EXPLORING THE OPPORTUNITIES FOR STREET FURNITURE TO CONTRIBUTE TO CLIMATE RESILIENCE AND SUSTAINABILITY

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This project was conducted under the mentorship of City staff. The opinions and recommendations in this report, and any errors, are those of the author, and do not necessarily reflect the views of the City of Vancouver or the University of British Columbia.

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ACKNOWLEDGEMENTS

I acknowledge that the work for this project took place on the unceded ancestral lands of the xwməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), and Səl̓ílwətaʔ/Selilwitulh (Tsleil- Waututh) Nations.

This report has not been created in consultation with these Nations, and I recognize the colonial and institutional perspective reflected in this work. It is important to recognize that colonialism has systemically oppressed the original inhabitants of this land and that to plan for the land without them is not good enough – we must do better.

It is with deep gratitude that I recognize and thank these communities for their past, present, and future stewardship of the land upon which we live. As uninvited guests and planners, working toward the healthy present and future of this land, it is our job to work with respect and care. It was in this way that I approached this report.

I would like to thank the following individuals for their contribution, feedback, and support throughout this project: Tara Gallen, Ben Mulhall, and Matthew Callow. Your expertise and passion are inspiring and I deeply value all that you have shared with me.

Also, a big thank you to Patrick Enbright, Jesse Wiebe, Brad Bedelt, Tamsin Mills, the Street Activities Branch, and everyone at the City and UBC who was so thoughtful and helpful during my time in this program.

Title image by Philip Jessop

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EXECUTIVE SUMMARY

CONTEXT

The City of Vancouver (CoV) is nearing the end of its contract with a vendor to provide street furniture and maintenance and the City staff are now exploring the opportunities that street furniture can provide to improve urban liveability. The contract is nearing 20 years old, and in that time, the urban and global landscape have seen significant changes.

In 2019, the City of Vancouver declared a climate emergency followed by Council approval of the Climate Emergency Action plan in November 2022. This plan outlines actions to reduce carbon pollution by 50% by 2030, which is aligned with the United Nations Intergovernmental Panel on Climate Change, a scientific body that urges leaders and policymakers to seek ways to limit global warming to 1.5°C by 2030. [1] This report examines the potential for the street furniture contract to contribute to this endeavour and work toward climate resilience and sustainability.

The furniture provided through the contract includes benches, bus shelters, wayfinding signs, digital advertising panels, bike racks, litter cans, and Automatic Public Toilets (APTs). This report focuses primarily on transit-related street furniture as much of the research available on street furniture addresses this particular asset. The transit shelter also shows potential in contributing to climate resiliency and sustainability. Additionally, transit shelters are featured in this report because they are complex structures that require a multitude of very specific materials.

SUSTAINABILITY AND CLIMATE CHANGE

Sustainable development considers how to support a growing population while reducing environmental impact. The City of Vancouver is carefully considering the environmental implications of building new street furniture infrastructure and looking to support and facilitate create more sustainable practices.

In this report, strategies and opportunities for climate resiliency and sustainability will be viewed as opportunities for “mitigation” and “adaptation”. Climate change is impacting communities now. All departments within the City need to consider how to reduce carbon output (mitigation) while also considering strategies to improve urban life in the present (adaptation).

Regarding street furniture, mitigation strategies include reducing dependencies on vehicles by increasing access to sustainable transportation through public transit, and active transportation like walking or biking. It also includes strategies to employ greener construction practices such as recycling and aiming for net-zero builds.[2] Reducing reliance on cars also calls for a significant investment in the experience of bus riders and those utilizing active transportation.

Adaptation is necessary because climate change is unavoidable and the damage to the environment thus far cannot be undone, and it is therefore required in addition to mitigation to deal with present day impacts. These responses can target specific solutions, such as cooling centres, and broader schemes, like public health and emergency management planning. In a street furniture landscape, this could include shade

[1] Vancouver, City of. “Climate Emergency Action Plan.” *City of Vancouver*, https://vancouver.ca/green-vancouver/vancouvers-climate-emergency.aspx.

[2] “Climate Change Adaptation and Mitigation.” *NASA*, NASA, 18 July 2022, https://climate.nasa.gov/solutions/adaptation-mitigation/.

structures, misting stations, and shelter from rain. Additional approaches include solar power, smart technology and placemaking strategies.

EQUITY

It is impossible to talk about climate change and climate resilience without looking at each through the lens of equity. This is because "*We know that the most vulnerable are at the greatest risk from climate change, and that they have done the least to cause it".* [3]

Climate change in Vancouver will see the increased frequency and severity of climate related hazards, particularly: extreme heat events, flooding, wildfires and wildfire smoke events, and ozone air pollution. These events cause emergencies for people resulting in illness, and injury and, for some, death. Anxiety, trauma, and other mental health issues will also be a significant result. In 2021, 619 people died in an extreme heat event, aptly named the "heat dome", in Vancouver.[4] The most vulnerable people to heat-related illnesses and death are those with chronic health conditions, those living in poverty, and people who are socially isolated.

Urban areas experience the Urban Heat Island (UHI) effect wherein the built environment contributes to unnaturally elevated temperatures. This is due to dark-coloured, and impermeable surfaces such as roads and roofs. Furthermore, a lack of tree cover and shade contributes to the UHI, most and it is often affecting the elderly, the disabled, those living in poverty, and those without homes. Shade is disproportionately distributed- both manufactured and natural shade.[5]

EMBODIED CARBON

"Embodied carbon" considers the total carbon footprint of a building or infrastructure project, from the resource extraction to the finished product. New buildings and infrastructure require the use of resources that have historically been very carbon intensive.

Even though street furniture production is relatively small in comparison with construction industry output, there is still a significant opportunity to mitigate climate change effects and contribute to embodied carbon reduction through this contract. The scale of materials used in urban furniture is still substantial and sustainability need not only apply to the biggest industries for there to be an impact. Applying sustainability practices to a street furniture program is beneficial in several ways.

Reducing upfront carbon is a crucial strategy, as initial product stage is the largest contributor to embodied carbon[6] and can be done now by creating policies and incentives for both the CoV and its partners/ vendors to follow sustainability practices. To maximize carbon reduction potential The City would keep all existing furniture in place. The next best option to reduce carbon would be to repurpose the materials. If the City was to build their own infrastructure they could do so sustainably by building "clever" and "efficiently". This means choosing construction processes and technologies that utilize lower carbon strategies.

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[3] "Adaptation." *UN Climate Change Conference (COP26) at the SEC – Glasgow 2021*, 1 Nov. 2021, https://ukcop26.org/cop26-goals/adaptation/.

[4] Denis, Jen St. "One Year after Heat Deaths, Coroner Pushes for Change." *The Tyee*, The Tyee, 7 June 2022, https://thetyee.ca/News/2022/06/07/One-Year-After-Heat-Dome/.

[5] Bloch, Sam. "Shade." *Places Journal*, 1 Apr. 2019, https://placesjournal.org/article/shade-an-urban-design-mandate/.

[6] http://www.athenasmi.org/wp-content/uploads/2017/09/BC_MURB_carbon_benchmarking_final_report.pdf

INTRODUCTION

PROJECT PURPOSE AND SCOPE

This research project aims to inform specific City staff working in the Street Activities team of the potential for street furniture to increase urban livability in a changing climate, and to help reduce the carbon footprint of street furniture. This will be done by exploring and comparing the carbon footprint of existing and novel materials to be used. In addition, it will consider how street furniture itself could enhance urban climate change resiliency.

Vancouver, like many global cities, is working to meet goals to slow climate change. The City of Vancouver has also created ambitious green and sustainability strategies and plans. Even so, the City must work diligently across all departments to create healthy processes and practices to serve us now and in the long-term.

This report is intended to serve as an introduction to themes, trends, and opportunities to inform future research and work. The contributing research here entailed a literature review of academic works, news reports, manufacturer information, and data from other cities. To this end, interviews were conducted with city departments in North America and Australia. The interviews were very valuable and afforded insight into the high-level planning practices and the best practices therein.

A City of Vancouver policy review was also conducted, with several strategies and plans referenced. There are many more City policies that can and will inform this work going forward.

BACKGROUND AND CONTEXT

Street furnishings provide important amenities for pedestrians by adding functionality and vitality to the pedestrian realm. They announce that pedestrians are welcome and that the street is a comfortable place to be. These amenities provide a functional service to the pedestrian and provide visual detail and interest.

- *SF Better Streets*[7]

[7] "Street Furniture Overview." *SF Better Streets*, 22 May 2019, https://www.sfbetterstreets.org/find-project-types/streetscape-elements/street-furniture-overview/.

CONTRACT

The City of Vancouver, like many global cities, works in partnership with a third party to provide and maintain a number of street furniture assets within the street furniture program. The City currently has a contract with Outfront JC Decaux which expires in December 2023.

The furniture provided through the contract is described further below, and includes benches, bus shelters, wayfinding signs, digital ad panels, bike racks, litter cans, and Automatic Public Toilets (APTs). There is a points-based system to allow for upgrading or trading pieces. This is useful to note, because as technology progresses and peoples' needs change, so does the streetscape. An example is newsstands and public telephones that many cities utilized previously as part of their street furniture offerings but are not as common presently.

A project team is currently examining the options for future opportunities for Vancouver's street furniture. This examination spans multiple departments and includes multiple phases over several years to investigate the best direction for a new street furniture program.

STREET FURNITURE / CURB ZONE

Figure 1: Street Furniture, Curb Zone[8]

This investigation is specific to the street right-of-way/ utility strip and does not factor in furniture and amenities beyond this zone, such as those found in parks or plazas. The street right-of-way is often congested with heavy traffic and its furniture and amenities support urban life where people sit, gather,

[8] Ink, Social. "Urban Street Design Guide." *National Association of City Transportation Officials*, 13 Nov. 2017, https://nacto.org/publication/urban-street-design-guide/.

catch the bus, walk, shop, dispose of trash and recycling, access information, park their cars, lock up their bikes, and more.

This zone is also required for electricity, trees, fire hydrants, plumbing, lighting, stormwater management, and utility poles that exist below, above and share the surface space. All these activities need to happen in a carefully considered balance to support holistically designed street life.

The dimensions and needs of any particular street will determine how street furniture can be successfully incorporated into the urban landscape. Multi-configuration seating installations will likely prove most flexible, and therefore tenable, for Vancouver's purposes, but limitations such as size, safety, and logistics must be considered. Figure 2 illustrates two examples of where furniture might be placed in relation to the sidewalk (walkway zone).

Figure 2: Furniture Zones[9]

SAFETY AND LOGISTICAL CONSIDERATIONS

There are considerations that might influence one design choice over another, as the physical space that holds street furniture is often limited and sightlines might take precedence over a design element that could address climate adaptation: extended rain cover, or any rain cover/ shade structure at all. Specifications for all street furniture and amenities can be confirmed by consulting the CoV's *Engineering Design Manual*.

The above-mentioned manual provides specifications for the coordination of furniture with fire hydrants; lighting allowances; mandated setbacks from the sidewalk and street; parking considerations; and other spatial factors. Another influence might also be specifications from the vendor. For example, transit shelters that require a "cast-in-place concrete" foundation demand a different strategy than a bicycle rack can be bolted to asphalt.

[9] Hamilton, City of. "City of Hamilton, Ontario, Canada." *City of Hamilton*, https://www.hamilton.ca/sites/default/files/media/browser/2016-04-29/city-street-furniture-guidelines-aug-2015.pdf.

BUS SHELTER PLACEMENT AND CLEARANCE GUIDELINES

An example of specifications can be seen here, in the City of Vancouver's guidelines for bus shelter placement. This document describes options for narrow spaces, minimum clearances, and safety guidelines. These examples show that although a transit shelter, bench, or bike rack would be beneficial in a particular area for rest or shade, there are existing policies regarding safety and access of emergency infrastructure such as fire hydrants, that might preclude their install.

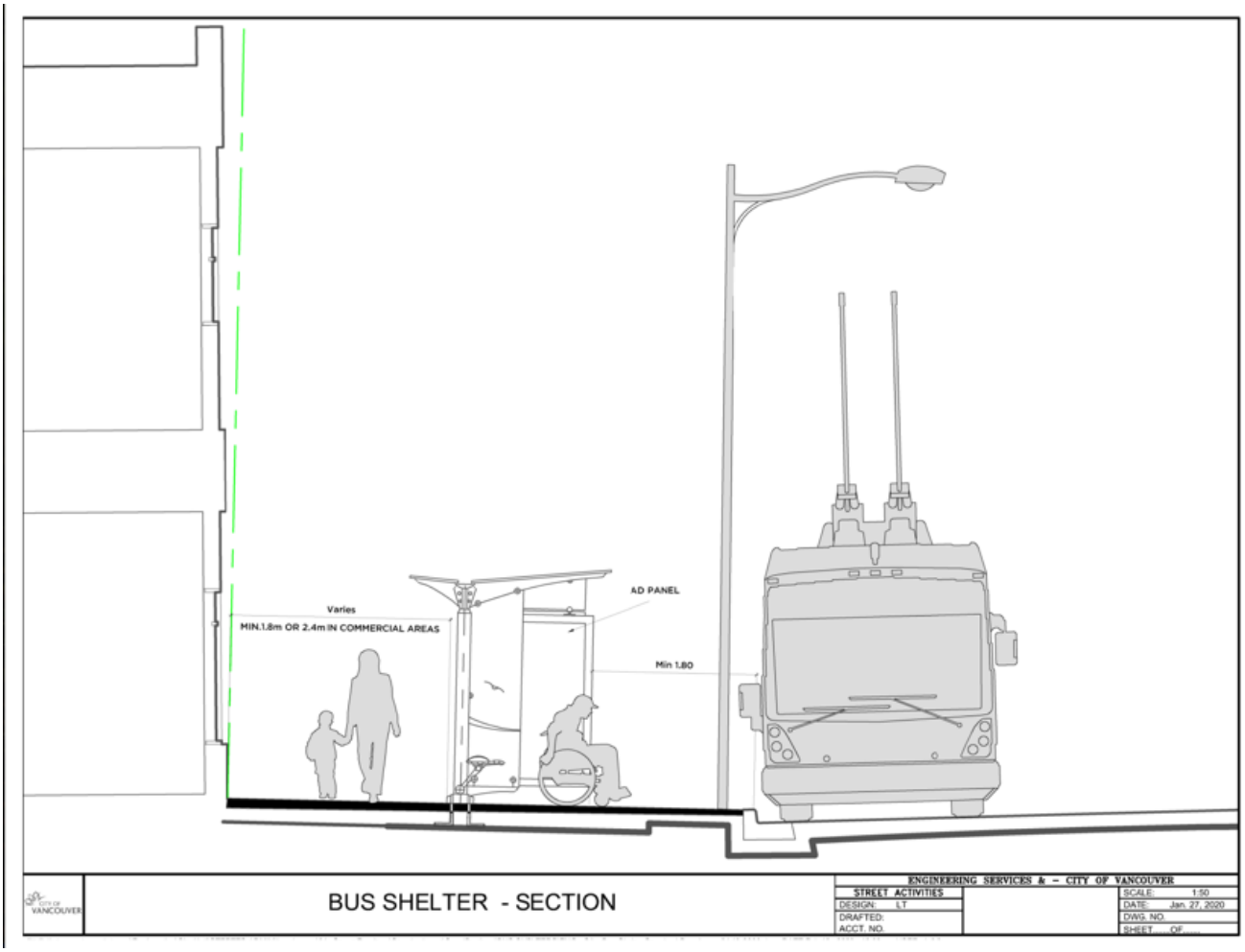


Figure 3: Bus Shelter Guidelines, City of Vancouver[10]

I. Placement of bus shelters on the street right-of-way

a) The shelter shall be no farther than 9.0 meters from the bus I.D. pole for passenger convenience.
b) The closest portion of the shelter should maintain a minimum lateral clearance of 0.6 meters from the curb face to avoid contact with a bus (to account for the maximum rear sweep of a bus).
c) In narrow areas where adequate space is not available to site a bus shelter, it may be prudent to put the shelter immediately downstream. Passengers waiting in the shelter must be able to clearly see approaching buses.

[10] City of Vancouver Policy: CoV Bus Shelter Guidelines, Updated February 10, 2020 "Shelters and Winter Response Strategy." *City of Vancouver*, https://vancouver.ca/people-programs/shelters.aspx

II. Minimum clearances

a) A minimum sidewalk width of 1.8m is required or 2.4m in commercial zones.

b) Minimum 3.0m clearance away from fire hydrants.

c) Minimum 2.0m away from other street furniture such as bike racks.

d) Minimum 1.8m away from street trees or above ground appurtenances that may impede access to the shelter. (Ad panel to not be obstructed)

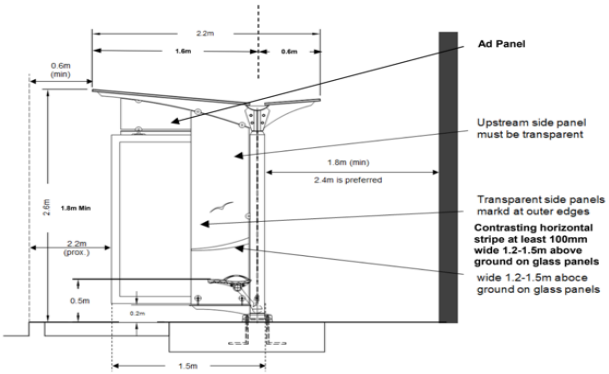
e) Minimum 1.5m distance away from utility access points.[11]

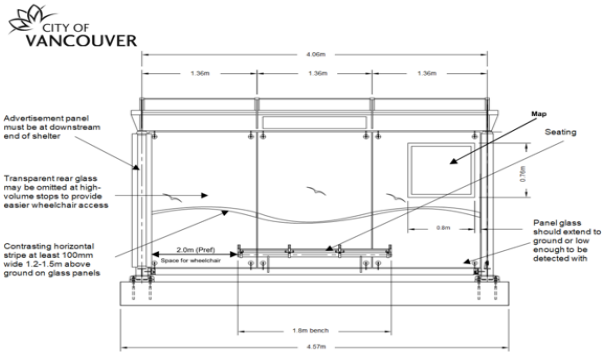
[11]City of Vancouver Policy: CoV Bus Shelter Guidelines, Updated February 10, 2020 "Shelters and Winter Response Strategy." *City of Vancouver*, https://vancouver.ca/people-programs/shelters.aspx.

