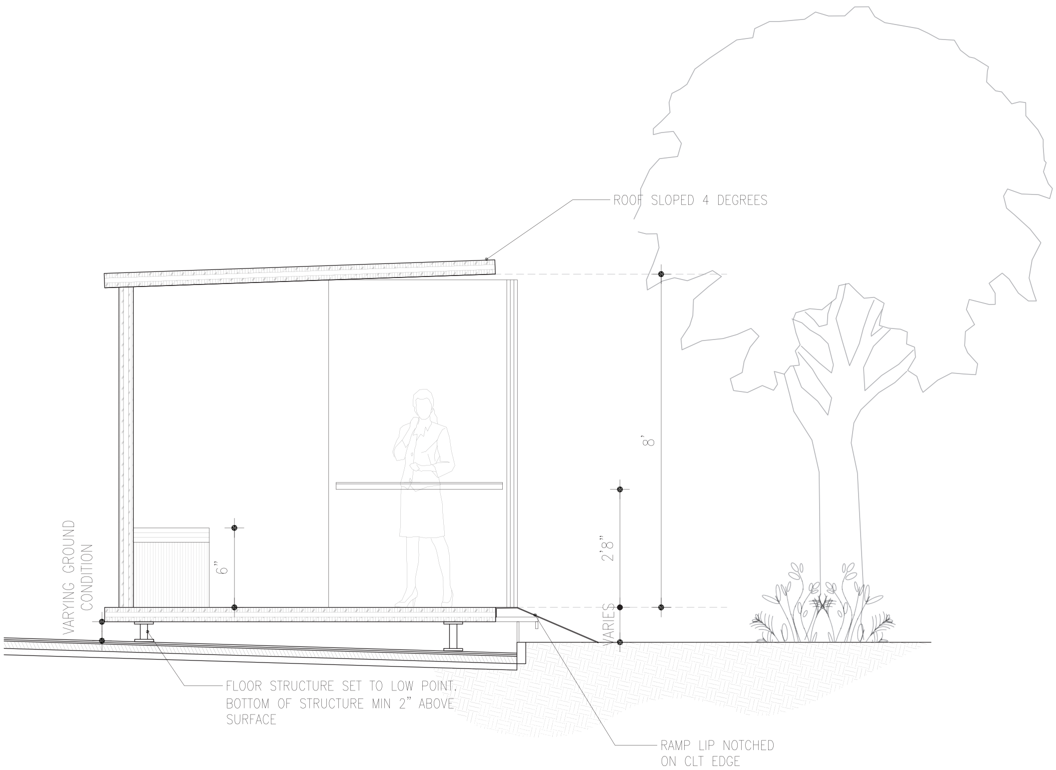
Materials are flat-packed to the site.

