



GREEN ROOFS AND FACADES: A STEPPINGSTONE ON THE PATH TOWARD SUSTAINABILITY

Abstract

This paper will discuss what makes a sustainable city and how the City of Spokane can adopt innovations from the Netherlands to support Spokane's shift toward sustainability. Specifically, this paper will focus on the building and energy sector of a sustainable city. The Netherlands supports research within this sector and has adopted many innovations to make their cities sustainable. One such innovation that can and should be adopted by Spokane is green roofs and facades. Green roofs and facades are tactics that place native vegetation on the sides and tops of building to help reduce greenhouse gasses, the heat island effect, and make buildings more sustainable. This report will dive deeper into why this innovation should be focused on and how it can be implemented in Spokane.

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Chapter One: Introduction

As cities such as Spokane grow, their environmental footprint expands as well. Expanding urban environmental footprints in combination with the increasing impacts of climate change put the population at risk of experiencing increasingly severe weather conditions and climate related health issues. Human beings are being challenged to make their cities more sustainable. Sustainable cities will help to curb the rapid expansion of climate change and create safe urban environments for the current generation as well as future generations. While environmental considerations are the most obvious and crucial factor, such considerations are only one part of what makes up a sustainable city. The current definition of sustainable developments or cities focuses on human wellbeing and ensuring that the development meets the needs of current occupants while not sacrificing the needs of future generations. Thus, for a city to be truly sustainable there must be social and economic considerations to ensure that the occupants of the city have the opportunity to live healthy and fulfilling lives (Ayers, 2017). Creating a sustainable city is a difficult but necessary balancing act between all three considerations (social, economic, and environmental). For example, if environmental considerations only are taken into account, it could place an unreasonable economic burden on the city as well as hinder the creation of meeting places, restricting social interactions. Successful sustainable city planning both increases human wellbeing and makes the city and the surrounding environment more resilient.

While sustainable cities are becoming more prevalent across the world, they are not yet as common as they need to be. Cities across the globe currently account for more than 60% of the world's greenhouse gas production and consume 78% of the world's energy (The United Nations, n.d.). The main barrier to the implementation of sustainable cities is that they must be conceived of and built at the local and not national level. There are several key factors supporting the rationale for city level sustainability planning. The first reason is that sustainability will look differently for each city based on its environmental, social, and economic situation. To first discuss the environmental considerations, each unique city experiences different environmental conditions and needs different resources from the environment. Social and economic factors also vary greatly city to city and can affect sustainable decisions such as creating shelters to help the unhoused population during times of extreme weather or investing in renewable energy sources to build the city infrastructure and create jobs.

Another important reason for sustainability to be pushed at the city level and not a national or state level is to allow for a bottom-up approach. A bottom-up approach to sustainability focuses on getting individuals who live within the city involved in the move toward sustainability. It is almost impossible to do this at a large scale, since as a population increases it becomes increasingly difficult for leaders to build the feeling of solidarity between the population and the environment necessary to motivate the public without commanding them. It is easy for people to support a movement when they personally see and feel the direct impact that the movement. At the city level it is possible for leaders to target specific local needs while a national government can only focus on broad impacts. In “The Urban Green” the effectiveness of the bottom-up approach was evident. While every city featured in the movie was incredibly sustainable, it was obvious that those who focused on a bottom-up approach, such as Seoul, made the largest strides towards sustainability (Sweden, 2016)

In redesigning Spokane to make it more sustainable it is necessary to focus on changing the city’s infrastructure. Civil engineering, with its focus on the built environment, is at the core of making the shift towards a more sustainable Spokane. The main sectors of civil engineering, transportation, water, buildings, and environmental, all play crucial roles in creating a sustainable urban environment. Transportation engineering designs new ways for people to safely travel with a smaller environmental footprint by maximizing the usage of bicycles, trains, and other public transportation. Transportation engineers can redesign Spokane to prioritize bike and pedestrian safety which will not only lower carbon emissions, but give people a safe place to socialize outdoors, effectively building social capital. Water management allows a city to use water more efficiently and to store, withdraw, and transport it safely. Structural engineers can create energy efficient and long-lasting buildings using sustainable materials. Buildings that are energy efficient are not just beneficial for the environment but also cheaper in the long-term, allowing Spokane’s economy to grow. Finally, environmental engineers work to design methods to reduce pollution and keep Spokane’s air and water safe.