CURRENT ASSETS

Vancouver currently includes the following assets within the street furniture program:

BUS SHELTERS





Figures 4, 5, Bus Shelter Guidelines, City of Vancouver[12]
Figures 6, 7: Bus Shelters in Vancouver[13]

INVENTORY:

Installed by contractor: 850 shelters
Installed/owned by the CoV: 32 shelters
Other: 1 shelter

MATERIALS:

Metal, wood, glass, concrete, electrical wiring

[12] City of Vancouver Policy: CoV Bus Shelter Guidelines, Updated February 10, 2020 "Shelters and Winter Response Strategy." *City of Vancouver*, https://vancouver.ca/people-programs/shelters.aspx.
[13] Note: Images by Amy Liebenberg

LITTER CANS




Figures 8, 9, 10, 11: Litter cans in Vancouver[14]

INVENTORY:

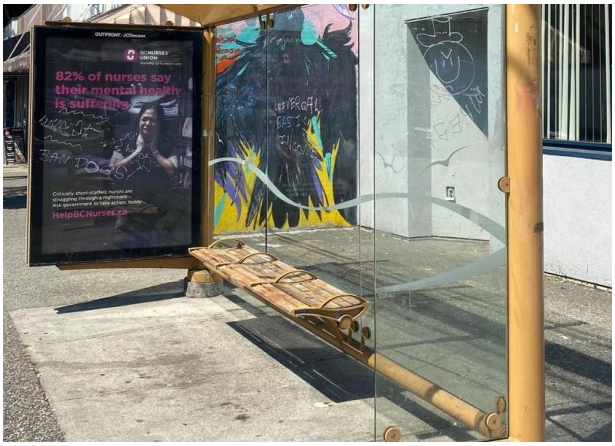
Installed by contractor: 1213
Installed/ owned by the CoV: 1695
Other: 98

MATERIALS:

Various metals
Some are designed/ ordered in partnership with a BIA, and there isn't one singular design for all of Vancouver.

[14] Figure 8: Blackett, Matthew. "Vancouver's Bus Shelters and Garbage Bins." *Spacing Toronto*, 21 Jan. 2013, https://spacing.ca/toronto/2007/08/15/vancouvers-bus-shelters-and-garbage-bins/.
Figures 9, 10, 11, Amy Liebenberg

BENCHES:



Figures 12, 13, 14, 15: Benches in Vancouver[15]

INVENTORY:

Installed by contractor: 694
Installed/ owned by the CoV/ BIA: 949
Other: 46

MATERIALS:

Various metal, wood, concrete or a combination
Some located in transit shelters, some located free-standing on the street. Some are designed/ ordered in partnership with a BIA, and there isn't one singular design for all of Vancouver.

[15] Figures 12, 13, 14: Amy Liebenberg
Figure 15: Image by City of Vancouver

AUTOMATED PUBLIC TOILETS

Figure 16: Large APT
Figure 17: Small APT[16]

Inventory:
10 x APTs- small and large models, some accessible, self-cleaning, connected to electrical and plumbing systems
Comfort stations x 2

MATERIALS:

Various metal, wood, concrete, plastic, plumbing, electrical

[16] City of Vancouver

WAYFINDING MAP STANDS

Figure 18: Large Map Stand
Figure 19: Narrow Map Stand[17]

INVENTORY:

Narrow Map Stand or Large Poster
Contract x BIA x 220

MATERIALS:

Metal and Plexiglass

[17] City of Vancouver

BIKE RACKS

Figures 20 - 27: Bike Racks: City of Vancouver 18

INVENTORY:

Contractor owned and installed x 132
City owned and installed x 2243
Another x 12

MATERIALS:

Powder coated or galvanized steel

MANY OTHER ITEMS MAY BE CONSIDERED STREET FURNITURE THAT ARE NOT CURRENTLY INCLUDED IN THE CITY'S CONTRACT. THEY INCLUDE THE FOLLOWING:

- Non-transit shelters
- Planters
- Parklets
- Gateways
- Light pole mounted Banners
- Placemaking items
- Bike storage lockers
- Water fountains
- Bollards
- Community kiosks
- Interpretive signs

[18] Figures 20 - 25, Amy Liebenberg
Figures 26, 27: City of Vancouver

SUSTAINABILITY AND CLIMATE CHANGE

Sustainable development is a multi-faceted approach to delivering a built environment wherein economic, social, and environmental concerns are considered. The City of Vancouver is carefully considering the environmental implications of building new street furniture and looking to support and facilitate more sustainable practices through strategies such as policy reform and incentives. A new or renewed contract may lead to the building of new street furniture, and this might entail an overhaul of some or all assets, which would require a significant number of materials, such as concrete, steel, and aluminum.

Sustainable development is a crucial component of any strategy to support the planet's growing population and can be manifested by building new infrastructure and buildings in a manner that mitigates environmental impact by reducing carbon pollution. Both transportation and the construction industry are two of the biggest contributors to carbon emissions, making each a priority when contemplating infrastructural change.

In 2019, the City of Vancouver declared a climate emergency followed by Council approval of the Climate Emergency Action plan in November 2021. This plan outlines actions to reduce carbon pollution by 50% by 2030, which is aligned with the United Nations Intergovernmental Panel on Climate Change, a scientific body that urges leaders and policymakers to seek ways to limit global warming to 1.5° C by 2030. [19]
According to the Climate Emergency Action plan, almost 40% of Vancouver's carbon pollution comes from vehicle emissions and over half the city's carbon pollution comes from heating buildings, and therefore considering sustainable transportation and building practices are crucial to the success of the Action Plan.

A big goal for the City is to see fewer people driving cars to reduce carbon emissions produced by vehicles. Street furniture plays a large role in supporting and elevating both bus ridership and active transportation– the assets involved include transit shelters, bike racks, and benches, each of which form an integral part of the experience. This report will explore some of the ways in which these assets contribute to the overall user-experience, and how these contributions impact the public's choice to utilize public and active transport.

The creation of new street furniture will utilize innovative materials that are now frequently employed in the construction of constructing buildings, extending successful development strategies from large to small scale. Sustainability and climate change, therefore, are inextricably linked and will be explored together throughout this report.

[19] Vancouver, City of. "Climate Emergency Action Plan." *City of Vancouver*, https://vancouver.ca/green-vancouver/vancouvers-climate-emergency.aspx.

MITIGATION AND ADAPTATION

In this report, strategies and opportunities for climate resiliency and sustainability will be viewed as opportunities for "mitigation" and "adaptation". Climate change is impacting communities now. All departments within the City need to consider how to reduce carbon output (mitigation) while also considering strategies to improve urban life in the present (adaptation).

MITIGATION STRATEGIES

Mitigation aims to reduce and stabilize greenhouse gases in the atmosphere that trap heat.[20] Broadly speaking, mitigation strategies are trying to slow down the rate at which the environment is impacted by changing the way we behave. Some such strategies are embracing renewable energy and retrofitting buildings to operate more efficiently.

In regard to street furniture, mitigation strategies would involve reducing dependencies on vehicles by increasing access to sustainable transportation through public transit, and active transportation like walking or biking. Mitigation strategies would also include the employment of greener construction practices such as recycling, building lighter, and aiming for net-zero builds.

ADAPTATION STRATEGIES

Adaptation refers to strategies that respond to the climate change effects already happening. These responses can target specific solutions, such as cooling centres, as well as broader schemes, like public health and emergency management planning. Adaptation is necessary because climate change is unavoidable and the damage to the environment thus far cannot be undone. Adaptation is therefore required in addition to mitigation to deal with present day impacts.

The Vancouver Climate Adaptation Strategy explains that *"Continuous learning and re-navigation is essential for adaptation planning given the underpinning of uncertainty and extended timelines prevalent with many climate drivers and impacts".*[21]

Adaptation is therefore an approach that must be nimble and flexible to allow for the unexpected weather events that climate change brings. It can be challenging to predict the occurrence of a flooding event or a heatwave, despite their suspected increase in frequency in the coming years. Adaptation provides an opportunity for the City to examine how street furniture, an essential thread in public infrastructure, can be woven into community resilience. Infrastructure that is built to create safety, comfort, and promote a healthy urban environment will contribute to the resilience required to navigate challenges, now and into the future.

[20] "Climate Change Adaptation and Mitigation." *NASA*, NASA, 18 July 2022, https://climate.nasa.gov/solutions/adaptation-mitigation/.

[21] *Climate Change Adaption Strategy - Vancouver*. https://vancouver.ca/files/cov/climate-change-adaptation-strategy.pdf.

RESILIENCE AND EQUITY

The City of Vancouver defines resilience as, *"…the capacity of individuals, communities, institutions, businesses and systems within a city to survive, adapt and thrive, no matter what kinds of chronic stresses and acute shocks they experience."*[22]

A resilient community is also equitable and inclusive. It provides access to vital infrastructure and services, enabling people to support one another. Working collectively to manage risks, shocks, and stresses will better equip the urban populous to adapt and recover from emergencies and difficulties.

Climate change in Vancouver will see the increased frequency and severity of climate related hazards, particularly: extreme heat events, flooding, wildfires and wildfire smoke events, and ozone air pollution. These events cause emergencies resulting in illness, injury and, for some, death. Anxiety, trauma, and other mental health issues will also be a significant result.[23]

Understanding our future weather events will enable us to be more proactive in planning for them, especially when it comes to the impact on public space and our options for its use. Climate change will impact if and how people are able to interact with infrastructure in the public realm through extreme weather events, especially transit-related use as extreme weather limits peoples' tolerance of outdoor exposure. Through utilizing both mitigation and adaptation strategies to guide our management of public spaces and infrastructural assets like street furniture, cities like Vancouver will be able to see the impact of immediate and long-term resilience in action.

The infographic below indicates the ways in which Vancouver will change in the next 60 years–this information is a crucial consideration when redesigning the public realm to adapt to extreme weather events. Some of the adaptation strategies listed are shaded areas, green roofs, and supports for vulnerable people during heat waves. These can be easily implemented in the urban environment and, in particular, in street furniture design.

[22] *Climate Change Adaption Strategy - Vancouver*. https://vancouver.ca/files/cov/climate-change-adaptation-strategy.pdf.

[23] Health, Vancouver Coastal. "Community Health and Climate Change." *ArcGIS StoryMaps*, Esri, 22 Aug. 2022, https://storymaps.arcgis.com/stories/7bf7141bb6fd41fb9b61a02cfbc61ecd.

Vancouver and Climate Change

The climate determines almost everything about how we design, build, and live in our cities. As the climate changes, the safety and prosperity of our cities is put at risk. Climate change is a challenge that requires us to work together, locally, nationally, and globally. With technical know-how, political will, targeted investments, and collective commitment, we can mitigate the severity of climate change and build resilience to its impacts.

Climate Change and Health

High temperatures in urban centres can be hazardous, especially for the elderly, the chronically ill, and those without air conditioning. High and prolonged heat can also impact air quality, facilitate the spread of harmful diseases, inhibit outdoor activities, and cause stress and anxiety. We can adapt with measures such as shaded areas, green roofs, and supports for those who need help during heat waves.

Climate Change and Oceans

Sea level rise threatens to overtake low-lying areas, increase coastal erosion, worsen storm surges, and pollute freshwater resources. Ocean acidification caused by rising carbon dioxide levels threatens marine life. Reducing greenhouse gas emissions can help to mitigate these impacts, but adapting to change will be essential for coastal communities.

Climate Change and Economics

Climate change will affect all sectors of the economy, but especially resource industries such as fishing and forestry. Research makes clear that there are enormous benefits to early investment in adaptation. Acting now will reduce economic risk and save on the rapidly increasing long-term damages and costs associated with climate change.

High-Carbon Climate Change Projections*

Change	1976-2005 Mean	2051-2080 Low	2051-2080 Mean	2051-2080 High
Typical hottest summer day	29.3 °C	30.5 °C	33.7 °C	36.9 °C
Typical coldest winter day	-8.3 °C	-7.6 °C	-2.1 °C	2.6 °C
Number of +25 °C days per year	18	43	72	100
Number of +30 °C days per year	1	2	16	35
Annual precipitation	1567 mm	1294 mm	1695 mm	2118 mm
Mean annual temperature	10.6 °C	12.8 °C	14.2 °C	15.5 °C
Number of below-zero days per year	30	0	5	15

[24]

Figure 28: Climate Atlas of Canada showing Vancouver's High-Carbon Climate Change Projections

[24] "Climate Atlas of Canada." *Climate Change in Canada*, https://climateatlas.ca/sites/default/files/cityreports/Vancouver-EN.pdf.

EQUITY

It is impossible to talk about climate change and climate resilience without looking at each through the lens of equity. This is because "*We know that the most vulnerable are at the greatest risk from climate change, and that they have done the least to cause it".* [25]

In 2021, 619 people died in an extreme heat event, aptly named the "heat dome", in Vancouver.[26] The most vulnerable people to heat- related illnesses and death are those with chronic health conditions, those living in poverty, and people who are socially isolated. This heat event was the deadliest weather event in British Columbia's history, and three times the amount of people in BC died than in Washington and Oregon combined despite the entire region battling extreme temperatures.[27] What we can learn from this is that emergency planning for climate change needs to happen on all levels. This report will further explore where equity plays a role in this effort as it relates to public infrastructure in the street right-of-way and beyond. The opportunity for street furniture in helping to combat the effects of heat and heat-related incidents will be described in subsequent sections.

In 2020, Vancouver Coastal Health (VCH) created heat maps to show vulnerability and sensitivity across the City of Vancouver. The colour gradient representing VCH's data demonstrates that the City needs to place a greater focus on protecting people in geographical areas that are most susceptible (the darkest colours indicate the highest temperatures.) This tool also shows layers of geographical *sensitivity,* where age and pre-existing health conditions play a factor in how susceptible someone is to a climate-related illness, injury, or death.

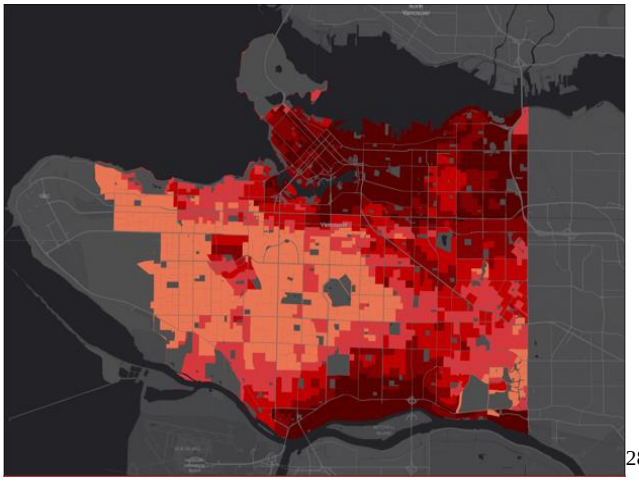
 [28]

Figure 29: Heat Vulnerability in Vancouver

[25] "Adaptation." *UN Climate Change Conference (COP26) at the SEC – Glasgow 2021*, 1 Nov. 2021, https://ukcop26.org/cop26-goals/adaptation/.

[26] Denis, Jen St. "One Year after Heat Deaths, Coroner Pushes for Change." *The Tyee*, The Tyee, 7 June 2022, https://thetyee.ca/News/2022/06/07/One-Year-After-Heat-Dome/.

[27] Denis, Jen St. "Inside June's Deadly Heat Dome. and Surviving the next One." *The Tyee*, The Tyee, 14 Mar. 2022, https://thetyee.ca/News/2022/03/14/Inside-June-Deadly-Heat-Dome/.

[28] "Vancouver Coastal Health: Heat Map." *Map Viewer*, https://vch.maps.arcgis.com/apps/webappviewer/index.html?id=e720500da7b24fcd984ed48ac1d63bfa.

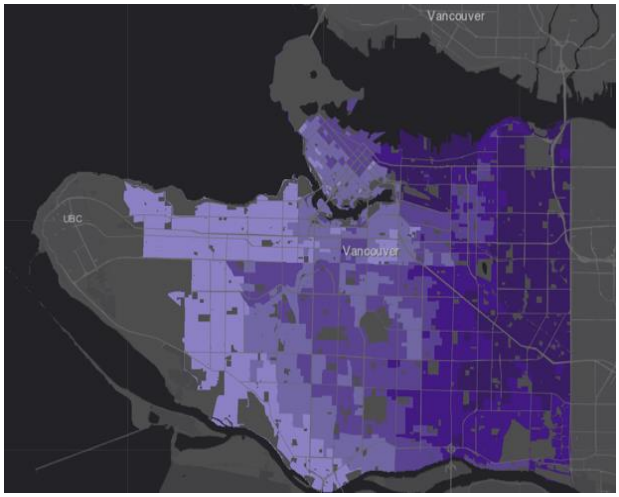


Figure 30: Smoke Vulnerability in Vancouver

Figure 31: Flooding vulnerability in Vancouver

Urban areas experience the Urban Heat Island (UHI) effect wherein the built environment contributes to unnaturally elevated temperatures. This is due to dark-coloured, impermeable surfaces such as roads and roofs. Furthermore, a lack of tree cover and shade contributes to the UHI, most often affecting the elderly[29], the disabled, those living in poverty, and those without homes.

In a memo to Council[30] regarding heat preparedness in Vancouver, short- and long-term actions for 2022 were identified and those that are most relevant to street furniture are:

1. Developing and implementing neighbourhood-based solutions in priority areas to improve heat-response infrastructure including indoor and outdoor cooling spaces (both civic and non-civic) and access to water. Spatial information, including but not limited to, temperature, heat vulnerability and demographics is being

[29] Atiya Mahmood, Gracen Bookmyer. "How to Save the People Most at Risk in Deadly Heat Waves." *The Tyee*, The Tyee, 20 July 2022, https://thetyee.ca/Analysis/2022/07/20/How-To-Save-People-Most-At-Risk-Heat-Waves/

[30] *Council Memo - Planning for Extreme Heat and Air Quality ... - Vancouver*. https://vancouver.ca/files/cov/2022-03-10-council-memo-planning-for-extreme-heat.pdf.

used to identify priority areas.

7. Working with partners such as the health authority and Environment and Climate Change Canada (ECCC) to ensure effective public communication of heat alerts and warnings.

10. Planting street trees in areas known to be heat islands, such as East Hastings, using Climate Levy funding approved by Council in the 2022 budget.

Proposed cooling spaces are an opportunity to employ street furniture such as misting and shade structures, as described below. Trees, in particular, are a natural shade-producing element that have the potential to alleviate the detriment of urban heat islands. Regarding effective public communications, emergency visual messaging can be incorporated through wayfinding or through digital ad panels.

