

Case Study Analysis

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Final Report

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Summary

From now on cities need to be built with sustainability in mind. Resources are being depleted and weather is becoming harsher, so cities need to be designed for this. Building materials need to be reused, resources need to be used efficiently, and money needs to be spent wisely. Civil engineers are at the front of it designing and planning for cities to be sustainable. Spokane can learn from the Netherlands to incorporate sustainable techniques that can be incorporated quickly as well as ones that take more time and planning. Conserving water in showers is an easy way that addresses goal to of the Spokane Sustainability Action Plan and encourages users to decrease water usage in the shower. To get to a fully sustainability city it takes time and the participation from everyone, so it is important to get everyone aware and the Amphiro Digital Water Shower is a great place to start.

Part 1 – Sustainable Cities

A sustainable city is where the social, economic, and environmental conditions of the city meet the needs of the current citizens without compromising the ability of future generations to meet their needs (Artic 2017). It ensures that cities are building infrastructure that are not only effective for use by people but also good for the environment and are built in sustainable ways such as the materials that do not hurt the environment and allows for people to get more out of their money. Ensuring sustainable infrastructure is important to do because over the next few decades the population will be substantially grow from 7.7 billion to around 9.7 billion in 2050 which will lead to more infrastructure needed (United Nations 2019). More materials and money will be needed to build it and if they cannot be used effectively, cities will struggle to meet the needs of people., Current cities are using more resources than what the planet can give, meaning that if cities continue to do what they are doing, the planet will run out of materials. To sustain current practices, four times the Earth's current resources would be needed, which shows how people need to turn to more sustainable practices (McDonald 2015). Multiple actions can be taken in order to make a city more sustainable such as encouraging biking and walking instead of driving. An example of this is seen in Portland, Oregon.

Over the last few years Portland has tried to build new infrastructure with sustainability in mind. One of the actions they have taken is encouraging the use of bikes more often. This is done by having bike lanes in high density areas. In downtown, one of the main roads on the waterfront is being redesigned to include designated bike and pedestrian paths and safer crossings. Less used roads are also getting painted green near intersections as well to ensure that the bikers feel safe. Nike has also partnered with the city and has placed bike racks throughout the city that can be rented for use as a sustainable way for transportation.

Sustainability at the city level (i.e., bottom-up approach) is more effective and important compared to the state and national level. At the national level as well as the state level, it is hard for the governments to regulate what every city is doing and ensuring that they are meeting sustainability goals. This is why the bottom-up approach is far more effective. At the city level, governors are able to monitor progress towards a sustainable goal in a more efficient way. It can be argued that cities are able to make goals and choose plans that maximize sustainable impacts for their city, whereas this is close to impossible at a national level. For example, it does not make sense for a city to require solar panels in a place that is cloudy most of the time when they could encourage using other types of renewable energy such as wind.

Furthermore, with the bottom-up approach, citizens are able to get on board with the city's goals for being sustainable. Without citizens getting involved, it is harder to meet the goals because building sustainable buildings can only go far. Cities with big goals such as 80% renewable energy use or having 60% of vehicles on the roads be electric can only be achieved if they buy the cars or start installing solar. Cities encourage renewable energy by giving tax discounts on cars and solar or encourage selling back energy to the grid if not all of the solar panel energy is being used by the house.

Civil engineering plays a big role in promoting more economically, socially, and environmentally sustainable urban environments. They can do this by designing their buildings, roads, and other infrastructure to incorporate sustainable features. For roadway designs, as done in Portland, civil engineers can paint existing lanes green to encourage safe biking while not having to completely redo the whole roadway. They can also encourage using public transit by designing systems that are electric which is good for the environment and on time which helps

with the social aspect of sustainability. For building designs, current sustainable as well as new techniques can be used. In Portland, newer buildings are built with solar panels and sometimes small wind turbines to reduce the energy they need from fossil fuels as well as having green roofs to grow trees and plants. In Seattle, the remodel of the new Climate Pledge Arena recently finished. Built with sustainability in mind, the building is 100% carbon neutral. One of their focuses is water conservation which includes a rainwater collection system which collects up to 15,000 gallons of rain from the roof, stored, and then used for the ice on the hockey rink along with retention tanks, waterless urinals, and very efficient showers (Sustainability 2021). This is only possible by the mindset of the engineers to do such a thing and it will encourage other companies to build new arenas and buildings in a similar way. The next few years are going to be crucial for encouraging sustainability as more cities are setting strict sustainable goals so getting started sooner is more beneficial