The time for a shift toward sustainability is now. Human caused climate change is already impacting Spokane, and as time goes on the impact will only increase. Over the past century Spokane has experienced a consistent increase in temperature and a decrease in summer precipitation. (Spokane Climate Project, 2021). Hotter and dryer summers are only one effect of

climate change, and that change alone can lead to drought, increased wildfires, and increased heat related health problems. This situation is predicted to get worse unless action is taken to mitigate Spokane's environmental footprint. To protect the future of the environment and people of Spokane, civil engineering innovations must be utilized to make Spokane a more sustainable and resilient city.

The rest of this report will further show how civil engineering designs play a key role in creating sustainable cities. Specifically, it will discuss how buildings and energy play a role in the environmental impact of cities and how innovations within that sector help make a sustainable city. Chapter 2 will be an introduction to the buildings and energy sector and compare how Spokane and the Netherlands have addressed the problem. Chapter 3 will then discuss green roofs and facades as a strategy that should be introduced in Spokane to combat climate change. Finally, Chapter 4 will provide a summary of the report and provide final recommendations.

Chapter Two: Introduction to Buildings and Energy

The buildings and energy sector of the Spokane Action Plan (SAP) is one in which the potential for improvement is immense. Buildings encompass a large portion of Spokane's infrastructure, and create spaces in which the public can work, live, play, and socialize. Additionally, they provide shelter to people during times of extreme weather. The incorporation of energy efficiency into building planning provides residents with heat and electricity while reducing the usage of nonrenewable resources necessary to produce said energy.

The building and energy area of Spokane's action plan addresses the construction of new buildings, renovation of old buildings, and the management of energy usage in those buildings (Spokane, 2021). Currently buildings and the construction of those buildings play a large role in world energy consumption and greenhouse gas emissions. The U.N, 2020 Global Status Report states that buildings and construction account for 38% of the world's energy consumption and 35% of the world's greenhouse gas emissions (UN Environment Programme, 2020). Considering the large role that construction and energy play in both the flourishing of humanity and the

advent of climate change, Spokane has a vital opportunity to reduce the environmental impacts of building and energy while maintaining its societal benefits.

Spokane recognizes the problem that current buildings and energy use pose toward the environment and has outlined a proposed solution set within the Spokane Sustainability Action Plan (SAP). Within this plan the City of Spokane has pledged to reduce greenhouse gas emissions due to electricity and gas by 100% and 95% respectively (See Table 1).

Table 1: This table shows a chart of Spokane's emission reduction checkpoints from 2016 to the deadline of 2050 (Spokane, 2021).

Emission Source	2016 Baseline 2,108,796 MT		2030 Reduction Target 45% & 948,958 MT		2040 Reduction Target 70% & 1,476,155 MT		2050 Reduction Target 95% & 2,003,356 MT	
	Metric Tons CO ₂ e	Percent of Total	Metric Tons CO ₂ e	Percent Reduction	Metric Tons CO ₂ e	Percent Reduction	Metric Tons CO ₂ e	Percent Reduction
Electricity	587,418	28%	83,114	80%	41,557	90%	0	100%
Gas	381,273	18%	411,163	30%	205,581	65%	24,369	95%

To achieve this emission reduction target, the plan is broken into three main goals. The first goal focuses on the construction of new buildings and the renovation of old buildings. Specifically, Spokane wants to promote the electrification of buildings and encourage renovation instead of demolition and new construction (Spokane, 2021). The second goal encourages commercial and residential use of renewable energy. Spokane plans to create incentives for using renewable energy sources, extract energy from waste such as biofuels, and lower usage of fossil fuels (Spokane, 2021). The final goal within the Sustainability Action Plan is to mobilize the community towards the use of renewable energy. Spokane plans to do this mainly through educating the community and providing access to energy efficient solutions. While Spokane emphasizes the need to move away from nonrenewable sources of energy, the city plan also addresses the possible secondary impact on those who work in traditional energy sectors. Spokane's plan offers assurance that the city will support energy sector workers through the shift. While Spokane has set lofty goals, the research and actions necessary to complete these plans have not yet been implemented.