The memo also includes an appendix that lists a number of existing actions and further considerations that are pertinent to street furniture:

> Shade and Seating: (Engineering) Parklets created for shaded seating with many collocated near spaces near social services as reflected in the Downtown Public Space Strategy (Places for People) and the Urban Forest Strategy.
>
> Water: (Arts, Culture and Community Services and Engineering) collaborating to identify locations for water assets through an equity framework. Water access created through temporary drinking fountains and handwashing stations.
>
> Washrooms: (ACCS, Parks and Engineering) expanded temporary washrooms and water stations in the Downtown Eastside and portable toilets in various locations.
> (Homelessness Services and Social Policy) Washroom Trailer Program

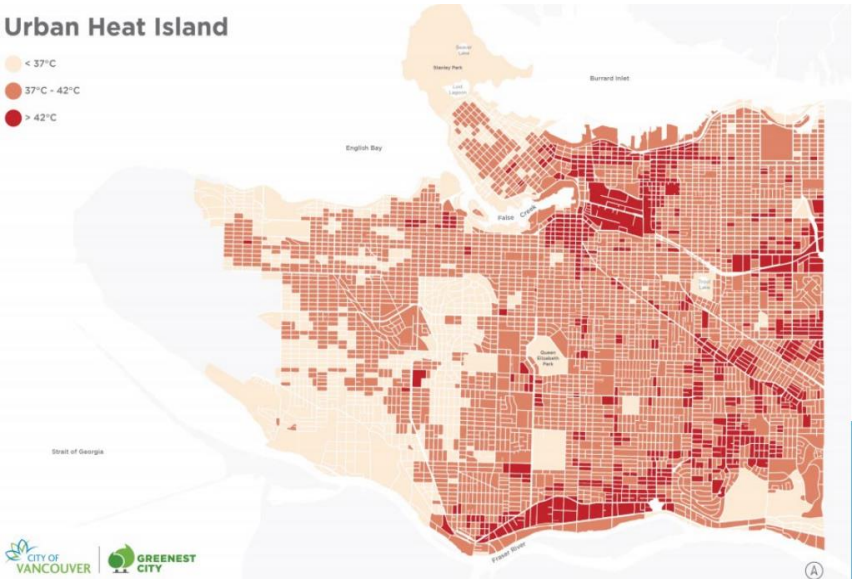
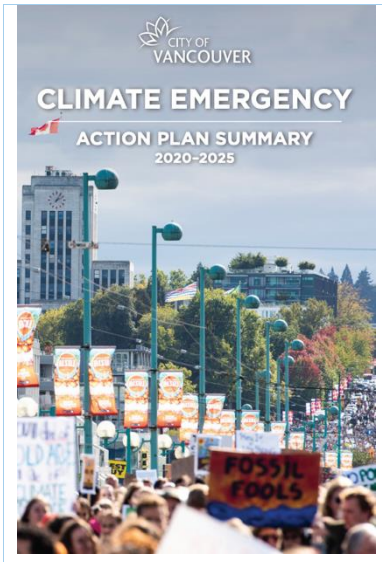


Figure 40: Urban Heat Island showing Vancouver's temperature Distribution[31]

[31] Health, Vancouver Coastal. "Community Health and Climate Change." *ArcGIS StoryMaps*, Esri, 22 Aug. 2022, https://storymaps.arcgis.com/stories/7bf7141bb6fd41fb9b61a02cfbc61ecd.

RELEVANT POLICIES, STRATEGIES: VANCOUVER

The City of Vancouver has issued a number of studies to explore the issues that climate change imposes on the land and the people of the City, and this section will look at some of the current policies, plans, and strategies that relate to street furniture and public amenities as they exist in both mitigation and adaptation.



Climate Emergency Action Plan

Vancouver is vulnerable to a wide variety of shocks and hazards, but our emergency plans can handle the vast majority of these situations by themselves. We must incorporate risk reduction and resilience into the future design as the frequency of incidents grows and as the growth of our city exposes more people to potential harm.

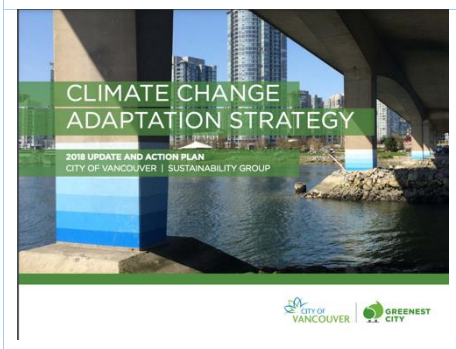
Carbon Capture: Vancouver captures carbon using its urban forest, which installed 150,000 trees from 2010-2020, and by rebuilding natural shorelines.

How we Move: A majority of the population should be able to get what they need within a short walk or roll by 2030. Two-thirds of all trips in Vancouver will include walking, biking, or using the bus.
Affordable, safe, and dependable sustainable modes of transportation will be readily available by the year 2030.

How we Build: By the year 2030:
- Zero-emissions structures will be available.
- More people will be educated and employed in low-carbon building and remodelling projects
- 2007 levels of carbon pollution from buildings for new buildings and construction projects to have 40% fewer embodied emissions than in 2018.

How we Construct and Renovate: A rise in the use of carbon-reducing technologies such as heat pumps, which may be reversed to cool a building in the summer.

Highest and Lowest Temperature Spikes By 2050, we can expect hot days to be 4^{O} Celsius hotter and more common, while the intensity of rainfall events will increase by 33–63 percent. Maintaining and regenerating natural systems, reducing the effects of climate change, protecting biodiversity, and developing an economy that benefits all people are all crucial to our resilience in the face of future shocks.



Heat-related illness is likely to become more common as heat waves become more common and last longer in Vancouver; higher summer temperatures may make some of the existing building stock uncomfortable due to the lack of air conditioning; temperatures will be amplified in urban areas due to the urban heat island effect; poor air quality days due to ground-level ozone2 and smoke.

Warm, wet winters can lead to flooding, resulting in damage to public and private buildings and infrastructure, an increase in the number of sewage backups
Rising sea levels can lead to more flooding along the coast and the Fraser River as a result of heavy rains, high tides, and storm surge in the winter. There will be effects on infrastructure, housing, parks, trails, and habitat.

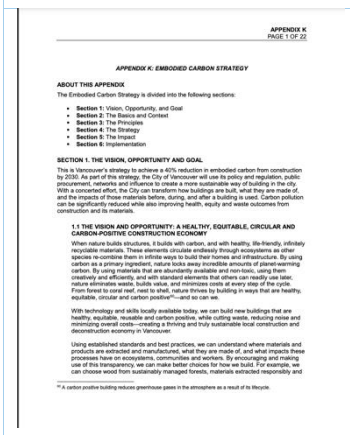
Vision: To ensure that Vancouver remains a livable and resilient city, maintaining its values, character and charm in the face of climate change.

Goals: Improve the resilience of constructed systems, ecological systems, and human systems to climate change; Incorporate a climate change adaptation lens into municipal planning, strategies, and policies; increase city staff members' awareness, knowledge, abilities, and resources to increase their ability for transformational change; increase opportunities for collaboration and coordination by creating networks and partnerships.

Climate Robust Infrastructure: The infrastructure of today will have to adapt to a wide range of conditions over its lifetime. In light of the ambiguity around the effects of climate change, it is prudent to create resilient infrastructure that can adapt to different future states. It has been demonstrated by the Pacific Climate Impacts Consortium (PCIC) that planning with future forecasts in mind outperforms using historical data in predicting future

Climate Change Adaptation Strategy

circumstances, even when uncertainty is present. With redundancy, variety, and asset management that considers emerging threats like climate change, the city is moving toward holistic integrated infrastructure planning.



APPENDIX K
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APPENDIX K: EMBODIED CARBON STRATEGY

ABOUT THIS APPENDIX

The Embodied Carbon Strategy is divided into the following sections:

- **Section 1:** Vision, Opportunity, and Goal
- **Section 2:** The Basics and Context
- **Section 3:** The Principles
- **Section 4:** The Strategy
- **Section 5:** The Impact
- **Section 6:** Implementation

SECTION 1. THE VISION, OPPORTUNITY AND GOAL

This is Vancouver's strategy to achieve a 40% reduction in embodied carbon from construction by 2030. As part of this strategy, the City of Vancouver will use its policy and regulation, public procurement, networks and influence to create a more sustainable way of building in the city. With a concerted effort, the City can transform how buildings are built, what they are made of, and the impacts of those materials before, during, and after a building is used. Carbon pollution can be significantly reduced while also improving health, equity and waste outcomes from construction and its materials.

1.1 THE VISION AND OPPORTUNITY: A HEALTHY, EQUITABLE, CIRCULAR AND CARBON-POSITIVE CONSTRUCTION ECONOMY

When nature builds structures, it builds with carbon, and with healthy, life-friendly, infinitely recyclable materials. These elements circulate endlessly through ecosystems as other species re-combine them in infinite ways to build their homes and infrastructure. By using carbon as a primary ingredient, nature looks away incredible amounts of planet-warming carbon. By using materials that are abundantly available and non-toxic, using them creatively and efficiently, and with standard elements that others can readily use later, nature eliminates waste, builds value, and minimizes costs at every step of the cycle. From forest to coral reef, nest to shell, nature thrives by building in ways that are healthy, equitable, circular and carbon positive[**]—and so can we.

With technology and skills locally available today, we can build new buildings that are healthy, equitable, reusable and carbon positive, while cutting waste, reducing noise and minimizing overall costs—creating a thriving and truly sustainable local construction and deconstruction economy in Vancouver.

Using established standards and best practices, we can understand where materials and products are extracted and manufactured, what they are made of, and what impacts these processes have on ecosystems, communities and workers. By encouraging and making use of this transparency, we can make better choices for how we build. For example, we can choose wood from sustainably managed forests, materials extracted responsibly and

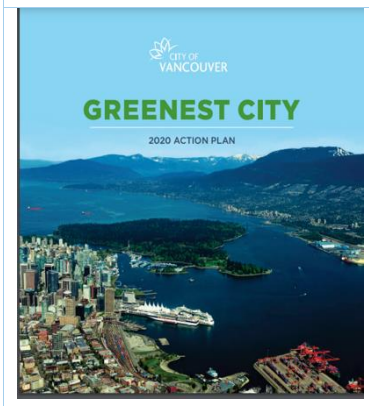
** A carbon positive building reduces greenhouse gases in the atmosphere as a result of its lifecycle.

Embodied Carbon Strategy

Vision: *"This is Vancouver's strategy to achieve a 40% reduction in embodied carbon from construction by 2030. As part of this strategy, the City of Vancouver will use its policy and regulation, public procurement, networks and influence to create a more sustainable way of building in the city.*

The city can make significant changes to construction practices, building materials, and the effects of these factors before, during, and after a structure's lifespan through coordinated action. Construction and its materials have an opportunity to drastically cut carbon pollution while simultaneously improving health, equity, and waste consequences. Using norms and best practices, we may learn about the origins of materials and goods, their composition, and the effects of production on ecosystems, communities, and workers.

Embodied Carbon Matters: Globally, construction accounts for 11% of annual carbon emissions, with concrete production accounting for 8%. 63 If the concrete industry were a country, it would be the third-largest emitter. These emissions are expected to grow in the coming decades as the global building stock doubles.



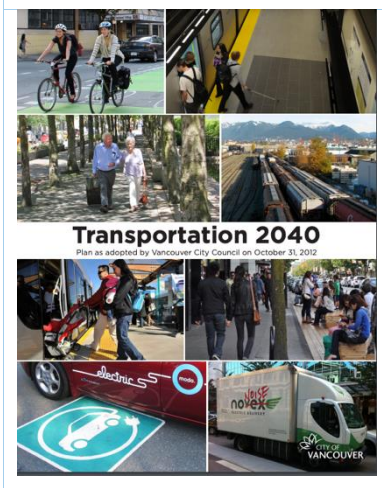
Greenest City Action Plan 2020

The city features what is likely North America's most environmentally friendly building code. Vancouver is rising to the challenge of green transportation by developing dense, walkable communities that facilitate commuting, shopping, and leisure. Instead of putting money into new highways, the city is now investing on pedestrian, bicycle, and public transportation infrastructure.

The ecological footprint of the people of Vancouver is three times higher than the planet can safely support. We consume significantly more than our fair share of Earth's resources due to the choices we make every day in how we get around the city, what we buy and eat, and how we dispose of our trash.

Target: Reduce 2007 community greenhouse gas emissions by 33%.

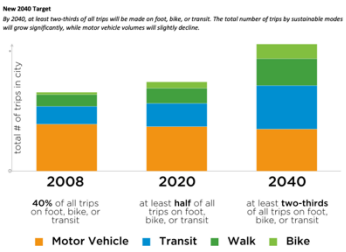
A person's standard of living can be greatly improved by improving their access to public transportation options in a city. The way we get around affects not just the air we breathe, but also the quantity of land we need, our physical health and well-being, and the price of gas.



Transportation Plan 2040

"By 2040, we envision a city with a smart and efficient transportation system that supports a thriving economy while increasing affordability; healthy citizens who are mobile in a safe, accessible, and vibrant city; and a city that enhances its natural environment to ensure a healthy future for its citizens and the planet."

The city's role in transportation includes Constructing and upholding public streets, sidewalks, and other city-owned public infrastructure.



Urban Forest Strategy 2018 Update

The tree cover in Vancouver has decreased from roughly 18% to 6% in the last century. The existing urban forest will be safeguarded through this strategy's four pillars: planning, regulation, education, and enforcement.

Due to uneven urban forest coverage, this plan prioritises tree planting in areas like the Downtown Eastside and Marpole. Planting trees is an efficient strategy for enhancing the standard of green space in congested urban neighbourhoods and so enhancing the health of the local population by decreasing summertime temperatures and air pollution levels. The Downtown Eastside, Marpole, False Creek Flats, and other high-need areas with little urban forest cover should have more street trees planted.

More and more people are beginning to understand the importance of urban forests to city health and sustainability. They contribute to Vancouver's "green infrastructure," which helps to prevent water from flowing into storm drains, remove pollutants from the air, cool the city during heat waves, provide habitat for birds and other species, and shade roadways and buildings. These ecological services are crucial to city life, just like the water, sewage, and road networks. As the consequences of climate change become more severe, the role of the urban forest will grow in significance.

Vancouver's urban forest helps achieve the Healthy City Strategy's three-pronged goal of improved human health, environmental sustainability, and social equity.

SUSTAINABILITY

EMBODIED CARBON

New buildings and infrastructure require the use of resources that have historically been very carbon intensive. “Embodied carbon” considers the total carbon footprint of a building or infrastructure project, from resource extraction to finished product. In the following section it is important to note that much of the information that exists regarding embodied carbon and sustainability refers to the construction industry and not necessarily the building of street furniture, although the materials used in both are likely sourced from similar vendors. The exact source of a vendor’s supply is beyond the scope of this project.

The studies cited in this report focus on the construction industry, as it is a significant contributor of C02 emissions, amounting to 40% of global C02 emissions. Of that 40%, one third is attributable to embodied carbon.[32] Although municipal bodies have made strides in creating efficiencies, such as using better insulation in buildings, sustainable design strategies, or LED lights for energy conservation, there has not been an equivalent focus on embodied carbon until now.

The World Green Building Council has created an extensive report for C40 cities, the results of which encourage the advancement of research towards a proactive approach to embodied carbon and the goal of net zero new builds, infrastructure, and renovations. Their studies also show what is necessary for new buildings, infrastructure, and renovations to utilize 40% less embodied carbon by 2030 with a significant focus on upfront carbon.[33]

[32] Pak, Anthony. “Embodied Carbon: Key Considerations for Key Materials.” *Canadian Architect*, 2 Nov. 2020, https://www.canadianarchitect.com/embodied-carbon-key-considerations-for-key-materials/.

[33] *Bringing Embodied Carbon Upfront - World Green Building Council*. https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf.

As seen in Figure 41, upfront carbon consists of the extraction of, raw materials, manufacturing, transportation and construction. In addition to upfront carbon, both operational carbon (the carbon emitted from the operation of the built asset, e.g., maintenance and use) and end of life carbon (the emissions created in the demolition and recycling or disposal of the built asset) contribute to embodied carbon.

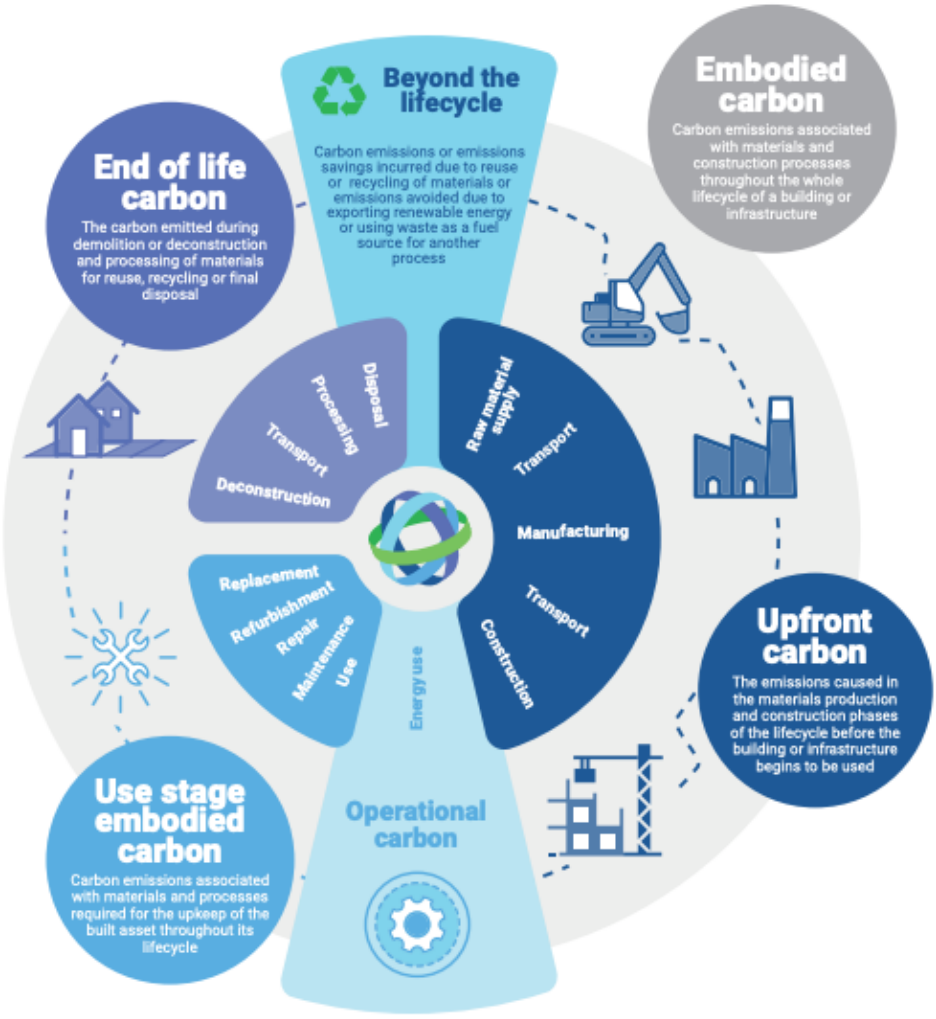


Figure 41: Project lifecycle showing both the scope of the definition and need for whole life consideration

A major takeaway from the World Green Building Council's report is the urgent need to reduce upfront carbon while working to create strategies to improve processes in the operational stage as well as the deconstruction/demolition, transport from site, waste processing and disposal phases for existing built assets. In this way, we can aim to achieve net zero embodied and net zero operational carbon. With current builds already in operation, we have the ability to reduce upfront carbon immediately by understanding materiality in construction and procurement while we work to improve the functionality of existing buildings. It should be noted that the initial product stage is the largest contributor to embodied carbon.