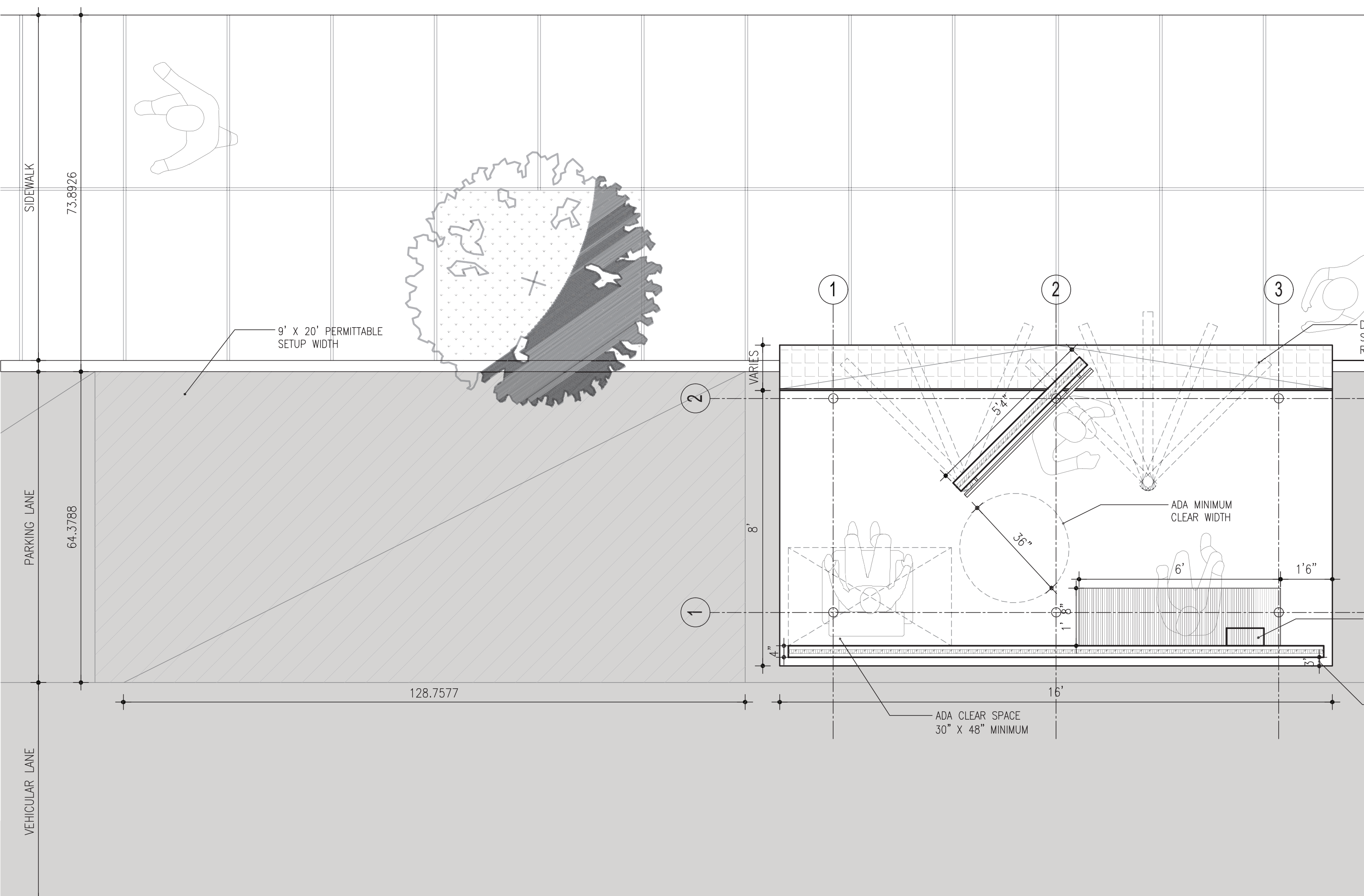
Levelers even the floor plate and raise the CLT above standing water.