Part 2 – Civil Area of Actions

Water resources is vital for the survival of humans, and it is crucial that it is managed well so that it can last for future generations. A water resource is anything that “includes natural and managed water systems that humans and other living things rely on to survive” (Spokane Sustainability Action Committee 2021). Natural water systems include lakes, rivers, oceans and groundwater and managed water systems include dams, water pumps, drinking water, as well as stormwater runoff and treatment. Having a strong understanding of water management and water systems is crucial in creating a sustainable city. In cities, water needs to be conserved and used wisely as global warming increases and longer droughts occur. This is shown in data collected from the Spokane River as shown in Fig. 1.

Month	January	February	March	April	May	June	July	August	September	October	November	December
Monthly avg flow change each year (cfs)	0.74	20	17	0.27	-34	-36	-25	-13	-5	12	-1.3	-0.65

Figure 1. Spokane River flow in 2022 compared to 129 year average (2022. [https://www.spokaneriverkeeper.org/water-](https://www.spokaneriverkeeper.org/water-conservation-2)

In the months highlighted in blue, flow has increased significantly from the 129 year average, most likely from melting ice or from rain instead of snow. From May to July, flow has decreased due to drought and increased water usage by the city (Spokane Riverkeeper 2022). Water usage in the City includes using treated water for watering lawns, running the washer, car washes, flushing the toilet and much more. This is an unsustainable use of the water, when instead it should be conserved during times of high demand.

Water is irreplaceable, used by everyone and at the core of sustainability. With most of the population expected to be living in cities by 2050 and where “1.7 billion live in river basins the water use exceeds the discharge”, cities need to understand water management well as well as exploring the use of water reuse through wastewater treatment and other ways (United Nations 2015). Everyone lives in a watershed and each day everyone makes some sort of impact to the watershed affecting the quality and health of it. With the strategic planning and efficient management of water resources, cities can strengthen their social, environmental, and economic systems.

Water is at the heart of the Spokane area. The area is covered with bodies of water including lakes, wetlands, streams, rivers, and most importantly, the Spokane Valley-Rathdrum Prairie Aquifer. Spokane must protect the aquifer as it is “an Environmental Protection Agency designated ‘sole source aquifer’” meaning that it is really the only source of drinking water for the area (Spokane Sustainability Action Committee 2021). As more people are expected to move to the area in the coming years, it is important to understand how that will affect both the Spokane river and aquifer, as they are hydraulically connected together. It is important to understand how to use the water more efficiently and start thinking about reusing water for tasks that do not require the treatment of drinking water. Spokane has started treating stormwater for reuse in some areas along with increasing “on-site stormwater treatment projects like storm gardens and bioswales” (Spokane Sustainability Action Committee 2021), which is a step in the right direction to help resupply the aquifer and river with pollutant free water.

Water resources have a big impact on economics, natural environment, and the wellbeing of the city. As defined in the Spokane Action Plan, economics “refers to the balance of costs and opportunities associated with adapting to and mitigating the climate crisis” (Spokane

Sustainability Action Committee 2021). As more water is used and the resource declines, prices to use it are most likely going to increase to discourage people from using too much from it. However, by adapting new ways of reusing water such as only using drinking water for drinking and reusing wastewater for flushing the toilet, wastewater can be used more efficiently and it will get more use out of it before it is returned to the river. Investing in ways to recover rainwater through bio swales or retention ponds can reduce lifetime costs for water needed as well.