As it applies to street furniture, if new assets are built from scratch, the most sustainable impact will arise from sourcing sustainable materials and ensuring the design considers the deconstruction and end-of-life of the assets once they are no longer in use.

"*In one study, about 80% of embodied carbon from a new building is from the product stage, emitted before materials and products leave the factory. This means it is critical to reduce the amount of new material used, to use the lowest-impact materials… Approximately 10% comes from transportation to site and construction processes like excavation, meaning nearly 90% of embodied carbon today is upfront carbon"*[34]

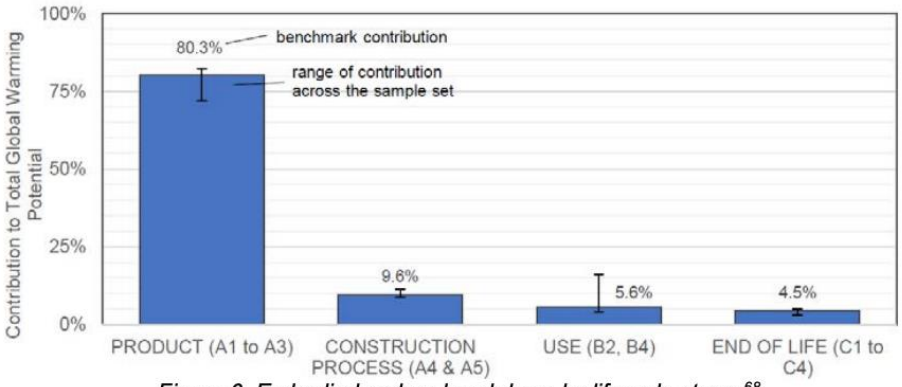


Figure 6: Embodied carbon breakdown by lifecycle stage.[68]

35

Figure 42: Embodied carbon breakdown by lifecycle stage

In order to meet the IPCC and City of Vancouver Embodied Carbon Strategy's 2030 goals, the City needs to work toward sustainability across all sectors. Even though street furniture production is relatively small in comparison with construction industry output, there is still a significant opportunity to contribute to embodied carbon reduction through this program. The scale of materials used in urban furniture is still substantial and sustainability need not only apply to the biggest industries for there to be an impact. Applying sustainability practices to a street furniture program is beneficial in a number of ways:

- It reduces reliance on unsustainable processes and practices
- It will have a positive environmental impact now and, in the future,
- It approaches the City's sustainability goals in a meaningful, immediate, and visible manner
- It creates a precedent for other cities to follow
- It also creates a precedent for other large contracts to reference when seeking successful examples of programs focussed on sustainability outcomes
- It can serve as a pilot program to experiment with sustainable materials and practices
- It encourages suppliers to source more sustainable manufacturers and processes

[34] *Www.athenasmi.org*. http://www.athenasmi.org/wp-content/uploads/2017/09/BC_MURB_carbon_benchmarking_final_report.pdf.

[35] http://www.athenasmi.org/wp-content/uploads/2017/09/BC_MURB_carbon_benchmarking_final_report.pdf

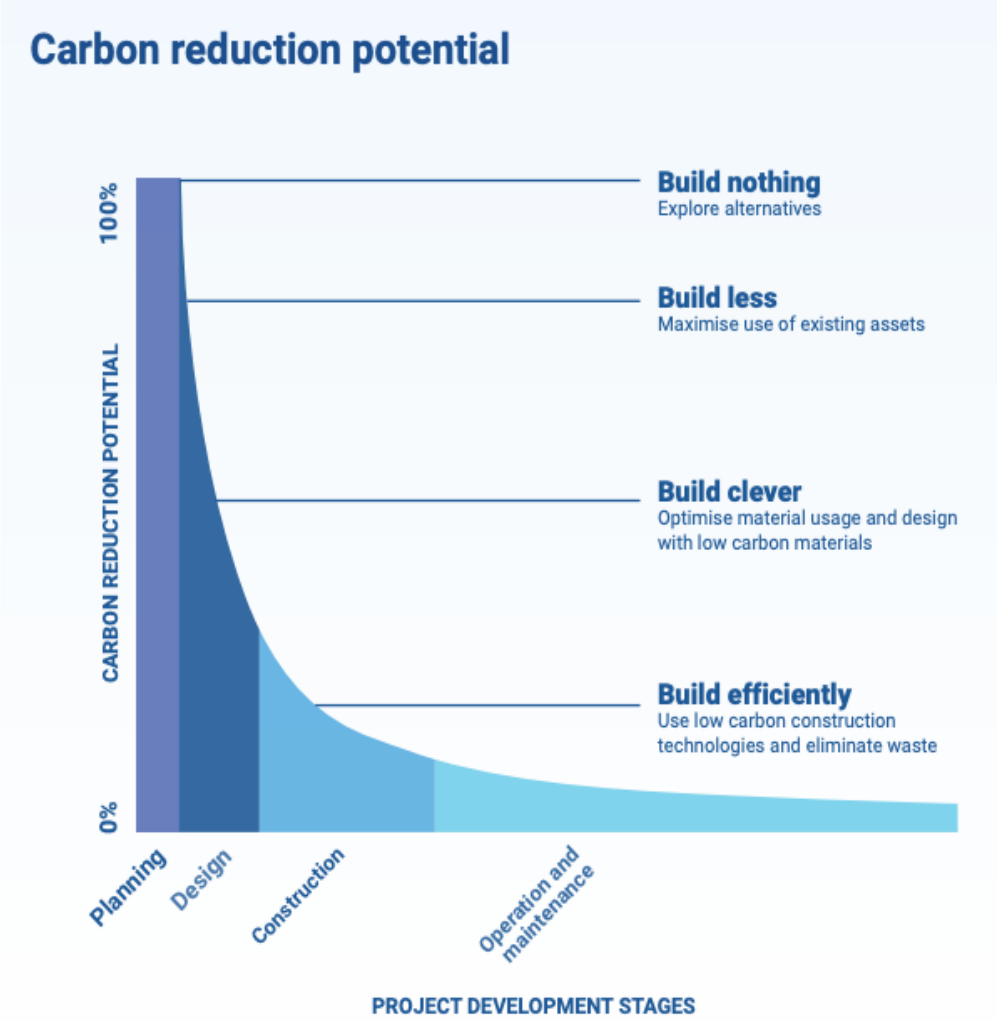


Figure 4: Opportunities to reduce embodied carbon from stage of design process.
Source: HM Treasury: Infrastructure Carbon Review, 2013

[36]

Figure 43: Opportunities to reduce embodied carbon from stage of design process

If we were to apply the carbon reduction potential model, pictured above in Figure 43, to the City's upcoming street furniture contract, the highest carbon reduction potential would be met by keeping all existing furniture in place. The next best option to reduce carbon would be to repurpose the materials. If the City was to build their own infrastructure they could do so sustainably by building "clever" and "efficiently". This means choosing construction processes and technologies that utilize lower carbon strategies.

Currently, the City's assets arrive pre-constructed by the vendor. If the City chooses to maintain this model of furniture procurement, the best solution might be to require vendors to commit to an embodied carbon reduction program. As a part of this City-vendor agreement, an additional requirement would be to demonstrate life cycle assessment planning.

[36] *Bringing Embodied Carbon Upfront - World Green Building Council.*
https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf

The Carbon Leadership Forum has created toolkits for designers/ architects[37] and also for policymakers[38] to further explore opportunities involving embodied carbon during the creation of new buildings and infrastructure, including "buy clean" strategies.[39] These tools will be very helpful for City staff to consider as they move further along with building infrastructure.

MATERIALITY

The Carbon Leadership Forum's research shows that upfront emissions from materials and products used in construction, as well as building maintenance and renovation, represent a significantly larger source of embodied carbon than other stages.[40] Their solutions- applicable to street furniture- include reusing existing buildings and structures; designing lightweight, efficient structures; selecting carbon-storing materials such as bio-based materials like wood; using salvaged materials; and designing for disassembly to enable recycling and/or repair. Another solution is selecting the most appropriate materials by optimizing the concrete mix to select a more sustainable option; sourcing responsibly harvested wood; and identifying embodied carbon as a priority.[41]

It is worth noting that durability of materials is extremely important in the public realm, and that in selecting materials, the cost and impact of replacing materials must be weighed against building for the duration of the structure's use.

LIFE CYCLE ASSESSMENT

Life Cycle Assessment, or LCA is a tool that can calculate embodied carbon by quantifying environmental impacts across a product or structure's entire lifecycle. It is a tool that monitors carbon emissions in addition to material, water, and energy use and allows us the opportunity to compare materials and processes using consistent metrics.[42] LCA is commonly referenced in the tools and guides listed below.

CEMENT, METALS, GLASS, AND WOOD

Cement, metals, glass, and wood are the main materials that make up street furniture in Vancouver. Two materials express emissions deemed "hard to abate" are concrete and steel. This is because they require very high temperatures to produce, and their manufacture directly releases carbon dioxide. These materials are used in very high quantities in construction and cement manufacture is responsible for approximately 7% of global carbon emissions and steel, 7-9%. Building and construction makes up 50% of these percentages. By

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[37] Andrew.himes. "AIA-CLF Embodied Carbon Toolkit for Architects." *Carbon Leadership Forum*, 9 Aug. 2022, https://carbonleadershipforum.org/architects-toolkit/.

[38] Andrew.himes. "CLF Embodied Carbon Policy Toolkit." *Carbon Leadership Forum*, 22 Aug. 2022, https://carbonleadershipforum.org/clf-carbon-policy-toolkit/.

[39] Andrew.himes. "5 - Guidance on Implementing Buy Clean." *Carbon Leadership Forum*, 12 Aug. 2022, https://carbonleadershipforum.org/guidance-on-implementing-buy-clean/.

[40] Andrew.himes. "Part 3 - Carbon Reduction Strategies." *Carbon Leadership Forum*, 19 July 2022, https://carbonleadershipforum.org/toolkit-3-strategies/.

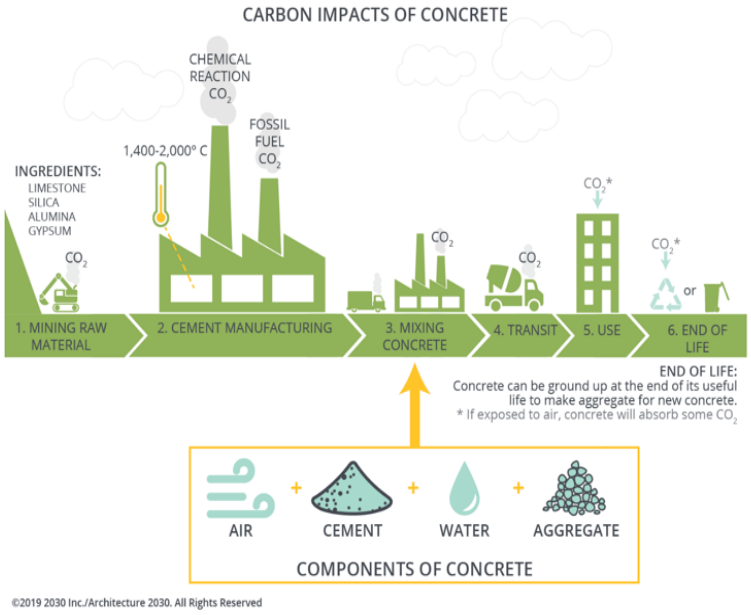
[41] Andrew.himes. "AIA-CLF Embodied Carbon Toolkit for Architects." *Carbon Leadership Forum*, 9 Aug. 2022, https://carbonleadershipforum.org/architects-toolkit/.

[42] *Bringing Embodied Carbon Upfront - World Green Building Council*. https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf.

2050, concrete consumption is projected to increase by 23% and steel by 30%.[43] These materials, therefore, need to be more sustainably sourced for the creation of street furniture or alternative options should be used.

Aluminum and glass also require high temperatures in their manufacture, with much of this energy supplied by fossil fuels.[44] Some materials–wood, bamboo, cork, and hemp–absorb carbon from the atmosphere at specific points in their lifecycle. Although deforestation is still a prevalent problem, sustainably harvested timber works to sequester carbon and offsets upfront carbon. [45]

The Architecture 2030 Carbon Smart Materials Palette is a tool that can be used to identify key attributes that contribute to a particular material's embodied carbon impact. The Materials Palette also offers options and guidelines for reductions of this impact, including information on low-carbon material alternatives.[46]



47

Figure 44: Carbon Impacts of Concrete

Regarding concrete, the Materials Palette offers solutions such as: decreasing the amount of concrete used, employing different mixes, using alternative kiln solutions, considering the mixing method, specifying stronger aggregates, and adjusting in the design guidelines.[48]

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[43] *Bringing Embodied Carbon Upfront - World Green Building Council*. https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf.

[44] *Bringing Embodied Carbon Upfront - World Green Building Council*. https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf.

[45] *Bringing Embodied Carbon Upfront - World Green Building Council*. https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf.

[46] "Actions for Reducing Embodied Carbon at Your Fingertips." *Carbon Smart Materials Palette*, https://materialspalette.org/.

[47] "Concrete." *Carbon Smart Materials Palette*, https://materialspalette.org/concrete/.

[48] "Concrete." *Carbon Smart Materials Palette*, https://materialspalette.org/concrete/.

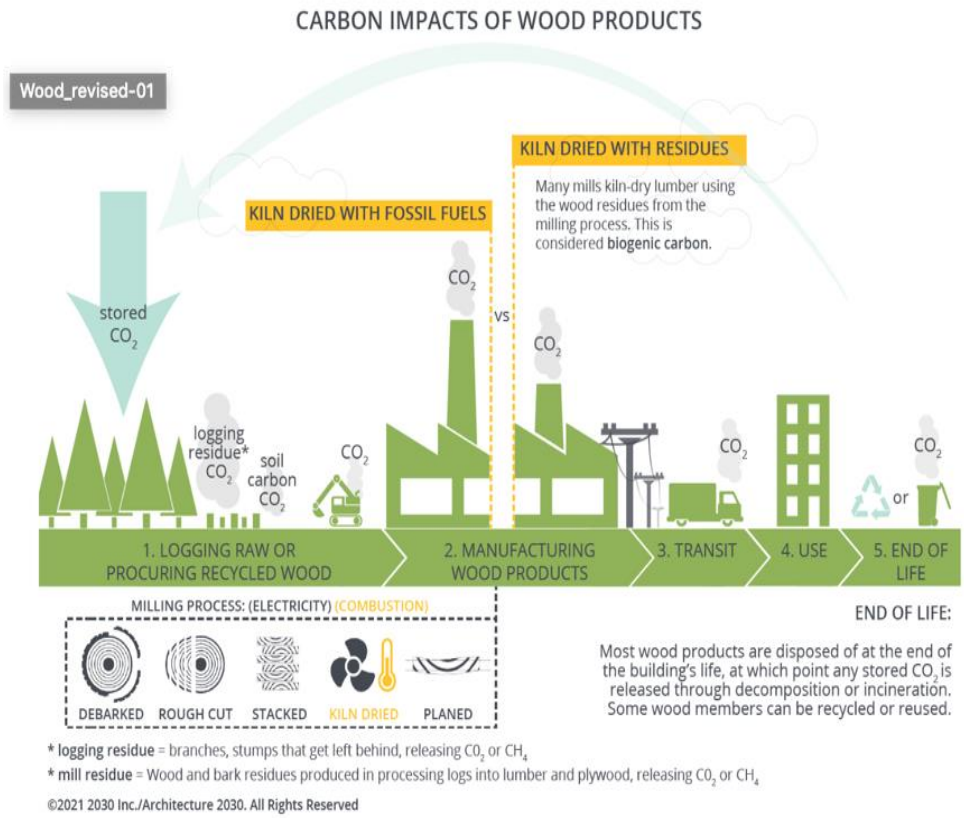


Figure 45: Carbon Impacts of Wood Products

The Materials Palette recommends that wood be sourced from climate-smart forests, reclaimed wood be used, locally harvested and manufactured products be specified, all products be air dried, and design prioritize longevity.[49]

[49] "Wood." *Carbon Smart Materials Palette*, https://materialspalette.org/wood/.

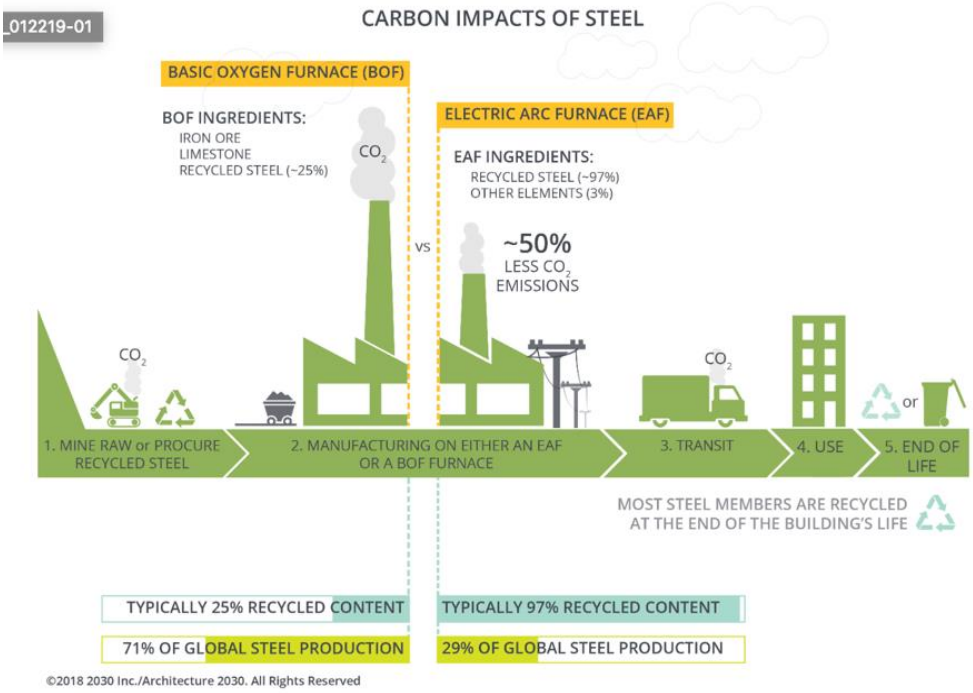


Figure 46: Carbon Impacts of Steel

The Materials Palette recommends that steel be sourced from electric arc furnaces, with recycled steel noted as a preference. Another recommendation is to utilize higher grade steel and lighter members than rolled shapes.[50]

The Building Transparency tool is an extensive and robust tool that can visually sort supply-chain specific material data to plan and compare buildings and reduce embodied carbon emissions.[51]
This is another tool that the City will be able to utilize in addition to the Architecture 2030 Carbon Smart Materials Palette to further investigate materials as plans develop for either building infrastructure or working with vendors to source the most sustainable choices.

