Urban Heat Island Guidebook

Mitigation Strategies for the UBC Vancouver Neighbourhoods

EXECUTIVE SUMMARY

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Disclaimer

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Background

There is a growing urgency to address the increasing intensity and frequency of climate change-induced heat waves in British Columbia, as highlighted by the heat dome event of 2021 which led to over 600 deaths in the province[1]. Urban areas are particularly vulnerable to the Urban Heat Island (UHI) effect, where heat-absorbing materials such as concrete and asphalt retain solar energy and slowly release this energy as heat into the surrounding environment. This can result in temperatures being 2°C to 12°C higher in urban areas, exacerbating heat waves and making cities more challenging to live in during extreme heat events and droughts[2]. UHIs pose significant risks to human health (via heat stress, dehydration, and increased UV exposure) as well as natural systems and wildlife (impacting local temperature gradients, disrupting resources) and can contribute to biodiversity loss[3,4]. Furthermore, elevated temperatures result in higher peak electricity demands due to an increased reliance on air conditioning, creating a feedback loop where waste heat generated by indoor cooling systems further intensifies the UHI effect[5,6].

A recent study on the UBC Vancouver campus revealed that surface temperatures during the 2021 heat dome varied by up to 10°C, with cooler areas linked to denser tree canopy[7]. This underscores the essential role of natural assets in mitigating extreme heat. Climate projections for the campus and its surrounding neighbourhoods further emphasize the urgency of embedding climate resilience into residential planning. These forecasts point to rising temperatures, shifting precipitation patterns, and an increased frequency of extreme weather events in the coming decades[8].

Purpose

As a key action in the Neighbourhood Climate Action Plan (NCAP), UBC Campus and Community Planning (C+CP) are exploring a combination of nature-based and engineered solutions to address urban heat island effects in both current and future residential neighbourhoods on campus. These strategies focus on reducing heat absorption and enhancing cooling by increasing tree canopy cover, expanding green infrastructure assets, and creating restorative, resilient landscapes. Prioritizing these solutions supports Campus Vision 2050's objective of fostering more comfortable and equitable living environments for all residents[9].

To further these goals, this guidebook provides comprehensive strategies for mitigating the urban heat island (UHI) effect within UBC Vancouver neighbourhoods. This includes nature-based (NbS) and other design solutions that can be implemented at neighbourhood and site scales, aimed at enhancing outdoor shading, reducing cooling demands in buildings, and promoting sustainable transportation use during periods of extreme heat. Through offering recommendations and actionable insights, this guidebook aims to be a valuable resource for UBC C+CP planners, architects, University Neighbourhoods Association (UNA) staff, and community members working to build a more resilient and climate-adaptive campus for all residents.

Research Approach

The guidebook was produced by conducting a detailed literature review on nature-based and other resiliency design approaches for urban heat island mitigation, with a primary focus on Metro Vancouver and the Capital Regional District (CRD). Relevant information from other jurisdictions was also considered to provide a broader context. I also conducted a local government jurisdictional policy scan to assess existing policies and practices relating to UHI mitigation. The insights from both the literature review and policy scan informed the development of recommendations for UHI mitigation strategies on the UBCV campus. Strategies were categorized as either neighbourhood scale or site scale interventions and selected based on their alignment with the goals outlined in UBC's Neighbourhood Climate Action Plan (NCAP) and Campus Vision 2050. Additionally, this research identifies areas where further study is needed to enhance the understanding and implementation of UHI mitigation strategies.

Summary

The project's final deliverable 'Urban Heat Island Guidebook: Mitigation Strategies for UBC Vancouver Neighbourhoods' opens with an introductory chapter, followed by three chapters that outline UHI mitigation strategies; *Chapter 2: Street Trees & Greenways, Chapter 3: Green Roofs, Chapter 4: Cool Buildings*. *Chapter 5: Next Steps* closes the guidebook with recommendations for how these strategies can be integrated into UBC Vancouver neighbourhoods through policy, programming, and community involvement, along with other key equity and accessibility considerations.

Chapter 2: Street Trees & Greenways

Chapter 2 explores the critical role of urban greening in mitigating the Urban Heat Island (UHI) effect and enhancing urban resilience. Urban greening strategies, such as street trees and greenways, are highlighted as effective and cost-efficient methods for cooling city environments[10]. For example, a study from Manchester showed that a 5% increase in mature deciduous trees could reduce surface temperatures by 1°C on a summer day[11]. In Vancouver, simulations have demonstrated expanding neighbourhood canopy cover by 175% could reduce building cooling energy demands (BCED) by 48% and increase building shading by 22%[12]. However, tree shading was more effective for low- and medium-height (3-11 metres; one to five storeys) buildings than tall buildings (>11–58 metres; six or more storeys). As such, alternative UHI mitigation strategies such as cool roofs and cool exterior walls may be more effective solutions for achieving BCED reduction targets for high-rise residential buildings.

The chapter also explores the broader benefits of urban greening. For instance, green parks and 'green islands' can lower surrounding air temperatures by up to 6°C and extend their cooling effects up to 1.25 kilometres[13,14]. Increasing tree canopy coverage in streetscapes leading to and from schools can encourage active transportation use for school journeys as a result of improved perceptions of safety, aesthetic value, and thermal comfort[15]. For bicyclists, street trees have been shown to positively contribute to bike route preferences[16]. Urban greening is an integral part of both NCAP and Campus Vision 2050, which outline future initiatives to expand greenways, improve ecological connectivity, and support active transportation on the UBC campus[9].