The natural environment is highly affected by water resources. Humans are not the only ones who need water to live, but also other plants and animals living in the surrounding areas. Water management must be done sustainably and efficiently as long as cities do not want to harm the environment. If citizens of Spokane want to keep using “235 gallons of water per day” per person, the city will either need to incorporate new ways to manage the water system to resupply the aquifer to ensure it does not run out or find water reducing ways to lower that number closer to the country average of “138 gallons a day” or less (Spokane River Keeper 2022). Water resources is having a management that balances water consumption and the supply which cannot be done without solidarity,

Health and wellbeing are defined as “the work of creating a city with local leadership that prevent potential problems by proactively investing in public health, emergency services, housing and resiliency infrastructure” (Sustainability Action Committee 2021). Water needs to be available and safe in order to keep cities healthy. Wastewater treatment facilities are an important piece to that in order to keep the Spokane river pollutant free to ensure the aquifer continues to produce clean drinking water. The use of bio swales, retention ponds, and groundwater filters help filter out pollutants and are crucial to reduce demand on treatment facilities when stormwater occurs. This can often overflow the system causing it pollutant mixed water to be dumped straight into the river. Furthermore, having the public understand the importance of water resources and how it can have a negative effect on their life can help create solidarity, thus ensuring better management and protection of the water.

The Netherlands gives great examples on how to deal with water resources. They deal with water every day because not only do they need it as a source for drinking water and other daily activities, but it also poses a flood risk. The success comes from solidarity within the

citizens as well as a well-organized water management system. Success also comes from flexibility as they have to constantly adapt to current situations in order to survive. Furthermore, they live by sustainability and design current infrastructure for multiple uses and are aware of how they are building it and the materials they are using. For the country, water policy management is changing as “financial resources available are decreasing, tasks are being decentralized, and society itself is increasingly becoming both initiator and implementer of measures” which then leads to new partnerships and fundings for sustainable management (Ministerie van Algemene Zaken 2021). Furthermore, the Netherlands is worried about climate change, limited raw materials and population growth and how that will impact current infrastructure within their dikes, waste water treatment plants and drinking water supply systems. Since they are very much a water country, the biggest pressing issue is how to get others involved and aware of the current situation, keep them informed, and get them on board to help protect water resources and most importantly to not flood.

Water usage strategies can be brought over from the Netherlands to the United States and even Spokane. The City of Spokane can learn from them and apply strategies that make sense to apply to city. As the length and number of droughts increase in Spokane and the rest of the country, water usage needs to be reduced when possible.

Part 3 – Shower water usage

The Amphiro Digital Hand Shower addresses water usage during the shower and encourages users to reduce water during showers. The device connects directly to the shower hose and can be easily installed, shown below in Fig. 2.



Figure 2. Amphiro B1 Shower

https://www.amphiro.com/assets/studies/Amphiro_PWN_FinalReport_MainPart_2016_04_28.pdf

Powered by hydropower, the device monitors water, temperature, and energy consumption and reports in back to the user in real time on the device, but also records in on the app. During the shower, the screen gives a grade for how much water is used and shows an image of a polar bear on an ice sheet which slowly decreases as water is used, with the goal trying to not “kill” the bear. Goals can be set from the app to reduce consumption and trends can be viewed to ensure the user is making progress.

The Amphiro Shower positively impacts the environment, creates economic gains, and increases health and well-being. With its on-screen data, grades, polar bear simulation, as well as statistics on the app, the device encourages users to help the environment by decreases the amount of water used and electricity used. A three-month study completed by Amphiro compared people who showered without the device compared to people who were given it. In the study they linked energy consumed with water usage, so the more energy used, the more water was consumed. The results are found in Fig. 3 and Fig 4.