The Dutch government has set the goal of reducing greenhouse gas emissions by 95% by 2050. Since buildings and energy play a large role in these emissions, the government has created several measures for the built environment. These measures include enhancing energy efficiency in residential homes, ensuring that new buildings do not use natural gas for heating,

renovating old buildings, encouraging towns and cities to take steps to make their neighborhoods emission free, and generally creating more incentives for clean energy (Government of the Netherlands, n.d.). In addition to these measures (as of 2021), all new buildings within the Netherlands must be energy neutral or “almost” energy neutral (GT Law, 2021). To support these stringent goals and restrictions, the Netherlands, specifically TU Delft’s Green Village, conducts ongoing research on how the Netherlands can best meet their sustainability goals. The Green Village is a space on the campus of TU Delft which is dedicated to researching sustainable building, renovation and energy systems (The Green Village, n.d.). The Netherlands sets high goals for buildings and energy and supports the ongoing research to make current and future goals a reality.



Figure 1: A photo captured during our visit to The Green Village showing a solar energy system that is designed to move to allow sun to reach the plants below it.

Shifting towards sustainable buildings and energy will lead not only to environmental benefits, but to economic and health benefits as well. While the upfront investment to construct and remodel energy efficient buildings is high, there are clear long-term economic benefits. Investment in energy efficient buildings and renewable energy will allow Spokane to generate their own energy and reduce the amount of money spent on imported fossil fuels. A decreased reliance on outside sources of energy will also increase the economy’s resiliency, minimizing the effect of fossil fuel shortages and price gouging on Spokane’s economy. Focusing on local material and labor sources for renovating and sustainable construction could offer an additional boost to the local economy. The health and wellbeing benefits of prioritizing a more sustainable built environment are also clear. Increased ventilation, seen in sustainable buildings, helps to improve indoor air quality which can reduce asthma, reduce infectious disease, and lead to

higher levels of productivity (USGBC, 2022). Sustainable buildings may also utilize greenspaces in their designs which can help to reduce depression and increase productivity (Affinity Health, 2021).

While buildings and energy contribute significantly to greenhouse gas emissions around the world, there are many opportunities for the City of Spokane to make improvements to their built environment. Spokane has acknowledged the lack of sustainable building and energy management but has yet to make meaningful change to the city's systems and infrastructure. Adapting techniques and research that the Netherlands has accumulated will allow the city to address the climate crisis quickly and effectively. These techniques have been tried and tested in the Netherlands, minimizing the risks of mistakes for Spokane's own implementation.

Chapter Three: Green Roofs and Facades

Green roofs and facades are a strategy that places grasses, flowers, and other vegetation on the tops and sides of buildings to create a more resilient and sustainable urban environment. There are two main types of green roofs: intensive and extensive. Extensive roofs are simpler and focus on vegetation that can live in a thin layer of soil and survive harsh weather conditions (see Figure 2). Extensive roofs tend to be cheaper and require less maintenance. Intensive roofs are more complex and could feature trees and walkways. Intensive roofs are used as a garden while extensive roofs are more focused on environmental benefits (United States General Services Administration, 2011). While both roof types have their benefits, extensive roofs give Spokane a cost-effective way to cover a large percent of the urban surface area in green roofs and facades.



Figure 2: A simple extensive green roof found outside of Delft, NL.