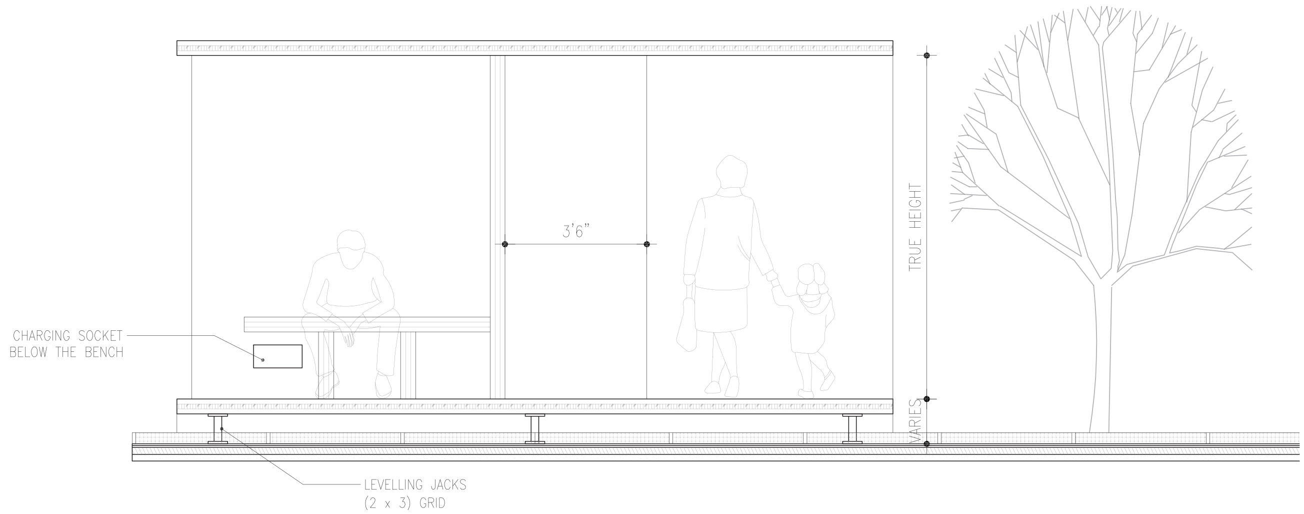
The back wall is lifted and attached to the base.