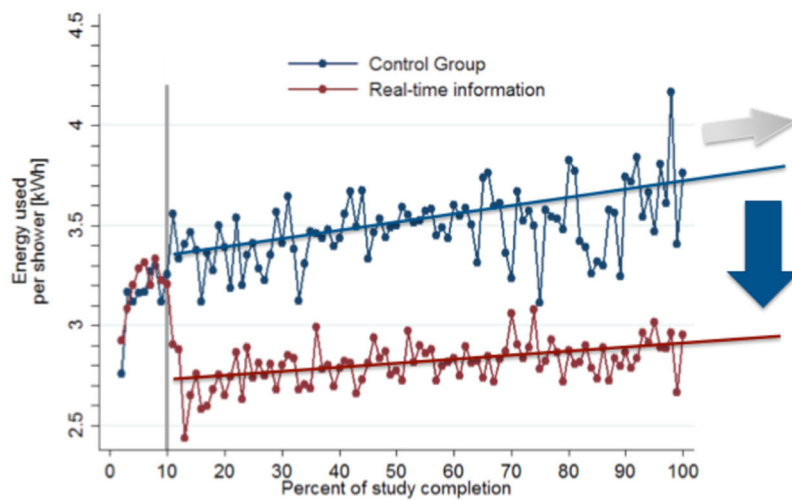


Figure 3. Energy consumption results https://www.amphiro.com/assets/studies/Amphiro_PWN_FinalReport_MainPart_2016_04_28.pdf

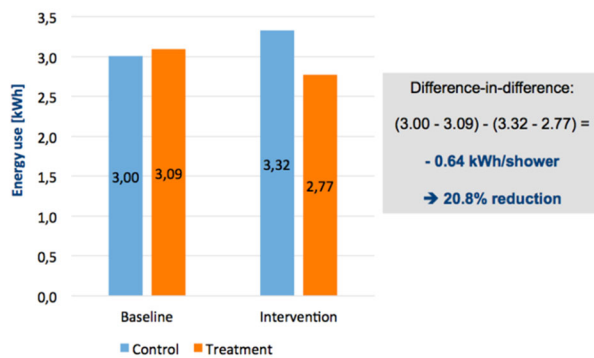


Figure 4. Energy use reduction https://www.amphiro.com/assets/studies/Amphiro_PWN_FinalReport_MainPart_2016_04_28.pdf

They found that people who showered without Amphiro used just over 3.5 kWh per shower whereas users used approximately 0.64 kWh less per shower or over a 20% reduction in energy and water usage. (Staae 2016). Reducing energy and water by 20% can lead to quite a lot of economic savings. Using the energy values obtained from the study and using an average of six showers per week, savings for energy and water can be calculated shown in Fig. 5.

Household size	1 person	2 persons	2.3 person	3 persons	4 persons
Energy savings	558 kWh	1'117 kWh	1'284 kWh	1'675 kWh	2'233 kWh
Water savings	8.7 m ³	17.5 m ³	20.1 m ³	26.2 m ³	35 m ³
Investment per kWh saved	0.107 EUR	0.054 EUR	0.047 EUR	0.036 EUR	0.027 EUR

Figure 5. Energy and Water Savings for within Three Years

https://www.amphiro.com/assets/studies/Amphiro_PWN_FinalReport_MainPart_2016_04_28.pdf

On average a three-person household is saving 26.2 m³ of water and 1675 kWh in three years which in Spokane is saving just about \$2,400 for water assuming \$0.35/gal and \$1,100 for energy assuming \$0.658/kWh. (City of Spokane 2022). That's a lot of money that can then be used for other things and the savings will most likely increase as utility prices increase. With this, users are generally happier, and users continue to use the shower monitor after the study.

The Amphiro device fits into goal 2 of the SAP: ensure sustainable water supply because it helps reduce the water consumption from the Spokane aquifer. It specially touches on WR 6.10 which talks about "assisting residents in decreasing water use through conservation and efficiency strategies" (Spokane Sustainability Action Committee 2021). The device allows residents to install their own device to conserve water while obtaining benefits talked about previously. If the Amphiro shower was implemented in the city in hotels, homes, and other buildings, residents and guests would become more aware of the amount of water they are using. Most likely they would get inspired to start reducing their water or purchase one themselves, and for residents who have it in their homes, water reduction would increase. Overtime, the city would most likely see a decrease in water usage in homes and therefore have more water in the aquifer for drinking.