[50] "Steel." *Carbon Smart Materials Palette*, https://materialspalette.org/steel/.

[51] *Building Transparency*, 29 June 2022, https://www.buildingtransparency.org/.

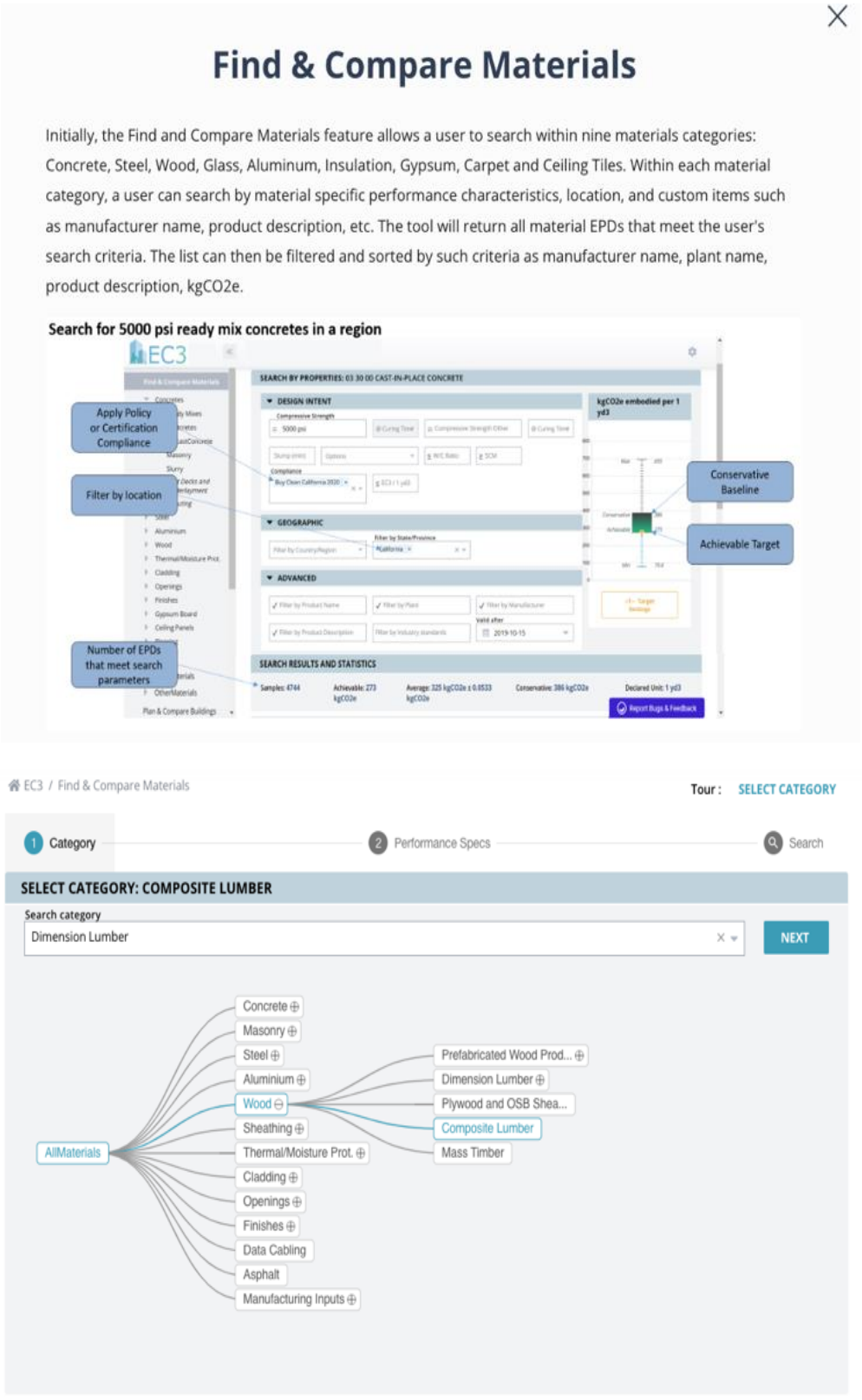


Figure 47 and Figure 48: Building Transparency tool

GLASS

Glass is used in transit shelters to improve sightlines, allow passengers to observe oncoming buses, and to protect people from inclement weather while letting in natural light. Glass is an excellent material in this regard, although glass production requires very high temperatures and is therefore very carbon-intensive.

5.8.3 Embodied energy/carbon of glass

Table 5.1 shows a comparison between the embodied energy and carbon values of glass and the two mostly-used construction materials, concrete and steel.

Table 5.1 – Embodied energy and carbon values of glass, concrete, and steel (Hammond and Jones, 2006)

Material	Embodied Energy MJ/kg	Embodied Carbon MJ/kg
Float Glass	15	0.232
Toughened glass	23.5	0.346
Reinforced concrete	1.39	0.057
Steel (Bar and Rod)	24.6	0.466

[52]

Figure 49: Table showing the embodied energy and carbon of glass in comparison to concrete and steel

The 2016 study, *Sustainability of Glass in Construction,* [53] notes that glass has a very high embodied energy unity per mass in comparison to concrete. As seen in Figure 49, Concrete's enormous global impact is greater than that of glass mostly due to the large volumes of concrete used in the construction industry. The study also points out that recycling glass sheets, often used in construction as windows, is rarely done because the energy to melt down and reproduce glass is similar to its initial creation. In addition to this challenge, there are complex considerations when recycling glass due to the coating with which sheet glass is usually treated, rendering it impossible to recycle. Thus, there are few energy and carbon saving opportunities for recycling sheet glass, unlike metals, glass bottles, plastic, and paper.

Although glass sheets are not recyclable, a significant opportunity for waste glass to be reused is to be added as an aggregate in concrete or asphalt mixtures.

[52] *Sustainability of Glass in Construction - Researchgate*. https://www.researchgate.net/publication/307584942_Sustainability_of_glass_in_construction.

[53] *Sustainability of Glass in Construction - Researchgate*. https://www.researchgate.net/publication/307584942_Sustainability_of_glass_in_construction.

Fig. 5.7 Use of glass aggregate in concrete

Fig. 5.8 Surface of a road constructed using glassphalt

Figure 50: Use of recycled glass in concrete and asphalt

GLASS VS PLEXIGLASS

Plexiglass looks similar to glass, although its composition and wear are distinct. Whereas glass is a natural material, Plexiglass is a type of acrylic glass made from plastic polymers. It is often used instead of glass as a shatter-resistant option that is lighter and cheaper. The choice between the two materials is a matter of preference and desired results, as well as budgetary liberties. Glass is used in transit shelters in Vancouver as opposed to Plexiglass. One of the main issues with any material in the public realm is vandalism and glass is particularly susceptible to this as it is relatively easy to damage compared to the steel structure of a transit shelter.

Numerous news stories have outlined the struggles cities have had with the defacement of transit shelters, costing municipalities like Kelowna thousands of dollars in damages.[54] In Calgary, Lexan and Plexiglass were tested as alternatives before the City returned to glass. The project revealed that Plexiglass discolours easily and can be burned or etched without much effort.[55] In Calgary, where vandalism spiked during the pandemic, pilot projects to deter defacement are underway.[56] Other cities prefer glass for various reasons. In Edmonton, the clarity and ability to clean glass over Plexiglas is valued,[57] even though the City is replacing

[54] Michaels, Kathy. "59 Kelowna Bus Shelters Hit by Vandals - Okanagan." *Global News*, Global News, 8 Mar. 2022, https://globalnews.ca/news/8666996/kelowna-bus-shelters-vandalism/.

[55] "Bus Shelter Vandals Strike during Pandemic Leaving 300 Unrepaired in Calgary | CBC News." *CBCnews*, CBC/Radio Canada, 20 Jan. 2022, https://www.cbc.ca/news/canada/calgary/calgary-transit-bus-shelter-vandalism-1.6318308.

[56] White, Ryan. "City Tests Stronger Materials to Deter Bus Shelter Vandals." *Calgary*, CTV News, 26 June 2014, https://calgary.ctvnews.ca/city-tests-stronger-materials-to-deter-bus-shelter-vandals-1.1886459.

[57] *Keeping Edmontons Bus Shelters In Top Shape Is a Big Job for Repair Crews*. https://edmontonjournal.com/news/local-news/keeping-edmontons-bus-shelters-in-top-shape-is-a-big-job-for-repair-crews.

glass every three days. Ottawa's decision to stick with glass is due to glass's clarity and resistance to melting and scratching.[58] Similar reasons exist in Halifax, in addition to glass breaking more safely than Plexiglass.[59]

Plexiglass is known to be easy to scratch, and has the propensity to become opaque when abraded, making it less effective than glass in providing visibility.[60] Further research could explore treatments or coatings to prevent discolouration in Plexiglass and fragility in glass.

[58] "Bus Shelter Vandalism Costs the City $225K | CBC News." *CBCnews*, CBC/Radio Canada, 5 May 2012, https://www.cbc.ca/news/canada/ottawa/bus-shelter-vandalism-costs-the-city-225k-1.1226006.

[59] "Halifax Transit Stands behind Glass Shelters after Vandalism Spree | CBC News." *CBCnews*, CBC/Radio Canada, 13 Mar. 2017, https://www.cbc.ca/news/canada/nova-scotia/halifax-transit-bus-shelters-glass-panels-smashed-vandalism-1.4022358.

[60] "Bus Shelters." *RSS*, https://www.pps.org/article/busshelters.

STREET FURNITURE APPROACHES

This section of the report features approaches and trends in street furniture and amenities approaches as they relate to climate resilience, sustainability, and equity. The approaches are representative of both mitigation and adaptation strategies. Many of these strategies overlap, as the solutions are integrated and holistic.

These approaches are presented as examples and case studies to illustrate what ideas are being considered, built, ideated, and prototyped for a variety of purposes and conditions. Furthermore, an examination of the external and climate influences that inspire these design interventions will be provided.

This report focuses primarily on transit-related street furniture as much of the research available addresses this particular asset as an effective option for how street furniture might contribute to climate resiliency and sustainability. Additionally, transit shelters are featured in this report because they are complex structures that require a multitude of very specific materials. Here, embodied carbon considerations will have the largest impact. This report also focuses on heat-related strategies as this is the deadliest climate-related issue that Vancouver is facing, and one where street furniture can make a significant impact.

CLIMATE RESPONSE AND ADAPTATION IN TRANSIT SHELTERS

In a 2020 study, "Heat-Moderating Effects of Bus Stop Shelters and Tree Shade on Public Transport Ridership", the impact of both heat and shade on transit ridership was examined in cities in the US, focusing on Austin, Texas.[61]

The author found although that ridership decreased with high temperatures in several cities, bus stops with shelters had more ridership during these warm days, in addition to days with cold temperatures and heavy precipitation, than the stops without shelter. The study also indicated that shelters are more likely to be installed in areas with higher household incomes. Tree canopy, which the study points out as an effective heat management strategy near bus stops, is inequitably distributed.

The study showed that warm temperatures correlated to a significant decrease in transit use, while the difference between warm and hot temperatures was a very insignificant decrease. When examining this discrepancy, the author found that for populations who are dependent on transit as their only transportation option, having trees or shelters will not influence ridership volume. It is those who have access to vehicles that can be swayed by a more enjoyable transit experience. *"Transit-dependent individuals have no choice but to use bus stops, regardless of whether shelters or nearby trees are present to provide respite from adverse heat conditions."*

If this is the case, then ridership numbers cannot be the sole indicator of whether or not a stop needs shelter. What this study shows is that people who are transit-reliant are going to use transit stops in all weather. To apply an equity lens, a city can determine where there is a distinct lack of cover, and determine how to create an equitable distribution of shade and cover to protect all riders.

[61] CP;, Lanza K;Durand. "Heat-Moderating Effects of Bus Stop Shelters and Tree Shade on Public Transport Ridership." *International Journal of Environmental Research and Public Health*, U.S. National Library of Medicine, https://pubmed.ncbi.nlm.nih.gov/33435530/.

Regarding Pacific Northwest climates, the author emphasizes that extreme heat is now becoming more prevalent, and infrastructure needs to adapt. Even in milder years, these regions should prepare for extreme weather events to help save lives. Trees and bus shelters are both solutions to issues caused by extreme heat, though each has pros and cons.[62]

One solution that is being explored in cities across the globe to increase climate resiliency and equity is the increase of ridership across all demographics. In order to pursue this resolution, the City needs to determine how to make ridership more enticing. Improving and increasing amenities may be the most effective way to accomplish the sought-after increase in ridership. The City plays a vital role in improving the waiting experience for transit users, promoting intermodal connectivity, and facilitating improved transit reliability through transit priority measures.

Transportation 2040[63] , commits the City of Vancouver to the following:

> "Provide safe and comfortable waiting areas at all bus stops where sufficient sidewalk and boulevard space exists. In locations where sidewalk space is too limited for a full shelter, pursue opportunities to locate amenities on private property."

The C40 Climate Leadership Group[64] recommends that in streets, transit routes, and corridors, cities implement the following:

> Cool pavements (with higher solar reflectance) on bus routes and waiting areas to lower surface temperature.
> Greening of transit routes: e.g., grass on tramlines to lower surface temperature, or street trees to create shade.
> Greening and shading of walking and cycling main access routes.

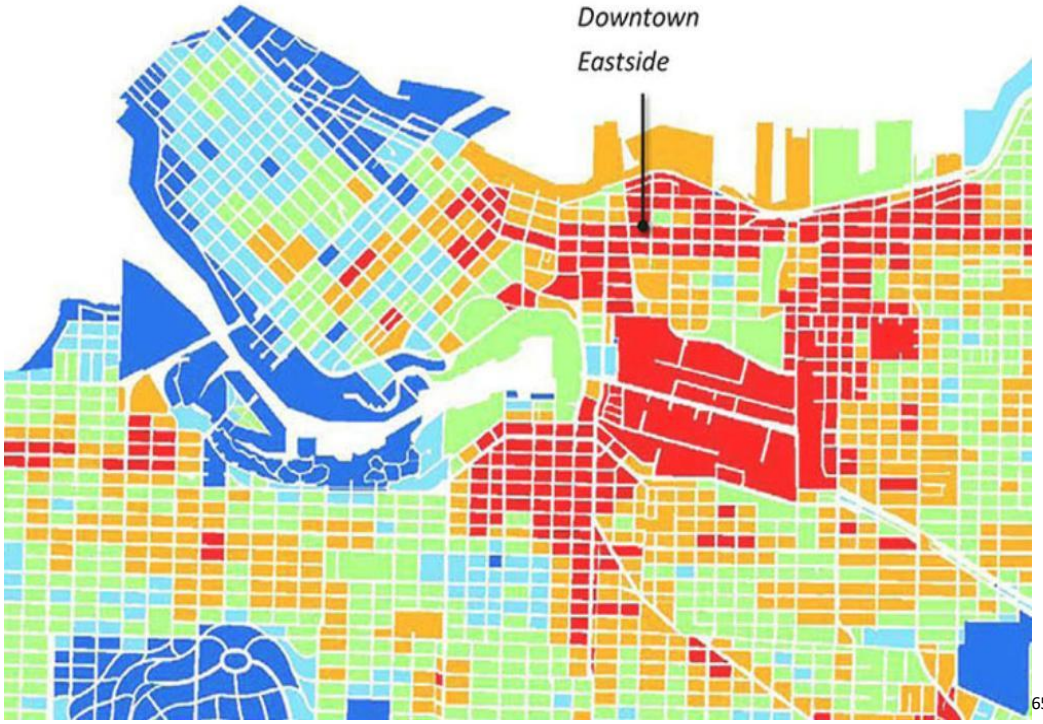
And specifically implementing the following at transit stations:

> Shading & greening of transit stations (e.g., green walls, cool roofs).
> Misting systems on waiting areas (however, being conscious about energy and water demands and the ability for riders to move away from the mist if they don't want it).
> Drinking water fountains.

[62] Baruchman, Michelle. "How Cities Can Help Protect Transit Riders from Extreme Heat." *The Seattle Times*, The Seattle Times Company, 23 Aug. 2021, https://www.seattletimes.com/seattle-news/transportation/how-can-cities-help-protect-transit-riders-from-extreme-heat/.

[63] Vancouver, City of. "Transportation 2040 Plan." *Transportation 2040 | City of Vancouver*, https://vancouver.ca/streets-transportation/transportation-2040.aspx.

[64] *Reducing Climate Change Impacts on Mass Transit*. 1 Dec. 2021, https://www.c40knowledgehub.org/s/article/Reducing-climate-change-impacts-on-mass-transit?language=en_US.



[65]

Figure 52: Map of Vancouver's shade distribution, where red areas are the least shady and blue are the most shady

Shade is a very effective way to reduce heat. Shade, whether manufactured or natural, can significantly reduce the temperature in comparison with surrounding areas. Access to shade, globally and especially in the built urban environment, is often an equity issue.

In some instances, removing shade is an example of hostile design. An example of this was in Pershing Square in Los Angeles, where, in 1951, trees were removed to prevent "deviants and criminals" from accessing the area. Los Angeles struggles with shade on an exceptional scale, where the tree canopy cover is about 10 percent, compared to 53 percent in the nearby Bel Air neighbourhood.[66]

Lack of access to shade might not always be the result of overt action like the example above; however, the evidence of heat-related issues among marginalized and racialized demographics is undeniable. Even though shade has historically been treated as such, it has never been a luxury, but rather a necessity. Considering extreme heat events, it is now a crucial part of our civic infrastructure.

[65] Cheung, Christopher. "Vancouver's Shady Inequality." *The Tyee*, The Tyee, 29 June 2021, https://thetyee.ca/News/2021/06/29/Vancouver-Shady-Inequality/.