Finally, the front wall and roof are lifted and screwed into place. The bench (with structural supports underneath) and metal ramp are added last.

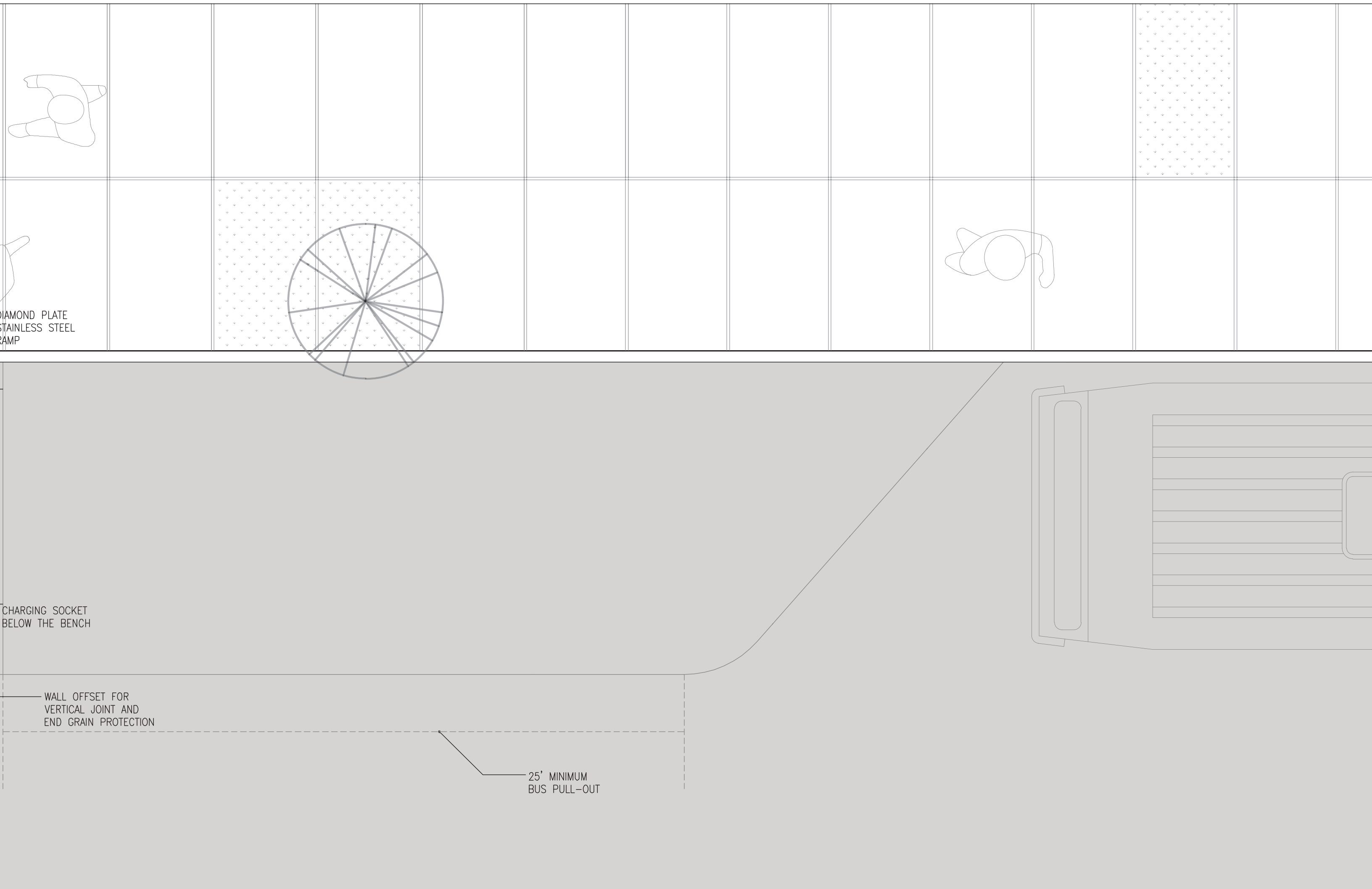
Cool Shelters







3'6"
TRUE HEIGHT
VARIES
CHARGING SOCKET
BELOW THE BENCH
LEVELLING JACKS
(2 x 3) GRID



DIAMOND PLATE
STAINLESS STEEL
RAMP
CHARGING SOCKET
BELOW THE BENCH
WALL OFFSET FOR
VERTICAL JOINT AND
END GRAIN PROTECTION
25' MINIMUM
BUS PULL-OUT

Cross-Laminated Timber (CLT)

Contrasting the aluminum status quo, the design deploys cross-laminated timber (CLT)—an engineered mass timber that is strong, durable, and environmentally responsive. Formed by layering boards in alternating directions and pressing them into solid panels, CLT allows us to rethink the material, performance, and experience of the bus shelter.

Sustainability: CLT stores carbon absorbed during tree growth and supports a regional, circular material economy. As mass timber production expands in the Northeast United States, CLT offers a scalable, lower-carbon alternative to aluminum and concrete (Atnoorkar et al., 2024).

–6.7 tons CO_2	vs	+9 tons CO_2
Cool Shelter		*Conventional Aluminum Shelter*

The Cool Shelter may store more carbon than it emits.
Preliminary cradle-to-gate estimates suggest that carbon stored within the CLT structure exceeds the embodied emissions associated with its production—while remaining substantially lower than those of a comparable aluminum shelter frame.*

Thermal Insulation: Timber moderates heat transfer more effectively than highly conductive metals, improving comfort within the shelter envelope and allowing a more comfortable seating and leaning experience (Hunt, 2019).

Durability & Maintenance: Solid wood panels simplify construction and reduce points of failure. Unlike shattered glass or scratched polycarbonate panels, wood surfaces can often be repaired, sanded, and refinished in place, supporting long-term durability and lower-maintenance upkeep.

Aesthetics & Placemaking: Wood has been linked to stress reduction, acoustic comfort, and increased feelings of warmth and well-being (Fell, 2010; Tsunetsugu et al., 2007; Burnard & Kutnar, 2015). CLT transforms critical infrastructure into a welcoming public space.