Implementing the shower monitor has the potential to work well but in order to do so residents need to be aware of it and its benefits. The monitor works well in the Netherlands due to solidarity and knowing that it is the right thing to do in order to save water. A similar thing will have to happen in Spokane starting small with getting hotels on board and then larger communities and homeowners to do it will really help get the device implements throughout the city. Residents also need to be willing to reduce their water and know that it will keep their life happy. Citizens

of the U.S. love to have long showers so it is important to start to change that mindset even if it is just cutting a shower by a little bit at first. It will take time, but the benefits on the environment, economy, and health outweigh the change in mindset.

Part 4 – Conclusion and recommendations

A sustainable city is a city where the economy, environment, and social conditions are not affected by the current generation and do not hurt future ones. It is important to build new and update current infrastructure with this mindset in order to have enough resources for the growing population. Water resources is a current issue in many states as well as Spokane as the country enters a period of prolonged droughts. Citizens need to be aware of the current conditions and conserve and use water efficiently. The Amphiro Digital Water Shower addresses this and encourages users to reduce their water consumption during showers. During the planning process it would be beneficial to include a plan on ways homeowners or building owners can incorporate the digital shower or other resource conservation products into their homes or buildings.

Sources

City of Spokane. (2022, June 24). *Utility billing rates*. Utility Billing Rates - City of Spokane, Washington. Retrieved June 24, 2022, from <https://my.spokanecity.org/publicworks/utility-billing/rates/>

McDonald, C. (2015, June 15). How many earths do we need? BBC News. Retrieved May 23, 2022, from <https://www.bbc.com/news/magazine-33133712>

Ministerie van Algemene Zaken. (2015, December 15). National water plan 2016-2021. Policy note | Government.nl. Retrieved May 22, 2022, from <https://www.government.nl/documents/policy-notes/2015/12/14/national-water-plan-2016-2021>

Staake, T., Tiefenbeck, V., Schöb, S., & Kupfer, A. (2016, March 31). *Final report on the Amphiro-PWN-study effects of real-time feedback on ...* Effects of Real-Time Feedback on Hot Water Use. Retrieved June 24, 2022, from https://amphiro.com/assets/studies/Amphiro_PWN_FinalReport_MainPart_2016_04_28.pdf

Sustainability Action Subcommittee. Sustainability Action Subcommittee - City of Spokane, Washington. (2020, February 21). Retrieved May 22, 2022, from <https://my.spokanecity.org/bcc/committees/public-infrastructure-environment-and-sustainability/sustainability-action-subcommittee/>

Sustainability. Climate Pledge Arena. (2021, December 10). Retrieved May 23, 2022, from <https://climatepledgearena.com/sustainability/>

United Nations. (2015, July 9). Sustainable, development, United Nations, rio+20, decade, Water For Life, 2015, UN-Water, United Nations, MDG, water, sanitation, financing, gender, IWRM, human right, transboundary, cities, quality, food security. United Nations. Retrieved May 22, 2022, from https://www.un.org/waterforlifedecade/water_and_sustainable_development.shtml

United Nations. (2019). Growing at a slower pace, world population is expected to reach 9.7 billion in 2050 and could peak at nearly 11 billion around 2100 | UN Desa Department of Economic and Social Affairs. United Nations. Retrieved May 23, 2022, from <https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html>

Water conservation. Spokane Riverkeeper. (2022). Retrieved May 22, 2022, from <https://www.spokaneriverkeeper.org/water-conservation-2>

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What does a sustainable city look like? Promoting Urban Sustainability in the Arctic. (2017, July 30). Retrieved June 24, 2022, from <https://blogs.gwu.edu/arcticpire/2017/07/30/what-does-a-sustainable-city-look-like/>