[66] Bloch, Sam. "Shade." *Places Journal*, 1 Apr. 2019, https://placesjournal.org/article/shade-an-urban-design-mandate/.

SHADE: MANUFACTURED

While tree canopies are an excellent way to create shade, narrow streetscapes can't always accommodate trees themselves and often sufficient healthy soil to support them is lacking. Electrical and water lines can sometimes prevent trees from being planted as well. Trees need time to grow and thrive, making them good solutions for the long-term rather than for immediate climate adaptation. Street furniture that provides shade, whether a transit shelter or a purpose-built shade structure, can work to reduce heat until trees are mature enough to provide shelter. In areas where trees are not feasible, such structures are a particularly good option.

The following section provides examples of manufactured shade structures. A challenge for many cities is whether to create a single unified design across the urbanscape or to create site-specific interventions. A single design creates visual unity and can be more cost-effective when creating large orders, although they are less adaptable to a smaller site that might not be able to accommodate the design. Site-specific interventions can embody the identity of a neighbourhood and adapt more easily to a very specific area but can be more challenging to design and maintain.

An example of the latter is a pilot project in Los Angeles, as seen in Figure 53, that was created by a resident with the help of a technical school. It is designed to provide shade with the goal of sheltering many people at a transit island. [67] This intervention will remain in place until the city can formalize a permanent solution and demonstrates that there are some scenarios where adaptive measures can be implemented to meet urgent needs. This approach is not always possible or ideal, as seen in the bus shelter guidelines in a previous section where safety and logistics are the primary concern. Tactical interventions are therefore not always appropriate in the interest of public safety and lengthy engineering processes required for approval of each design.

Figure 53: Tactical intervention created by a citizen and technical school for a transit island

[67] Bloch, Sam. "Shade." *Places Journal*, 1 Apr. 2019, https://placesjournal.org/article/shade-an-urban-design-mandate/.

A quicker intervention, as shown in Figure 54, is something as simple as an umbrella as seen in another example from Los Angeles. “We need to start thinking of shade as a kind of infrastructure and from every angle. We plant trees to provide shade. We could design our street furniture so that it can provide shade.”[68] Los Angeles is a particularly hot city with very little shade and so tactical interventions such as these happen when there is a dire need.

Figure 54: A tactical intervention showing an umbrella installed on a bench at a bus stop

A solution that exists somewhere in the middle has been implemented in the City of Tempe, Arizona. They have a goal to shade every bus stop, whether by tree cover or man-made shelter. [69] Their approach is a singular design that is modular and includes solar power. This seems to be a good balance between the two extremes - a singular design that might not work in certain spaces, and an umbrella.

[68] Flores, Jessica. “LA's Answer to Scorching Sidewalks? Umbrellas.” *Curbed LA*, Curbed LA, 24 Oct. 2019, https://la.curbed.com/2019/10/24/20927608/umbrellas-bus-steps-los-angeles-shade.

[69] “City of Tempe, AZ.” *Transit Shelter Design Project*, https://www.tempe.gov/government/engineering-and-transportation/transportation/bus-light-rail-paratransit-streetcar/transit-shelters.

SHADE: TREES

Trees are an excellent source of shade. They also contribute to storm-water management, filter the air, provide shelter for biodiversity, buffer winds, and contribute to making people happier through biophilia.[70] Conversely, they are expensive to grow and maintain and can be challenging to plant after a streetscape has been designed with subterranean plumbing, electrical services, and poured concrete.

Neat Streets Miami recognized the danger of heatwaves for transit users and planted trees at 10 stops as a pilot project.[71] They also included public art in the process and held a haiku contest.[72]

> *The trees have also*
> *missed their bus — look how they wave*
> *their many sad arms*
> *— Ariel Francisco*

Trees are an ideal solution if they are feasible, although they require longer-term planning, special maintenance, and attention to unique pests and diseases. Ultimately, they demand careful consideration before being installed in the context of any urban environment.

TREES IN VANCOUVER

Although trees are not considered street furniture, they are an important element to consider in the planning of manufactured shade as a measure to combat climate-related impacts by street furniture. Trees are often planted in the street right-of-way and contribute to heat mitigation strategies by creating a cool, shaded environment. A pleasant streetscape makes street furniture, such as transit shelters, bike racks, and benches, much more enticing to utilize. As seen in (Figures 55 and 56), the tree canopy cools urban and residential areas significantly and areas with tree density are much cooler than those without.

Vancouver's Urban Forest Strategy provides examples of how planting trees can help to reduce the urban heat island, filter the air from vehicles on the road, and mitigate rainfall interception. These actions should be considered alongside street furniture strategies to maximize effects of climate adaptation and create a collaborative approach with street activities.

Strategy: Plant trees to support green infrastructure and reduce climate change impacts.

Action 16. Increase tree planting to create cool streets and parks where vulnerable populations are at risk from urban heat.
Action 17. Identify tree species, varieties, cultivars, or geographic seed sources that are suited for Vancouver's future climate.

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[70] "How Biophilic Design Is Making Humans Happier." *TerraMai*, 11 Aug. 2022, https://www.terramai.com/blog/biophilic-design-making-humans-happier/.

[71] *Guidelines for the Placement Growing Green Bus Stops of Trees at Curb ...* https://www.miamidade.gov/parks/library/growing-green-bus-stops.pdf. ttps://www.miamidade.gov/parks/library/growing-green-bus-stops.pdf

[72] *Growing Green Bus Stops - Miami-Dade County*. https://www.miamidade.gov/neatstreets/library/growing-green-bus-stops-bus-stops-haikus.pdf.

Action 18. Plant trees to strategically improve air quality, especially as buffers between residential areas and truck routes or arterial streets.
Action 19. Increase canopy cover in conjunction with green infrastructure initiatives to improve rainfall interception and infiltration.

One way to consider a holistic approach to shade by both trees and manufactured shade, is to consider a shade audit. The Region of Waterloo conducted a shade audit to map natural and manufactured shade within the City.[73] A helpful approach to ensuring equitable shade in Vancouver would be to conduct a shade audit and determine where shade can be provided, either by trees or manufactured shade structures, through street furniture.

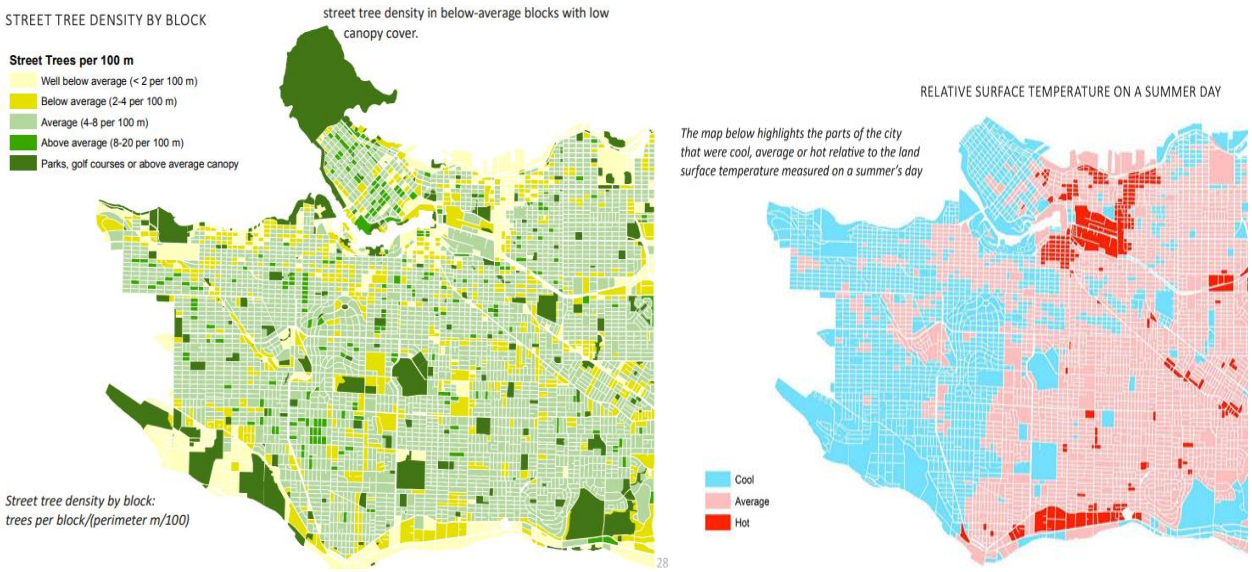

Figure 55: Street tree density by block in Vancouver
Figure 56: Reflective surface temperature on a summer day in Vancouver[74]

TECHNOLOGIES

In addition the higher level concepts of heat and shade, both natural and manufactured, there are many approaches to adaptation through technological interventions in street furniture. These approaches vary in effectiveness and maintain their own challenges. There is no one perfect solution for street furniture to address climate change impacts, and these opportunities offer an interesting approach that cities are taking to combat the worst impacts in their particular locations.

[73] "Region of Waterloo Shade Audit." *Region of Waterloo*, https://www.regionofwaterloo.ca/en/health-and-wellness/resources/Documents/ShadeAudit_GuideTool.pdf.

[74] *City of Vancouver Urban Forest Strategy*. https://vancouver.ca/files/cov/Urban-Forest-Strategy-Draft.pdf.

MISTING

Figure 57: A transit shelter with misting capability in Phoenix, AZ

In Climates that are extremely hot, misters are an option for transit shelters, ideally in addition to shade. The cooling properties of evaporating water are very effective. It is unclear as to whether transit users who do not want to be misted have shade to stand or sit beneath. This intervention is perhaps best suited where multiple shade options exist. Misting capabilities require connection to a water source – either plumbing or a water reservoir and pump. In cities that experience drought, this would be a challenge.

This Phoenix shelter (Figure 57) provided misting, ventilation, and shade, also included outreach to inform citizens about cooling centres as part of their HeatReady program. [75]

[75] "Misted Bus Shelter Installed near Uptown Phoenix." *City of Phoenix*, https://www.phoenix.gov/newsroom/public-transit/367.

Figures 58 and 59: Misting at a transit shelter in Chongqing, China

In Chongqing, China, (Figures 58 and 59) misters that are designed to spray chilled vapour are installed in bus shelters to cool off bus riders. The system is currently in a trial phase at four busy downtown bus stops and there are plans to expand the coverage to a total of 30 stops in the city center, operational in daylight hours.

In Victoria, British Columbia, misters are installed onto fire hydrants, (Figure 60) which create cooling spots without having to install additional plumbing or transport water in a tank.[76]

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[76] Chan, Adam. "Victoria Opens 14 Misting Stations amid High-Temperature Warnings." *Vancouver Island*, CTV News, 25 July 2022, https://vancouverisland.ctvnews.ca/victoria-opens-14-misting-stations-amid-high-temperature-warnings-1.6001725.

Figure 60: A misting station incorporated into a fire hydrant in Victoria, BC

Fire hydrants can be adapted to supply water for water stations such as this example (Figure 61) in Edmonton, Alberta. Fire hydrants offer an excellent opportunity to create water access because they already exist in the street right-of-way and are connected to the city's plumbing.[77]

Figure 61: A fire hydrant that connects to a drinking water station in Edmonton, AB

[77] "Extreme Weather Response." *Extreme Weather Response | City of Edmonton*, https://www.edmonton.ca/programs_services/emergency_preparedness/extreme-weather.

GREEN AND COOL ROOFS:

An effective way to lower urban temperatures is to remove dark, impermeable surfaces wherever possible. An excellent opportunity exists on unutilized roof tops. There are two popular strategies – green and cool roofs.

A green roof is either a permanent rooftop planting system or some sort of vegetative cover. In addition to reducing the urban heat island effect, these roofs can support biodiversity, absorb pollutants and C02, and increase stormwater retention.

Cool roofs are made of highly reflective materials and are very effective at cooling the interior of a building. According to the authors of *Economic comparison of white, green, and black flat roofs in the United States, Energy and Buildings,* cool roofs are three times more effective at cooling than green roofs and are often more cost effective than green roofs. Cool roofs, however, do require more maintenance than green roofs because frequent power washing must be employed to maintain the solar reflectivity properties.[78]

Green roofs in Rotterdam experiment with normalizing the idea through small scale projects and getting temporary buy in before the idea becomes the norm.[79] What the Rotterdam example exemplifies, is that cities can look to greening their street furniture shelter roofs to help the idea become more widely accepted in larger building rooftops. This is an example of a mitigation as well as an adaptive strategy because it provides the climactic benefits immediately and creates familiarity of the process for future projects at a larger scale. The maintenance needs of green roofs in Vancouver would be helpful to explore further, although with extensive rainy seasons, this strategy could work well.

[80]

Figures 62, 63: Green roof installed on a transit shelter in Utrecht, The Nederlands

[78] Sproul, AuthorsJulian, et al. "Economic Comparison of White, Green, and Black Flat Roofs in the United States." *HEATISLAND*, https://heatisland.lbl.gov/publications/economic-comparison-white-green-and.

[79] *What the City of Rotterdam Can Teach Us about the Power of Green Roofs*. https://nextcity.org/urbanist-news/what-the-city-of-rotterdam-can-teach-us-about-the-power-of-green-roofs.

[80] *Sempergreen*, https://www.sempergreen.com/en/about-us/news/green-bus-stops-ensure-a-future-proof-city.

Figure 64: Green roof installed on a transit shelter in Derby, UK.

Derby, UK is utilizing their bus shelter roofs to create spaces for native plantings that will attract bees and other pollinators. The impetus is to create beautiful structures that also absorb rainwater and showcase green solutions. Derby is home to the UK's largest network of living roof shelters, and where there are no green roofs, solar panels power low-energy smart lighting.[81]

These examples are opportunities to consider for underutilised real estate - transit shelter roofs. Considering that Vancouver has a very rainy climate, green roofs might be an easier mitigation solution than solar power.

SOLAR

Power in transit shelters is needed to generate lighting, as well as supply energy to electrical ad panels and digital bus schedules. Access to the power grid is a factor in determining where a transit shelter is placed. A huge benefit of solar powered street furniture is that it does not require electrical wiring connected to the city grid. This means that furniture may be installed in places where electrical connection is a challenge. With batteries and technology improving every year, even dark and rainy climates will benefit from solar power.

Solar power is also very expensive upfront, and additional costs stem from battery banks and charge controllers. [82] They also require regular maintenance and could become a large expense to maintain if subjected to consistent vandalism.

[81] Derby City Council, Council House. "Bee-Friendly Bus Shelters Coming to Derby." *Bee-Friendly Bus Shelters Coming to Derby - Derby City Council*, https://www.derby.gov.uk/news/2022/march/bee-friendly-bus-shelters-for-derby/.

[82] "Solar Power ." *BC Hydro - Power Smart*, https://www.bchydro.com/powersmart/residential/building-and-renovating/switch-to-solar-energy.html.

Some cities are employing solar power in their transit shelters. Edmonton, for example, has had solar-powered transit stops since 2012.[83]

The Telford shelter[84] depicted in Figure 65 will be powered by both wind and solar. The shelter will be off-grid and produce enough electricity to power both its lights and advertising panels. This pilot project aims to not only produce cleaner energy, but also to do so to reduce the bus fare prices in an effort to encourage bus ridership. With solar being an expensive upfront cost and susceptible to vandalism, it would be worth exploring the methods employed by cities like Edmonton.

Figure 65: A wind and solar-powered transit shelter in Telford, UK

SMART TECH

Smart tech is becoming more abundant in the public realm. The promise of smart tech in public spaces is that real-time data capture could assist with planning or maintenance efforts such as a sensor that indicates when a garbage can is full, or to count how much an item of furniture is used, whether it is damaged, or to adjust lighting. Smart tech can even be integrated into street furniture to provide services such as WIFI, emergency buttons, wayfinding, or charging stations. In the case of a transit shelter, smart tech expands the idea of a transit shelter as merely a place to wait for the bus, and it becomes a multi-use function. As space becomes more of a commodity with population growth and increased urbanization, there are ways for this type of approach to benefit those in the public realm.

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[83] Edmonton, City of. "Solar Bus Shelters." *Change for Climate*, https://changeforclimate.ca/story/solar-bus-shelters.

[84] "UK's First Wind and Solar Powered Bus Shelter Arrives in Telford." *ETESIAN GREEN SHELTERS*, 3 Sept. 2021, https://egshelters.com/uks-first-wind-and-solar-powered-bus-shelter-arrives-in-telford/.

Figure 66: The award-winning design for the new City of Miami transit shelter

The City of Miami proposed to adopt a new bus shelter design and the chosen design, (Figure 66) a winner of the reddot design award,[85] will include solar power, real-time bus arrival information, passenger security systems, and tempered glass frame with awning for protection against the elements. The City aims to install 300 shelters that would be different sizes depending on available space. As of 2020, their original solicitations received no bidders and industry leaders cited cost and lack of flexibility as the main deterrents.[86]

There are also adverse effects where data collection and commodification can become invasive and so cities incorporating smart tech are advised to find a safe balance between providing cities with useful information and protecting users' data.[87]

[85] Dot, Red. "Pininfarina Bus Shelters for the City of Miami Beach." *Red Dot Design Award: Pininfarina Bus Shelters for The City of Miami Beach*, 31 Aug. 2022, https://www.red-dot.org/project/pininfarina-bus-shelters-for-the-city-of-miami-beach-40374/.

[86] "Classy Miami Beach Designer Bus Stops Get No Operator Bids." *Miami Today*, 15 Sept. 2020, https://www.miamitodaynews.com/2020/09/15/classy-miami-beach-designer-bus-stops-get-no-operator-bids/.

[87] Justine Humphry Senior Lecturer in Digital Cultures, et al. "Smart Street Furniture in Australia: A Public Service or Surveillance and Advertising Tool?" *The Conversation*, 4 Aug. 2022, https://theconversation.com/smart-street-furniture-in-australia-a-public-service-or-surveillance-and-advertising-tool-157424.

Figure 67: Solar power on the CAPS shelter in Sydney, Australia

The Climate Adapted People Shelters (CAPS) project was a design competition that intended to create a transit shelter focussing on climate adaptation during Sydney's extreme heat events. It involved many stakeholders, and eight potential site options were identified for the pilot program.

The winning team, MM Creative chose to place their shelter design at a bus stop in the city of Penrith, New South Wales. The shelter site is located across the road from Nepean Hospital and is often used by elderly and disabled people. "*Commuters told us that the direct sunlight and lack of shade led people to wait inside the medical centre behind the bus shelter, which had air conditioning", MM Project Manager Liam O'Brien said. "This often resulted in them missing the bus. The elderly in particular struggle to make the bus when it arrives*."[88]

The shelter also featured ventilation through a beautiful design, employing passive design techniques as well as solar power to support the LED lighting. The insulated and expanded roof had significant thermal effects, demonstrating that the CAPS shelter was up to 4°C cooler than the older style bus shelter. Similarly, the older style shelter had higher roof temperatures for most of the day, with peak temperatures of up to 15°C higher than the CAPS shelter.