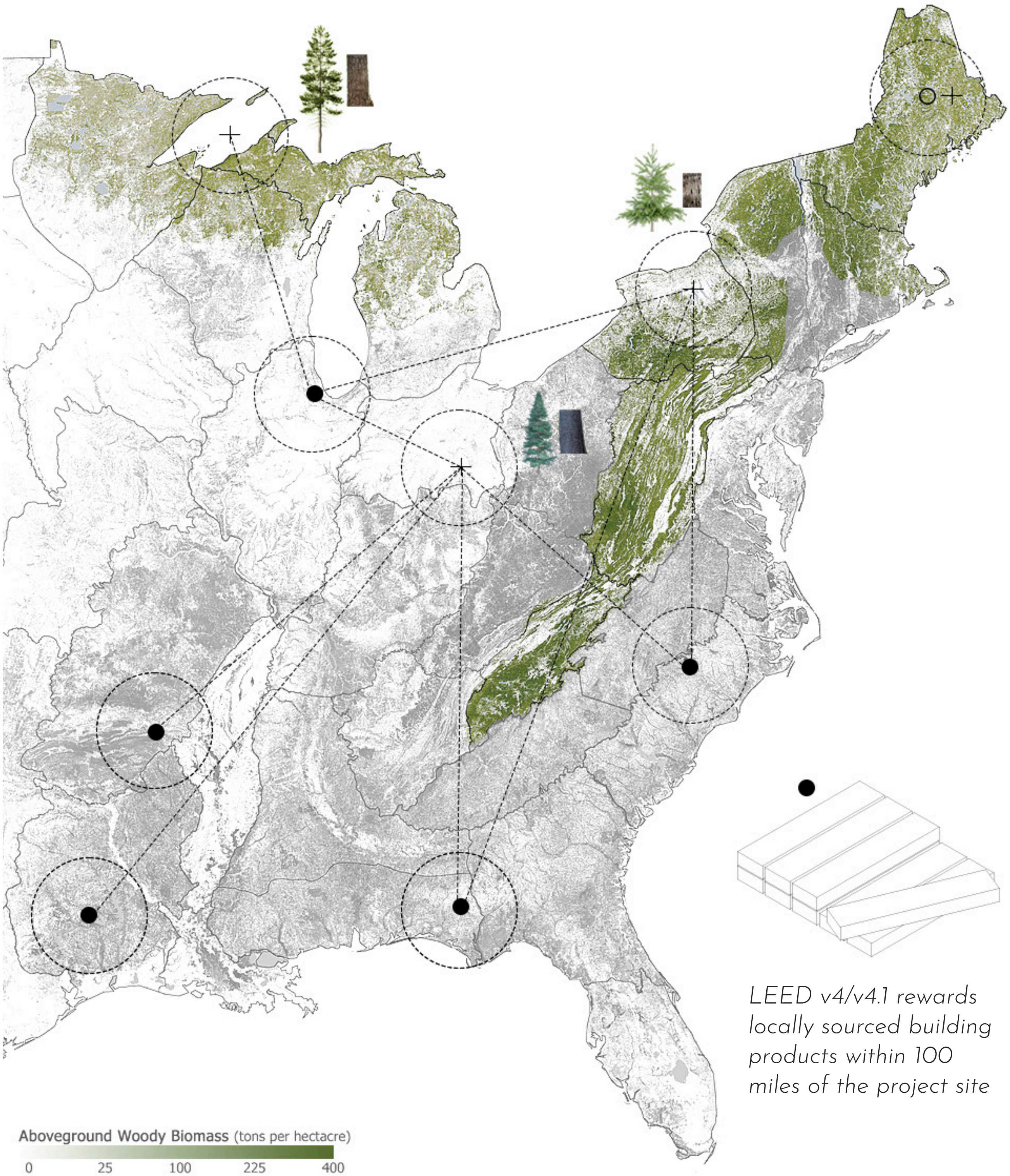
CLT panels are commonly manufactured in 3- or 5-ply sheets, typically 8–10 feet wide and up to 60 feet long, depending on the facility.

Shown here is a 2 ft × 2 ft sample of a 3-ply section approximately 4 inches thick—the planned material of Cool Shelters.

*Based on EC3 data, TerraLam EPDs, and modeled aluminum shelter specifications (Building Transparency, 2026; One Click LCA, 2022; Belson Outdoors, 2026).

Toward a Northeast Supply Chain

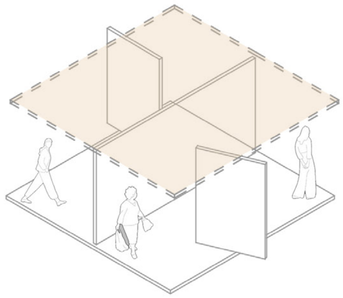
Mass timber production in North America remains geographically fragmented, with most CLT manufacturing concentrated in the Pacific Northwest and Southeast.
Emerging facilities in the Northeast—particularly in Maine—suggest the potential for a more regionalized supply chain with shorter transport distances and lower lifecycle emissions (Wolf, 2026).