Additionally, *Chapter 2* covers the importance of selecting appropriate tree species based on traits such as climate resilience, drought tolerance, and shade provision. Focus should be placed on selecting native and drought-tolerant species that can thrive in urban settings and quickly offer cooling benefits to the community. Maintaining tree health and ensuring proper planting and care are crucial for sustaining these long-term benefits.

Chapter 3: Green Roofs

Chapter 3 examines the effectiveness of green roofs in combating the Urban Heat Island (UHI) effect and improving energy efficiency in buildings. Studies investigating the cooling benefits of green roofs report 60-79% reductions in heat transfer (heat flux) into buildings when compared to conventional concrete roofs[17,18,19]. One study published by the National Research Council of Canada found extensive green roofs reduced daily energy demands for air conditioning by over 75% in summer months[20]. The energy savings associated with reduced indoor cooling demand are highly dependent on the thermal resistance (U-value) of the green roof[21]. Other factors, such as local climate, soil depth, and vegetation characteristics (e.g. Leaf Area Index (LAI)) also influence the energy savings outcomes of green roof systems[21].

Green roofs are categorized as extensive, semi-intensive, or intensive, with each type offering different benefits based on the depth of the growing medium, plant variety, and maintenance requirements. Proper design, planning, and maintenance is crucial to ensuring the long-term functionality of green roofs and maximizing cooling and energy-saving benefits.

Chapter 4: Cool Buildings

Chapter 4 discusses engineered solutions, such as cool roofs and cool exterior walls, for use in site-scale UHI mitigation. These products, made of high-albedo materials like reflective paints, sheet coverings, tiles, and shingles, can reflect up to 90% of solar radiation, significantly reducing surface temperatures and cooling both indoor and outdoor environments[22]. Cool building products are most effective for buildings with high sunlight exposure, making them ideal for use on high-rise rooftops[23]. Although exterior walls typically receive less direct sunlight than roofs, cool wall products applied to buildings can offer comparable energy saving potential[24]. In Metro Vancouver's climate zone (4C), cool roofs and walls offer the greatest energy savings in older buildings with limited insulation and in single-family or low-rise buildings, reducing cooling loads by up to 40%[23]. Energy savings are likely to be more modest for new buildings with insulation that adheres to UBC's green building rating system (REAP: EA M1-M3)[25]. Nonetheless, as the Lower Mainland is projected to experience more frequent and prolonged heatwaves in coming decades, integrating cool roofs and walls across the campus could be an effective strategy for enhancing building resiliency and energy efficiency. Cool roofs are particularly beneficial in densely built neighbourhoods with flat roofs, which could make them a strategic priority for UHI mitigation as UBC prepares for urban densification under its Campus Vision 2050 plan. A table summarizing common cool roofing and wall materials is provided at the end of this chapter.

Next Steps

Chapter 5 outlines next steps for implementing urban heat island (UHI) mitigation strategies across the UBC Vancouver neighbourhoods, focusing on policy tools, community involvement, and equity and accessibility considerations. The chapter opens with a discussion on how UBC's Residential Environmental Assessment Program (REAP)[25], a campus-specific green building rating system, could integrate heat island reduction credits similar to those found in LEED. LEED offers credits under its 'Sustainable Sites' category for heat island mitigation[26], including requirements for reflective roofing materials, green roofs, and vegetative cover. Expanding REAP's credit options to include similar measures would help to promote UHI mitigation in new and existing residential developments, aligning with UBC's long-term sustainability goals. Additionally, the inclusion of a 'Heat Island Mitigation with Cool Walls' credit akin to LEED's pilot credit could further incentivize the use of cool exterior walls to combat site-level UHI effects[27].

To strengthen urban greening efforts on the campus, it is recommended that guidelines be developed for tree planting, protection, and management, and that tree canopy targets be included in Neighbourhood Plans. I recommend that UBC focus on policies supporting overall canopy growth, including the protection of large and medium-sized shade trees. Replacement efforts for trees that cannot be retained should focus on preserving ecological benefits and maintaining canopy cover throughout the campus.

Establishing a Campus Urban Forestry Committee, as recommended by UBC students Lompart & Ikeda (2017) in their SEEDS report[28], could address gaps in urban forest governance and raise awareness of its benefits. Led by the University Neighbourhood Association (UNA), this committee could facilitate workshops, volunteer programs, and tree monitoring efforts to foster community involvement in tree planting and care. This would create a shared sense of responsibility for maintaining the urban forest and ensure that greening efforts align with the needs of residents.

Equity and accessibility must be central to UHI mitigation efforts at UBC, with a strong focus on prioritizing tree planting and canopy expansion in the hottest areas. NCAP Ecology sub-action ES-1.4[29] emphasises that future targets for neighbourhood shade coverage should aim to improve equity and provide similar service levels throughout neighbourhood areas. This will be an important consideration for future residential developments on the campus, such as the planned Stadium Neighbourhood. As the area undergoes future densification, urban greening projects such as the planned ecological park for Stadium Neighbourhood[30] will serve as valuable community resources for counteracting localized UHI effects. Additionally, NCAP Transportation & Mobility sub-actions TM-5.1 and TM-5.2[29] recommend developing resilience and safety standards for transportation networks and exploring retrofits to improve them. This could involve adding shading and covered shelters along greenways and near public transit stops to improve comfort and accessibility, particularly for individuals with mobility challenges, to encourage the use of sustainable transportation modes on the campus.

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