This design also incorporated smart sensor technology to capture climate data.[89] Smart sensors are a part of street furniture in several Australian cities to better assess what design adjustments are needed in service of the public. This includes feedback regarding temperatures, shade, moisture, lighting, and ventilation. Here, the concept relies on sensors indicating when a shelter is too dark, thereafter adjusting lighting in real time. If consistent data shows high temperatures, then the design of the shade structure can be reconfigured to better cast a shadow. If a green roof is installed, a moisture sensor could activate a watering system.

The CAPS project received feedback that users experienced heightened enjoyment of the visual aesthetics and appreciated the increased sun protection with the shade provided by an extended roof. Seniors appreciated the mobility considerations with additional handles on the seats.[90]

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[88] "Penrith Bus Shelter Beats the Heat." *WSROC*, https://wsroc.com.au/media-a-resources/wsroc-news-stories/penrith-bus-shelter-beats-the-heat.

[89] *Climate Adapted People Shelters: Field Assessment*. https://www.uts.edu.au/sites/default/files/article/downloads/CAPS%20final%20report%20220218.pdf.

[90] *Climate Adapted People Shelters: Field Assessment*. https://www.uts.edu.au/sites/default/files/article/downloads/CAPS%20final%20report%20220218.pdf.

Figure 67: Original shelter shown beside the revamped, CAPS shelter

A study, *Using smart technologies for climate change adaptation in Western Sydney: A CAPS Research Report Final Report,* captures the findings of the CAPS project and other smart tech in transit shelters and expands on extended service provision at bus shelters.[91]

"A major emerging trend in the design of bus shelters is the integration of other services that may not be immediately related to public transport functions and that are not necessarily connected to smart or digital technologies. Case studies in Paris London show how bus shelters with sufficient space available can incorporate bike sharing stations and/or recharge stations for electric bikes/cars. The Millennial Bus Stop prototyped in Saint Paul, Minneapolis, and the Project Bus Stop in Singapore, instead, feature bike racks as an integral part of the shelter design."

The study also points out the transit shelters are particularly adept at mitigating and adaptive strategies because they are wide-spread and because of their data capturing abilities about the microclimate in real time. The opportunity for cities to install data sensors in transit shelters means that qualitative data will generate to help inform planning decisions and assist with climate adaptation. If an air pollution sensor showed high levels in a particular intersection, for example, trees or shrubbery could be planted, or air filters installed in that particular area.

Transit shelters are uniquely positioned to broadcast emergency information and even incorporate emergency summoning technology. In extreme cases, shelters can provide air conditioning or even cool/ green roofs. Air filters and misting systems can be added or heaters in extreme cold, as seen in the examples below.

[91] Barns, Sarah. (2017). Using smart technologies for climate change adaptation in Western Sydney: A CAPS Research Report Final Report. 10.13140/RG.2.2.18671.48803.
https://www.researchgate.net/publication/331908423_Using_smart_technologies_for_climate_change_adaptation_in_Western_Sydney_A_CAPS_Research_Report_Final_Report.

Figure 68: The City Air Purification System prototyped in Hong Kong

In China, only eight out of seventy-four cities surveyed met basic national air quality standards, and some cities are exploring novel solutions. The City Air Purification System (Figure 68) was designed as a prototype transit shelter to filter pollutants as fine particulates that can be monitored remotely. The system is currently in use in Hong Kong with plans to test the system at a Beijing university and potentially expand to more cities.[92]

[92] "Outdoor Air Purifier." *Tech in Asia - Connecting Asia's Startup Ecosystem*, https://www.techinasia.com/outdoor-air-purifier-wait-bus-40-smoggy#!

AIR POLLUTION: FREESTANDING GREENERY

Innovations exist globally to introduce the air filtering and biophilic benefits of plants where trees are not feasible. These can be combined with seating.

Figure 69: The City Tree, an urban air purifier that incorporates seating

The product illustrated above in Figure 69, called the City Tree. This particular product claims nitrogen dioxide absorption capacities equivalent to 275 trees. It also has seating incorporated, as well as Wi-Fi, charging capabilities, and solar -powered sensors that can detect lack of humidity and if needed, activate the water pump that lives behind the moss walls and cools the area in a 5m radius. The product is currently piloted in Paris, Oslo, Berlin and Brussels where there are reductions in nitrogen of 15%. Brussels, noticing higher than normal temperatures, required additional water for the irrigation system after sensors detected low humidity.[93]

[93] Admin, Concerto. "When Urban Furniture Absorbs the Pollution." *Divercity*, 23 Aug. 2017, https://www.divercitymag.be/en/when-urban-furniture-absorbs-the-pollution/.

Figure 70: the Canopee creates a freestanding shade canopy with incorporated irrigation

Similarly, the Canopee, seen in figure 70 introduces living plants where perhaps trees are not feasible. This particular product will create a shade canopy as well with a minimal footprint. The Canopee is installed in cities such as Paris, Marseille, Bordeaux and Nantes, as well as in Spain, Morocco, the Gulf States and recently in Australia. The system also captures rainwater and irrigation is remotely controlled using humidity sensors. The product is also powered by solar energy.[94] This design would be useful in areas where pollution is high, shade is needed, and the space would benefit from biophilic elements.

[94] "Urban Canopée: Cooling down the City by Greening up - Plastics Le Mag." *Nom Du Site*, 18 Jan. 2022, https://plastics-themag.com/Urban-Canopee:-cooling-down-the-city-by-greening-up.

As stated, according to the C40 leadership group, cool pavements could be considered on bus routes and waiting areas. This approach to heat adaptation aims to try cool streets by reflecting heat and solar radiation off of the pavement. The theory is that reflective paint will divert radiation and thereby cool the urban heat island.

This strategy is being explored in Los Angeles by the Streets Department. They began a pilot program, using solar reflective coatings in residential blocks, in 2017. The goal is to decrease the city-wide average temperature by 1.7°C by 2035. This is a strategy that is being used alongside cool roofs and green infrastructure.

In a study done on this program, *Solar reflective pavements—A policy panacea to heat mitigation?,* the findings indicate that the coating does not work on its own and requires additional shade interventions to maximize the effect. [95] The findings also show that in the late afternoon, asphalt concrete reduces heat to cement concrete temperatures, however, the human heat load increases.

Figure 71: Solar reflective pavement coatings showing the difference between absorbent dark asphalt and light-coloured, reflective treatment

Critics of the plan talk about the reflective energies being absorbed by humans that walk on them, up to 7° warmer than blacktop.[96] It seems that the surface works best alongside additional strategies such as shade from tree cover.

[95] *Solar Reflective Pavements—a Policy Panacea to Heat Mitigation?* https://iopscience.iop.org/article/10.1088/1748-9326/ab87d4/pdf.

[96] "Reflective Pavement May Be Less Cool than It Seems." *Bloomberg.com*, Bloomberg, 3 Oct. 2019, https://www.bloomberg.com/news/articles/2019-10-03/reflective-pavement-may-be-less-cool-than-it-seems.

BEAUTIFUL DESIGN AND PLACEMAKING

"Placemaking is turning a public space from a place you can't wait to get through, to one you never want to leave." Fred Kent, Founder of Project for Public Spaces.

Beauty and good-looking design should not be disregarded as a "nice to have". Attractive design is a vital part of placemaking which becomes an important part of social resilience.[97] When people feel connected to their place, they are naturally more invested in it, and by proxy, their neighbours. When spaces increase the ability for people to connect, they do so, and community grows around shared experiences and places.

"Place is a key asset we can leverage to increase resilience. Our buildings and open spaces are the contexts in which stronger bonds, trust and human networks are built. The shape of space can increase the likelihood of social interactions and places can reflect the identity of a neighborhood, increasing pride and identification with place."[98]

Though creative placemaking is usually executed through tactical urbanism and more informal interventions, even a large street furniture contract can include elements of placemaking into street furniture assets. For example, through public art, biophilia, and creative community engagement. Public art is easily incorporated into street furniture to enhance cultural and spiritual value and can offer opportunities for education and relationship building.[99]

Image 72: Bench in Vancouver that includes public art[100]

97 "Public Furniture in the Art of Placemaking." Green Furniture Concept, 2 Aug. 2022, https://greenfc.com/stories/public-furniture-in-the-art-of-placemaking/.

98 Cities Building Community Wealth. https://community-wealth.org/sites/clone.community-wealth.org/files/downloads/CitiesBuildingCommunityWealth-Web.pdf.

99 Friedman, Avi. "Public Art and Street Furniture." SpringerLink, Springer International Publishing, 1 Jan. 1970, https://link.springer.com/chapter/10.1007/978-3-030-60865-1_31.

100 Friedman, Avi. "Public Art and Street Furniture." SpringerLink, Springer International Publishing, 1 Jan. 1970, https://link.springer.com/chapter/10.1007/978-3-030-60865-1_31.

For more quantitative evidence of the effects of beauty in an urban environment, a study on public transit infrastructure, *Public transit infrastructure and heat perceptions in hot and dry climates,* showed that the perception of a bus stop's pleasantness and beauty were significantly related to thermal sensation perception. In this instance, beauty is defined as aesthetically pleasing with artistic attributes and vegetation. Pleasant is more indicative of availability of seating, a back wall, and shade.

"Perception of stop beauty had a stronger influence on thermal sensation vote than did pleasantness. We found that for one unit of change on the ugly-to-beautiful scale, riders felt cooler by 0.8 points on the thermal sensation vote scale (unstandardized B = − 0.80, standardized coefficient beta = − 0.409, p < 0.001). For one unit of change from unpleasant to pleasant, riders felt cooler by half a point (unstandardized B = − 0.554, standardized coefficient beta = − 0.314, p = 0.004)."[101] Perception of pleasantness could be the difference between someone choosing to use public transit or drive their car. The same rationale could be applied to benches and bike racks- if the experience is pleasant or beautiful, that will create a further incentive to repeat the experience.

Biophilic design offers an interesting opportunity for intersectionality between sustainable materiality and beauty.[102] Biophilic design is the integration of nature into built environments. Biophilia is the notion that humans are instinctually connected to nature, and so by increasing natural elements in the urban environment, humans experience increased mental wellbeing.[103] In the context of street furniture, biophilic design elements could include simply planting trees, shrubs, or flowers beside benches. It also means that natural shapes, patterns, and colours could be incorporated into designs. Other sensations such as breeze, scent, light and shadow also are natural elements that could be considered when designing a structure and planning for its installation.

[101] Dzyuban, Yuliya, et al. "Public Transit Infrastructure and Heat Perceptions in Hot and Dry Climates." *Arizona State University*, Springer New York, 3 Mar. 2021, https://asu.pure.elsevier.com/en/publications/public-transit-infrastructure-and-heat-perceptions-in-hot-and-dry.

[102] "Biophilic Design Initiative." *International Living Future Institute*, 13 June 2022, https://living-future.org/biophilic-design/.

[103] June 23, 2020, Maria McCain - Alum. "Bringing the Outdoors in: The Benefits of Biophilia." *NRDC*, 25 June 2020, https://www.nrdc.org/experts/maria-mccain/bringing-outdoors-benefits-biophilia.

Images 73 and 74: Santa Monica's Big Blue Bus Shelters are flexible in size and configuration

An effective approach to incorporating attractive furniture that is at once durable and also flexible in its execution is the Santa Monica Big Blue Bus shelters. These iconic shelters can be installed in a multitude of settings with their small footprint. While perhaps not a singularly effective solution for very rainy climates like Vancouver, it does offer an excellent concept for adaptability in scale and shape without sacrificing unity and beauty in the collective design. [104]

Figure 75: A bench designed for senior citizens with a pole and higher seat height

Quick placemaking design interventions take place on multiple levels. At a community level, residential furniture such as dining room chairs and patio furniture can often be seen at bus stops where no street furniture is provided, and seating will happen with or without official intervention. With intention, senior citizens and those with mobility challenges can be given access to consistent seating that meets their specific needs such as higher seat heights and a pole or grab-bar/armrest to assist in standing.[105]

[104] Walker, Alissa. "How LA's Outdoor Furniture Creates a More Livable City." *Curbed*, Curbed, 20 July 2016, https://archive.curbed.com/2016/7/20/12217086/street-furniture-los-angeles.

[105] *Tiny WPA*. https://www.instagram.com/p/BphUKUxDH1I/?utm_source=ig_web_copy_link.

 [106]

Image 76: Bus stop benches constructed using Quicker, Lighter, Cheaper principles

Lighter, Quicker, Cheaper (LQC) principles of placemaking can serve as immediate public comfort and climate adaptation strategies, such as temporary seating and shade structures until a more formal plan is created. This strategy also offers the low-cost opportunity to collect data or pilot different types of furniture, as with the umbrella as shade, and bus shelter green roof solutions previously mentioned. As cities collect data to inform permanent solutions, LQC solutions can form a good intermediary.[107]

[106] Poon, Linda. "How Creative DIY Benches Can Fix Bad Bus Stops." *Bloomberg.com*, Bloomberg, 3 July 2019, https://www.bloomberg.com/news/articles/2019-07-03/how-creative-diy-benches-can-fix-bad-bus-stops.

[107] "The Lighter, Quicker, Cheaper Transformation of Public Spaces." *RSS*, https://www.pps.org/article/lighter-quicker-cheaper.

CASE STUDIES

Part of the research included investigating other cities' approaches to street furniture. From the literature scan, sustainability and climate resilience were not mentioned as part of the street furniture strategy for most cities.

Many global cities employ a coordinated street furniture program with a vendor, and others fabricate their furniture in-house. Each approach has its own merits, although it appears that an in-house approach yields the greater opportunity for employing sustainable practices such as an embodied carbon strategy.

The research also included interviewing city planners in three cities: New York, Los Angeles, and Melbourne.

NEW YORK

New York shares street furniture responsibilities with BIAs and other organizations. New York is experiencing a rapid increase in uses of micro mobility devices, such as electric scooters, for transportation as well as delivery services. The City is exploring ways that they can support this trend in their street furniture offerings, such as electric charging stations, scooter corrals, and safe storage.

SEE APPENDIX B

LOS ANGELES

LA is changing their contract from 20 to 10 years to be more flexible with changing trends and needs as the city grows. They are currently looking at new furniture including non-transit shade-shelters. They are also looking at planning for e-mobility like scooters and having more amenities at major transit stops to encourage transit use, like e-lockers where mail can be delivered.

The City prioritizes flexibility above all and is why they are building their infrastructure in-house. This allows the City to have more control over the design and maintenance, as well as larger revenue from advertising. The City's unique challenges are heat, drought and a lack of shade.

SEE APPENDIX C

MELBOURNE

Melbourne owns and builds their own furniture. In determining their strategy, they looked to European cities like Barcelona and Paris and decided to invest in longevity. Like the motor industry- parts are easy to replicate and build. Other Australian cities have followed suit. Low upfront carbon is possible when you build your own furniture and recycling can be ensured. Smart tech plays a big role in gathering data through sensors to better understand the needs of users. In an extremely Australian example, the designer explained that BBQs are installed in public parks and were being serviced twice daily. With sensors showing that the BBQs are used only twice a week, cleaning schedules were adjusted. In response to a lack of amenity space, the City has prioritized street furniture and has made it easier to take over parking spots, which reduces the emphasis of a car-centric city.

SEE APPENDIX D

CONCLUSION

Climate change is greatly impacting communities and will continue to do so at a greater scale. The City has created many plans and policies for reducing the impacts now and in the future. All departments must consider how to contribute to sustainability and climate resilience.

The street activities team should look for opportunities to create climate resilience and optimize sustainability as a dual approach of both mitigative and adaptive strategies. Mitigation will embody carbon strategies and prioritizing carbon sequestering elements such as vegetation. There are several ways to address embodied carbon, including not building at all, building new infrastructure with an embodied carbon strategy (whether built by the city or supplied by a vendor), and considering the end-of-life of the furniture.

Another mitigation strategy is to increase bus ridership as well as active transportation through making these experiences more pleasant and accessible. Adaptive strategies include reducing the effects of extreme heat events through cooling measures such as shade and reducing the effects of solar radiation. Another opportunity is to provide people greater access to water via water fountains and misting stations.

Climate adaptation should be considered for those who currently use street furniture and to encourage more opportunities for people to utilize street furniture throughout the year, and during extreme weather events. This can be done by focusing on heat and rain cover. Creating shade will help to protect the most vulnerable in our city from the impacts of the Urban Heat Island effect. Creating shade through more greenery and carbon-sequestering options will help to filter particulates while also assisting with stormwater management. In the absence of tree cover, manufactured shade elements will have the effect of protecting people from rain and sun, while also protecting people from Vancouver's rainy climate and extreme rain events.

Interesting new technology and designs in street furniture can increase the livability and effectiveness of the current offerings, including solar power, smart tech, beautiful design, and thermal regulation. Creating spaces that people want to spend time in will increase resilience through community building and providing infrastructure that supports all aspect of urban street life- transportation, gathering, waste and recycling disposal, and washroom access. Street furniture is vital part of urban life and can be an integral part of Vancouver's climate resilience and sustainability.

1. Determine whether the current assets need to be replaced at all. If so, look into the opportunities to reuse elements of the structures or if building from scratch, either:
    a. Source sustainable materials and utilize sustainable building practices (if creating custom pieces)
    b. Create requirements or incentives for vendors to consider and demonstrate sustainability goals and actions within their sourcing and manufacturing.

2. Collaboration: Continue to work with other departments to further investigate and collaborate on how sustainability and the embodied carbon strategy impacts street furniture procurement, design, and installation.

3. Examine the available industry tools when further investigating material options, such as:
    a. The Carbon Leadership forum toolkits for designers/ architects[108] and also for policymakers[109] including "buy clean" strategies.[110]

    b. The Architecture 2030 Carbon Smart Materials Palette can be used to identify key attributes that contribute to a particular material's embodied carbon impact and information on low-carbon material options.[111]

    c. The Building Transparency tool can visually sort supply-chain specific material data to plan and compare buildings and reduce embodied carbon emissions.[112]

4. Conduct a shade and rain cover audit that considers both manufactured and natural shade elements. Work with corresponding departments such as Urban Forestry to create a planned, holistic approach to streetscape cooling that includes vegetation, tree canopy coverage, shade shelters whether transit shelters or not. Shade will help to address the most life-threatening climate change event: heat. Structures or trees that provide shade will also protect people from rain in Vancouver's wet weather season.