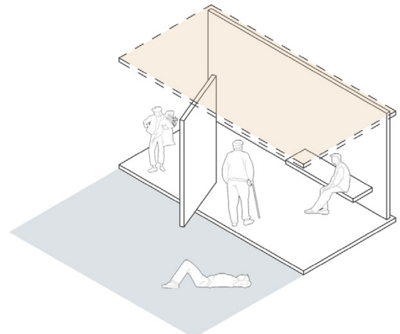


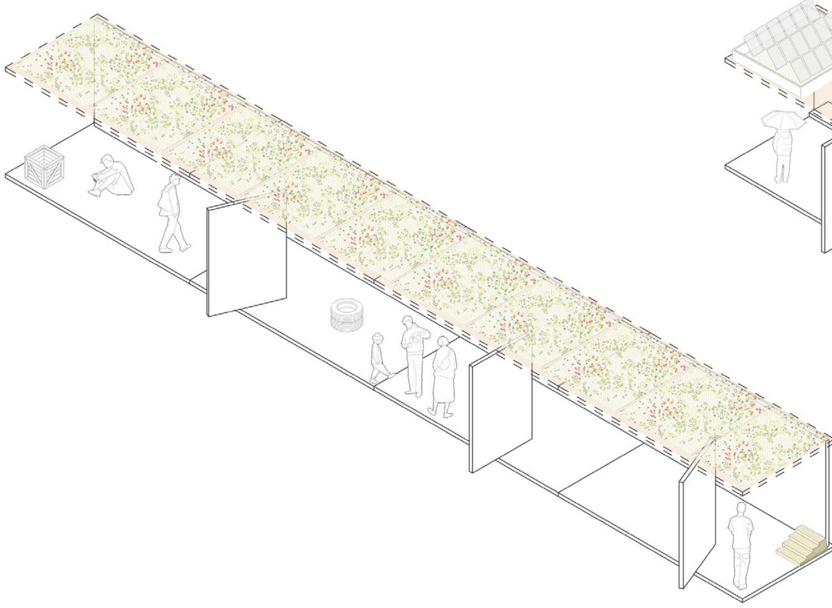
Map synthesized from CLT manufacturing data and regional forestry mapping (Atnoorkar et al., 2024; Simmon, 2012).

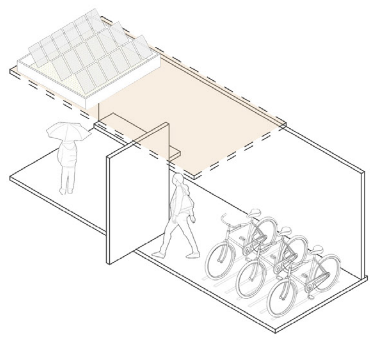
Potentials

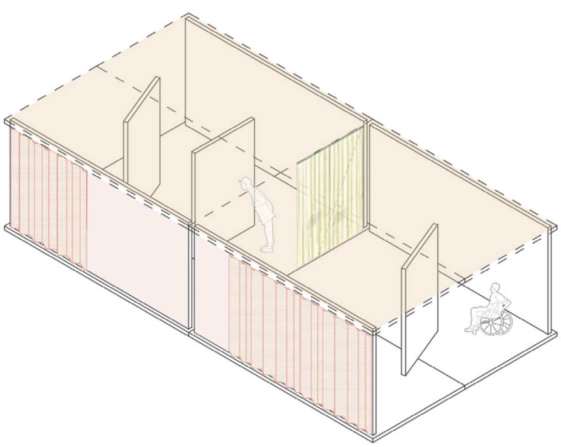
Cool Shelters is designed to grow with the needs of each community through a suite of optional enhancements. Electrical infrastructure can be introduced through on-grid connection or an integrated solar panel, powering amenities such as lighting, a fan for additional thermal comfort, and real-time bus arrival displays that improve the transit experience. The expanded wall opens the shelter further as a civic surface—accommodating educational content about local resilience hubs or local resources, or mural and art activations. Adding lighting and reducing empty space through meaningful information and art is a proven deterrent for graffiti (Project for Public Spaces, 2008). A green roof completes the system, offering additional thermal comfort, clean air, and extended pollinator and wildlife habitat.