Green roofs and facades offer several benefits in the environmental, economic, and social sectors which play key roles in building a sustainable city. In the environmental sector, green roofs and facades help to make cities more environmentally friendly in multiple ways. The first benefit is that green roofs and facades reduce greenhouse gasses through the plants ability to sequester carbon. Second, green roofs and facades reduce the heat island effect through the process of evapotranspiration in which plants release water particles that cool the surrounding air. Finally, green roofs and facades reduce the energy usage of buildings due to a combination of a reduction of the heat island effect and the fact that green roofs are a natural insulator (United States Environmental Protection Agency, 2021). While green roofs and facades cost money to build and require structural retrofits to ensure building safety, over the long-term green roofs and facades only bring economic benefits. These roofs and facades lower energy costs due to their insulation and create jobs related to the installation and continued maintenance of these features (United States General Services Administration, 2011). Green roofs and facades also increase the lifespan of the roofs on which they are placed by 2 or 3 times due to the heat protection offered to the roof (American Society of Landscape Architects, n.d.). The implementation of green roofs and facades also lead to an increase in quality of life for the people of the city. Green walls and roofs increase the populations interaction with nature which benefits human health as well as generally increasing the aesthetics of the city (United States Environmental Protection Agency, 2021).

While all these benefits help the city in general, green roofs and facades will specifically help Spokane to achieve multiple goals that have been set out in the SAP. The goals that are addressed in the Spokane Action Plan are BE 1.7, BE 2.4, and HW 3.4. The first two goals, BE 1.7 and BE 2.4, both focus on increasing energy efficiency while reducing excess materials throughout the process of making buildings energy efficient (Spokane, 2021). Green roofs and facades create a method to make both old and new buildings more energy efficient. The third goal, HW 3.4, emphasizes the need to minimize the effects of increasing temperatures on the vulnerable populations (Spokane, 2021). Goal HW 3.4 is clearly addressed through evapotranspiration which will help to cool and regulate the cities temperature (United States Environmental Protection Agency, 2021).

Within the City of Spokane, a large percentage of the office buildings, apartment complexes, and retail centers were built with flat roofs. When compared to the angular roofs seen in the suburbs, the flat roofs within the city present a prime place to build green roofs. A possible starting point for the shift toward green roofs could be the River Park Square Mall. The main building of this mall has an approximately 129,000 square foot roof (Google, n.d.). Using this area as a conservative estimate of the roof area in collaboration with a study done by the US General Services Administration (GSA), a rough estimate of the benefits of a green roof can be made. The GSA found that the reduction in energy usage caused by the reduced use of heating/cooling units lead to an annual savings of \$0.23 per square foot per year. The GSA also found that due to the increased energy efficiency of the roof there would be an approximate annual savings of \$0.166 per square foot per year (United States General Services Administration, 2011). After combining both savings and scaling up to the size of the River Park Mall roof the estimated savings would be around \$51,000 per year. The savings calculated here do not account for the extended life of the roof that is also made possible by the vegetation. The mall is a great starting point, but as Spokane builds more green roofs and facades the savings will grow while helping the environment and the people who live in the city.

As Spokane moves toward adopting green roofs and facades in the city's infrastructure, it is important to note the similarities and differences in how this innovation is applied in the Netherlands and how it can be applied in Spokane. One of the most obvious differences between the two locations is climate. To adjust for this difference, Spokane must use native vegetation

that will survive throughout all seasons and that does not require large amounts of water (See Table 2). Another difference between the US and the Netherlands that must be bridged is the relationship between the people and environmentally friendly and resilient technologies. Historically, The Netherlands has promoted strategies that help them live in better harmony with the environment, such as water management. The Dutch value a strong sense of solidarity, which promotes a symbiotic relationship between the environment and the human population. Solidarity may allow the people of the Netherlands to accept and support environmental technologies more quickly than Spokane. For that reason, education is critical within Spokane to build a sense of understanding and solidarity around sustainability initiatives. Like all environmental innovations, green roofs and facades require an upfront investment to reap a long-term benefit. Without a clear vision and compelling educational message, it may be difficult to convince Spokane residents to invest in and implement green roof innovations. While global climate change has sparked a shift toward solidarity with the environment, it is integral for the success of green roofs and other innovations that Spokane also creates a value of solidarity.