5. Consider how best to offer flexibility to better respond to climate adaptation. Flexibility can take the form of designs that accommodate the challenges presented with narrow spaces and logistical impediments for the current transit shelters. If working with a vendor, continue to look for ways to make provisions flexible to adapt to the changing climate and technological advances.

[108] Andrew.himes. "AIA-CLF Embodied Carbon Toolkit for Architects." *Carbon Leadership Forum*, 9 Aug. 2022, https://carbonleadershipforum.org/architects-toolkit/.

[109] Andrew.himes. "CLF Embodied Carbon Policy Toolkit." *Carbon Leadership Forum*, 22 Aug. 2022, https://carbonleadershipforum.org/clf-carbon-policy-toolkit/.

[110] Andrew.himes. "5 - Guidance on Implementing Buy Clean." *Carbon Leadership Forum*, 12 Aug. 2022, https://carbonleadershipforum.org/guidance-on-implementing-buy-clean/.

[111] "Actions for Reducing Embodied Carbon at Your Fingertips." *Carbon Smart Materials Palette*, https://materialspalette.org/.

[112] *Building Transparency*, 29 June 2022, https://www.buildingtransparency.org/.

6. Continue to investigate smart tech and how it might:
    a. Improve the experience of people using street furniture, such as by having Wi-Fi and charging stations integrated into street furniture.
    b. Improve the ability to meet the needs of street furniture users, through better understanding usage by analyzing data from sensors.
    c. Be incorporated into providing power such as through solar and also irrigation such as through moisture sensors on a green roof or in planted vegetation.

7. Focus on equity as it pertains to accessibility - those who are most vulnerable need additional support in preventing climate-related deaths and illnesses. Areas that have high concentrations of vulnerable and elderly people should perhaps be a focus of adaptation strategies such as shade and cooling opportunities. Create furniture that considers users' challenges such as mobility when launching a new design.

8. Utilize concepts such as biophilia and placemaking to improve spaces in the interests of social resiliency and to encourage active transportation and transit ridership. By creating spaces that people enjoy, amenities are more likely to be used. Increasing active transportation and bus ridership is a very powerful mitigation strategy for reducing vehicle emissions by incentivising alternative forms of transportation.

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APPENDIX A

Case study interview questions

1. What climate changes are you planning for? (e.g., flooding, heat domes, windstorms, smoke, etc.)

2. What are the ways in which you are planning for them in the public realm generally, and street furniture specifically?

3. Have you encountered any trends/ innovations we should be looking at?

4. How do you measure the environmental impact of the materiality/ shipping involved in the procurement?

5. Do you have a list of materials you do and do not use? If so, why those materials?

6. How do equity and social resilience fit into your strategy for climate resilience?

7. What assets encompass “street furniture”? - (e.g., Automatic Public Toilets, bike racks, bus stops, benches, garbage/ recycling receptacles, newspaper stands, info/ signage boards, parklets, coverings)

8. Do you choose/ place street furniture based on population-specific communities i.e., economically marginalized, age, different abilities, vulnerable populations, etc.

9. Do your assets get updated frequently or do they stay in place for the life of the contract (provided there is no damage)? i.e., if the climate is changing more rapidly, how do you account for this?

10. What design features play a leading role in your street furniture design?

Appendix B
Case Study: New York

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1. What climate changes are you planning for? (e.g., flooding, heat domes, windstorms, smoke, etc.)

- Increasing active transportation as a mitigation strategy: Working with bikes, transit, walking
- NYC is seeing more floods than before, subways that flood mean the City might have to move for resilient measures, build a berm/ levee although this mostly impacts parks and the highway. For street furniture, flooding the subway creates Wayfinding implications for emergency information.
-

2. What are the ways in which you are planning for them in the public realm generally, and street furniture specifically?

- Storm water is a major concern as it rains every three days in some seasons in NYC. A street furniture consideration is to buffer bike corrals with planters. These also serve to protect the corrals from cars and to help with stormwater retention.

3. Have you encountered any trends/ innovations we should be looking at?

- Secure bike parking and e-charging! There are many delivery systems by cargo bikes, and this is helpful in reducing vehicles on congested roads. Drivers are charging the bikes themselves and this can create fires in electrical systems not regulated to do so- such as at home. These delivery drivers need spaces they can congregate, store bikes and gear safely. This system greatly reduces dependence on trucks. Whole Foods is requesting space from the city for cargo bikes and UPS wants to grow in this. Delivery bikes have been in New York since the 90s and street furniture can help to make this a safe and sustainable industry.

4. How do you measure the environmental impact of the materiality/ shipping involved in the procurement?

- It's an ongoing process of finding what is simple and sustainable- these are not always the same thing. Wayfinding signs used to consist of panels on a frame. The map image was on vinyl and adhered to the back of the glass. This made it easy to update the artwork as new vinyl would just be applied to the glass. Printers find it labour intensive and prefer to just create new glass. Printing on glass reduces bubbles and vermiculation but is not reusable. The image on the back of the glass does make it graffiti proof.
- The bracket frame design is also difficult and heavy due to the glass that is built to withstand hurricanes. NYC staff are now considering aluminum image on a panel - done in house and easy to clean. It can have much smaller footing

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- Bus stops have digital information which could be usable in emergencies - the subways have touch screen technology which could also be used for emergency information and wayfinding; however, a printed map always works- even if there is no power
- Bike racks are made domestically - the City's goal is 10,000 bike racks in 5 years - the new mayor also want to broker things made domestically. The City's policies on these types of things can change with new governments.
- The previous racks were made in India as well as manhole covers. During the pandemic there were impacts with shipping delays, but the City had signed a multi -year contract. NYC is now thinking about Buy America - the pros are that this reduces shipping issues - converse is "anti-competitive" - contract is lowest bidder.
- The bike racks made in India are starting to rust- having foreign made items make it harder to figure out what has gone wrong and harder to resolve.
- Design of the bike racks used to be circles on old parking meters - these were rough to put on asphalt, now sleds are used which are easier to install and half the price.

5. Do you have a list of materials you do and do not use? If so, why those materials?

- Plastic, no, wood no. Reason: metal benches are easier to maintain, wood needs to be replaced every year - although wood is better to sit on
- NYC has very Tall buildings that provide shade. There are also many trees, and the goal is a million trees by 2030 - goal under Bloomberg
-

6. How do equity and social resilience fit into your strategy for climate resilience?

7. What assets encompass "street furniture"? - (e.g., Automatic Public Toilets, bike racks, bus stops, benches, garbage/ recycling receptacles, newspaper stands, info/ signage boards, parklets, coverings)

8. Do you choose/ place street furniture based on population-specific communities i.e., economically marginalized, age, different abilities, vulnerable populations, etc.

- Different neighbourhoods will have different wayfinding - e.g., near homeless shelters wayfinding will show where a methadone clinic is
- Not necessarily by design of program, rather as a result of funding opportunities under various governments
- Most wayfinding is for visitors, immigrants, transit - tourist things, hospitals, destination parks
- Footings get updated when capital projects are updating sidewalks
- Benches - lots of seniors use the benches and they are the target audience. Designs include leaning bars - these are also useful for narrow bus stops
- Bloomberg administration wants to standardize furniture
-

9. Do your assets get updated frequently or do they stay in place for the life of the contract (provided there is no damage)? i.e., if the climate is changing more rapidly, how do your account for this?

10. What design features play a leading role in your street furniture design?

- Sidewalk width - how can we make street furniture to fit in a variety of widths?
- During Covid, there was more agency - community engagement - vendors, stores, bus stops, storage, garbage
- Containerising garbage - The City has had various approaches to managing garbage. The City is now set to purchase lockers to be opened and operated by sanitation workers

- Recycling and garbage service is managed by the BIA in parts of the City
- City has recycling bins – maintained by sanitation/ parks
- Council can use discretionary funding for garbage/ recycling cans
- There are some bike racks, wayfinding, benches, public spaces, sidewalk, purchased and maintained by city
- Bus shelters, bike shelters, paid toilets, JC Decaux - advertising revenue
- Coordinated street furniture – Bernice (was not able to reach Bernice)
- Bike share and public phone (now WIFI terminals) have advertising on , new contract will have less advertising revenue

Case Study: Los Angeles
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1. What climate changes are you planning for? (e.g., flooding, heat domes, windstorms, smoke, etc.)
    - Coming to a closure of RFP process
    - LA is anticipating increasing temperatures - up 10° in 20-50 years
    - There is not much flooding: Feast or famine with rain - LA has a drought cycle
    - Shelters do provide rain protection
    - Earthquake designs have- seismic codes so that shelters will remain standing

2. What are the ways in which you are planning for them in the public realm generally, and street furniture specifically?
    - LA is methodical about where we place furniture and the City uses data sets to develop priorities about placements- such as the Heat index, equity community considerations, proximity to trip generators ,schools, and hospitals. Long wait times are also a factor, and these sports are created by the transit agency.

3. Have you encountered any trends/ innovations we should be looking at?
    - LA is updating its business model: The City is paying for all the capital costs to build and maintain their street furniture
    - The reasoning is that if you put traditional infrastructure costs into the contract, then vendor is in complete control and it's tough to adapt
    - Used to do 20-year contracts then the Internet came up during the last 20 years and in 2010 newsstands disappeared
    - Vendor is now operator, and this is more flexible. Flexibility is the most important consideration. LA has a 10 -year term now rather than 20.
    - Another change that might occur with gas prices going up is an influx of bus riders
    - If the program can't accommodate changes, then 10 years isn't too long to wait to change things up
    - We can adjust to tech needs/ infrastructure requirements:
    - Hydration stations and Hand sanitation stations Incorporated into the transit shelters
    - Emergency response calls- under development where a bus rider can interact with someone
    - Placement of 5G - tall column 15' above ground
    - Inductive charging station behind benches
    - Better WIFI would help transit shelters - if people are using scooters, they need to dock using cellular connection

4. How do you measure the environmental impact of the materiality/ shipping involved in the procurement?
    - Encourage what we have control over
    - Encourage local manufacturing and procurement
    - Materials have to be recyclable
    - Stay away from plastics
    - Resin based carbon fibre material uses flax and wheat as threads
    - This might be more expensive, but it works

5. Do you have a list of materials you do and do not use? If so, why those materials?

- No wood
- Sun beats it up and when it gets cold in LA - wood gets taken to burn in the winter
- Plastics are a necessary evil
- Lighting: Move away from CFL in lights and use more efficient lights e.g., LED
- Solar lighting in transit shelters
- Printing on vinyl isn't sustainable as - they can't be recycled
- Transit shelters use a digital media panel
- E paper screens are an option and could be used and would be different from advertising- could have Emergency messaging, Maybe solar powered as solar can energize e-paper. This could be very helpful in communication a bus route change, amber alert, and safety lighting

6. How do equity and social resilience fit into your strategy for climate resilience?

- The City works closely with LA metro - LA Metro has their own criteria- heat screens, targets minorities, lower income, BIPOC, zero car households.

7. What assets encompass "street furniture"? - (e.g., Automatic Public Toilets, bike racks, bus stops, benches, garbage/ recycling receptacles, newspaper stands, info/ signage boards, parklets, coverings)

- Toilet, transit shelters, litter receptacles public amenity kiosks- getting rid of publication kiosks going forward
- Amenity kiosks moving more like info like in a mall
- Public toilets not part of this program anymore - part of a larger city-wide strategy
- The City is addressing homeless concerns as the population is growing and growing - all parts of the city will have encampments and so the city will need to have a comprehensive strategy to address homeless folks and transit commuters
- More mobility oriented, transit shelters are the primary asset
- A new asset is scooter docks
- E lockers are a new consideration, and they can be used in conjunction with transit shelters- an e-locker can make the last mile connection where people can pick up a package from e-locker
- Stand- alone shade structures are an asset- These are a lighter version of transit shelters and in spaces too tight for regular transit shelters. The City is procuring 500+ shade shelters to supplement transit shelters
- Transit shelters used to just be benches and receptables
- A Standard transit shelter was 13 x 5' and there are now options for a 4 x 9'
- Thermal protection- to help with reducing heat impacts the shelters will be aluminum or steel with reflectivity built-in
- Bus bench company uses thermal plastic coating like playground equipment - otherwise steel is too hot

8. Do you choose/ place street furniture based on population-specific communities i.e., economically marginalized, age, different abilities, vulnerable populations, etc.

- Going to be looking at this with the contractor - still designing elements - seat heights for all ages and abilities
- Transit shelters will be prioritized near senior centres and senior populations as well as communities with mobility challenges
- The City reached out to disability community- they learned that these communities needed different height and poles with handles. Also, that two wheelchairs cannot comfortably fit in one shelter need more space, so they will look to extend the shade canopy
- Flashing digital media screens can cause seizures for people who are photo sensitive

9. Do your assets get updated frequently or do they stay in place for the life of the contract (provided there is no damage)? i.e., if the climate is changing more rapidly, how do you account for this?

- Options that allow additions/ alterations to the contract
- Still have structures from 1984 Olympics

10. What design features play a leading role in your street furniture design?

- The Department of Public Works and the Urban Forestry Division is working to integrate trees in the rear of the sidewalk. Trees beside buildings can cause conflict
-
- Trees are a great cooling mechanism
- Misting means water service although this is an option for attaching to a transit shelter
- Bike racks - dept transportation
-

Anything else that we didn't ask?

- LEAVING current furniture in place is most sustainable option
- Building and owning means being responsible for end of life- knowing for sure where it goes
- OR something in the contract to show plan and execution of advertising
- More flexibility in changing designs if custom

APPENDIX D

Case Study: Melbourne

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1. What climate changes are you planning for? (e.g., flooding, heat domes, windstorms, smoke, etc.)
    - Basically, heat and sun
    - The City recently changed all light points to LED,
    - Control of lights then goes from manual to digital. This is done with a smart meter with a network - and this allows lighting and dimming control as well as temperature control. If the City wants to find out if a tree lined street is in fact cooler, they can now prove it with evidence – LEDs are battery powered or - solar for low power amenities
    - If there is no way to grow trees in the ground, grow trees in planters - This is done in Paris in St Germaine - the City uses forklift to drive them in lane – then there is a canopy in lane. They will also add temporary seating. This way lanes can have services running through them. If the trees look ill, take them back to the sunshine to restore.
    - Green roofs are an option but never been designed to take lots of soil which makes them tough to grow in hot climates. Melbourne wants to try hydroponics and run the roof through water.
    - A roof painted white is easier

2. What are the ways in which you are planning for them in the public realm generally, and street furniture specifically?
    - Heat: Forest strategy - increase tree canopy
    - Saturated paving - allows water through it - uses storm water to water the trees
    - Buildings are a good place for reflectivity in roofs, and Melbourne has green roofs on buildings.

3. Have you encountered any trends/ innovations we should be looking at?
    - Melbourne has biggest influence in Australian street furniture- Sydney has adopted their approach, as has Perth. Universities have adopted it - they are a city and - own lots of property in Melbourne - Melbourne's is a very sustainable strategy.

4. How do you measure the environmental impact of the materiality/ shipping involved in the procurement?
    - It is vital to utilize fully recyclable material
    - Short term things are not sustainable - they increase carbon. By switching to LED lights, the City only must replace the bulbs every 20yearss which saves on labour to remove them as well as the trucks to drive around and do so.
    - All stuff is locally made - built in Victoria - keep it all local. LED is best from Europe - but can be sourced in Melbourne

5. Do you have a list of materials you do and do not use? If so, why those materials?
    - Recycled plastic - no - office chairs should be recycled back to office chair not into benches– at best the content is 40% recycled, and the rest is new plastic.

- Looking at systems to use recycled plastics for curb building, recycled glass in asphalt - good use of it

6. How do equity and social resilience fit into your strategy for climate resilience?
-

7. What assets encompass “street furniture”? - (e.g., Automatic Public Toilets, bike racks, bus stops, benches, garbage/ recycling receptacles, newspaper stands, info/ signage boards, parklets, coverings)
- BBQs along river were installed and cleaned by a contractor twice a day.
- Using smart tech, the city can see how often they are used and then alter cleaning schedules.
- Using GIS and GPS tracker technology to know when something was installed and needs upgrading
- APTS, use a contract - bit of a fail - get the installers to maintain them

8. Do you choose/ place street furniture based on population-specific communities i.e., economically marginalized, age, different abilities, vulnerable populations, etc.
- Design principles - Intersections are good for a bin - seats are good in the middle of a block as there is less movement

9. Do your assets get updated frequently or do they stay in place for the life of the contract (provided there is no damage)? i.e., if the climate is changing more rapidly, how do you account for this?

10. What design features play a leading role in your street furniture design?
- Replicated - Honnold designed blocks that are 90° to each other so defined geometry makes for an easy city to work on - it’s a planned city
- In order to increase space - take over the parking if assets are needed. The pandemic helped with parklets etc.

What about the ad revenue - if the city makes the furniture, is the advertising separated from build and maintenance?
- Bus stops and trams have advertising - subsidises the city and transit corporation. Bus stops are the only place we allow advertising - no other street furniture
- State govt does the advertising
- Furniture is the least expensive part of the street scape - paving is much more expensive. When you build your own furniture, you can control the quality and the location. This means controlling your own world/ details
- City crews do the cleaning/ maintenance - company contracts but city owns it.

Anything else?

- All furniture built designed in-house, themed to Melbourne.
- Staff designed coordinate furniture- themed round Melbourne. The idea was that they could reproduce assets anytime - in 200 years’ time. The material is mild steel - which was new tech at the time with new robustness. It was all designed like cars with spare bits so that it could be maintained. This is still the philosophy. It was cheaper to remake it after 5 years when the UV got to it and so stainless steel became the new tech as it has a 35-year life cycle, is easy to clean.
- Other materials are still natural materials - blue stone, granite, stainless steel, aluminium - minimize materials for simplicity. The City uses plantation timbers like black gum - nice greying effect-

- This is a simple strategy and was borrowed from Paris and Barcelona when Melbourne councillors toured European cities to see how they did it. It's all about long-term
- They incorporated design standards - and you can see these on the City website where they have logged every item from tree guards to paving - very extensive
- Stainless and aluminum are fully recyclable
- Robust to withstand rigours of city - easy to clean
- Clean city is an attractive city - this is how we've activated Melbourne
- Trade off of consistency and neighbourhood identity. Could be light poles that showcase individuality - or trees
- Furniture gets bashed must be robust - variety makes maintenance schedule challenging
- Use laminated glass - just replace. Polycarb is man-made and fades - you need special cleaners, it attracts dirt, it's easy to scratch
- Solar cells in the inter layers of glass
- Irrigation control - narrow planters to work - too little soil is hard to water correctly - sensors can control this
- Free WIFI in the city - need seating so people can use it