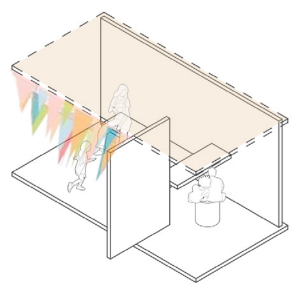








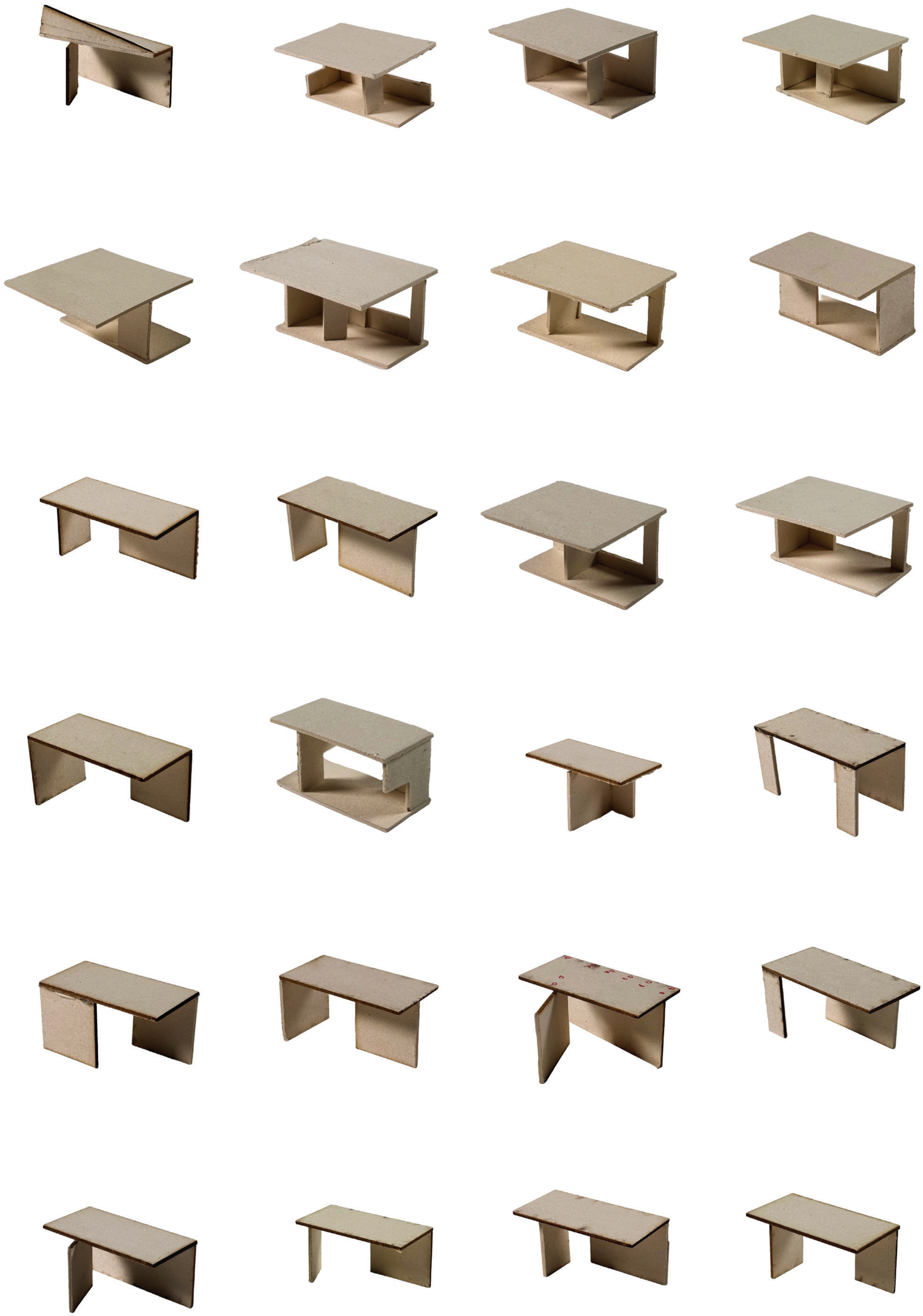




Beyond transit, Cool Shelters is conceived as a flexible piece of public infrastructure that can adapt to the changing needs of communities. The modular system can be leveraged for flea markets, green corridors, neighborhood cooling stations, exhibition spaces, and public events, transforming underutilized street space into active civic environments. By supporting a range of social, ecological, and cultural programs, it becomes a framework for community life and climate resilience.