Table 2: A chart that shows possible drought resistant plants that survive in Spokane's Climate (Washington State University, 2020).

Plant	Common Name	Ht./Width	Bloom	Sun/Shade	Hardiness Zone	Comments
<i>Berlandiera lyrata</i>	Chocolate Flower	12-15" x 18-24"	Yellow	Sun	4	Chocolate scent; most fragrant when planted in groups
<i>Calamintha nepeta</i> ssp. <i>nepeta</i>	Calamint	12-15" x 12-18"	White, Pale lilac	Sun	5	Attracts pollinators; long bloom period; fragrant foliage. Uses: rock garden, edging; self-sows - shear after flowering
<i>Callirhoe involucrata</i>	Poppy Mallow	4-6" x 24-36"	Magenta	Sun	4	Blooms all summer; taproot; long lived; Useful on slopes, over retaining walls and naturalized areas
<i>Calylophus serrulatus</i>	Yellow Sundrops	6-12" x 12-15"	Yellow	Sun	4	Native to the Great Plains; long-blooming; a tough, low maintenance plant; good in rock gardens
<i>Campanula rotundifolia</i>	Bluebell, Harebell	6-12" x 12"	Blue-purple	Sun/pt sh	3	Native; long blooming; attracts bees, butterflies. Uses: rock gardens, naturalizing
<i>Catananche caerulea</i>	Cupid's Dart	18-24" x 10-12"	Lavender-blue	Sun	4	Grass-like foliage with flowers on 8-12" stems; papery blossoms make excellent cut or dried flowers; self-sows
<i>Coreopsis lanceolata</i>	Lanceleaf Coreopsis	2-3' x 2'	Yellow/gold	Sun	4	Bright yellow daisy-like flowers on long stems; attracts pollinators; self-sows, good for naturalizing
<i>Echinacea purpurea</i>	Purple Coneflower	2-4' x 2'	Purple, Pink	Sun/pt sh	4	Many cultivars available; attracts butterflies, bees; good choice for a prairie, native or meadow garden; versatile and beautiful
<i>Epimedium alpinum</i>	Alpine Barrenwort	6-12" x 8-14"	Red and Yellow	Part shade to shade	4	Rhizomatous; heart-shaped leaves; excellent groundcover for shady areas

Chapter Four – Conclusions and Recommendations

With the ever-increasing impact of human activity on the environment, it is imperative that steps be taken to create more resilient and sustainable cities. Sustainable cities protect the environment while allowing humans to flourish and build connections to the environment. A truly sustainable city will balance environmental, economic, and social factors without letting

one overtake the others (Ayers, 2017). Buildings and energy play a large role in the creation of sustainable cities, and are necessary for human flourishing, but in their current state are harmful to the environment. The Netherlands comprehends the importance of sustainable buildings and energy and has created stringent regulations to guide their country toward sustainability. The Netherlands has not only created these regulations, but also support research into innovations that will allow the country to meet those regulations. Spokane has started the shift toward sustainability with the creation of the Sustainability Action Plan (SAS) and can adopt innovations from the Netherlands to help Spokane on the path toward sustainability. One of these innovations is green roofs and facades. Green roofs and facades help to reduce air pollution, reduce the heat island effect, increase energy efficiency in buildings, and boast numerous economic and social benefits (United States Environmental Protection Agency, 2021). Spokane experiences an extremely dry climate compared to the Netherlands, so green roof innovation in Spokane must utilize native vegetation that will survive without excess watering.

The Spokane City Council has taken a leadership role in the city's sustainability effort. The most important jobs for a leader are to create a vision that excites people, to build a team to execute on that vision, and to drive for results. This paper is intended to spark interest and excitement behind the creation of green roofs and facades as a tactic to make Spokane more sustainable. As this paper is only a starting point, it is important to understand that more research must be done to make practical decisions regarding Spokane's implementation of green roofs and facades, including what plants are most suitable. At its core, sustainability is about creating a safe future for future generations. Green roofs and facades are a valuable and beautiful steppingstone along that path.

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