YNH
Psychiatric
Hospital
ONE WAY

NEW HAVEN TRANSIT
Effective 12/13/2025
transit
No Standing
NO PARKING
2 Hour Limit
No Time Limit
ELEGANT
Theatre



Looking Forward

Given the escalating impacts of climate change on vulnerable communities, we are driven to design transportation infrastructure that meets the needs of both people and the planet. Where conventional shelter programs prioritize ridership demand, Cool Shelters builds a design framework that foregrounds heat vulnerability—treating communities burdened by urban heat island effects as the focal point, not an afterthought. Every component of the design reflects that commitment.

Shelters in Parking Spaces**:** Replacing street parking with mass timber shelters demonstrates that transportation infrastructure can champion both. Distributed bus sites can function as heat relief oases for both riders and those without adequate access to cooling.

Modular Structure**:** A modular base, with an adjustable wall and optional enhancements, provides an opportunity for cities to customize bus shelters to suite the unique needs of their community.

Simplified Design and Deployment**:** Sustainable innovation is often stifled by systematic red tape. This shelter delivers tangible improvements while operating within Connecticut procurement, New Haven zoning, and real construction and maintenance constraints for easy integration and deployment.

What this project ultimately offers is a framework as much as a form. The three principles that guided its development—context-specific heat mitigation, full-lifecycle sustainability, and place-based adaptation— are not arguments for one shelter in New Haven. They are arguments for how public infrastructure might be approached anywhere. **Every city has communities that bear its heat burden unequally. Every city has bus stops brimming with opportunity to strengthen community climate resilience.**

Acknowledgements

The team would like to thank our faculty advisors—Andrei Harwell, Aicha Woods, Matthew Rosen, and Alan Organschi—for their invaluable guidance, generosity, and support throughout the year. Their mentorship not only shaped the development of this project, but also helped each member of the team grow as designers, researchers, and collaborators working across disciplines and scales of public infrastructure.

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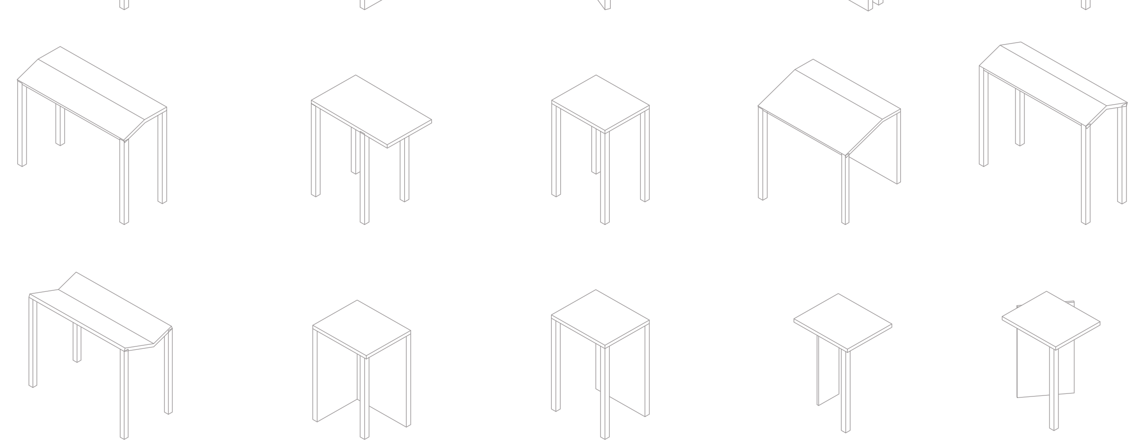

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