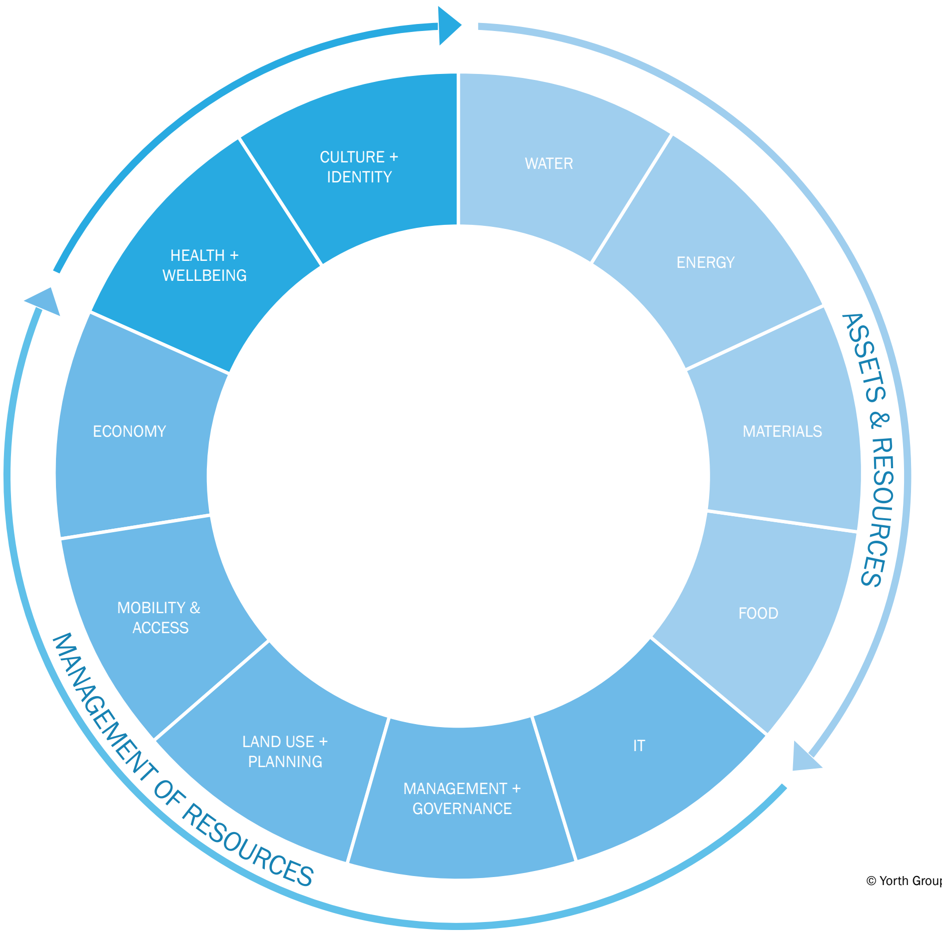
WATER

the axis resource

Restorative Development: Full Resource Integration to Power a New Local Economy

To assess performance, Yorth uses its proprietary Restorative City Standard™. The Standard has 11 performance areas, each with goals and key performance indicators (KPIs). When these are managed systematically and synergistically, net-positive results can be achieved.



As shown, the performance areas create a virtuous cycle of positive action. Effectively integrating physical resources such as energy, water, and materials in closed-loop systems creates economic, social and environmental benefits. This attracts new investments, industries and employment opportunities. If managed according to restorative standards, this new local economy improves residents' quality of life, which in turn strengthens culture and identity.

Through its integrated approach, restorative development generates the following outcomes:

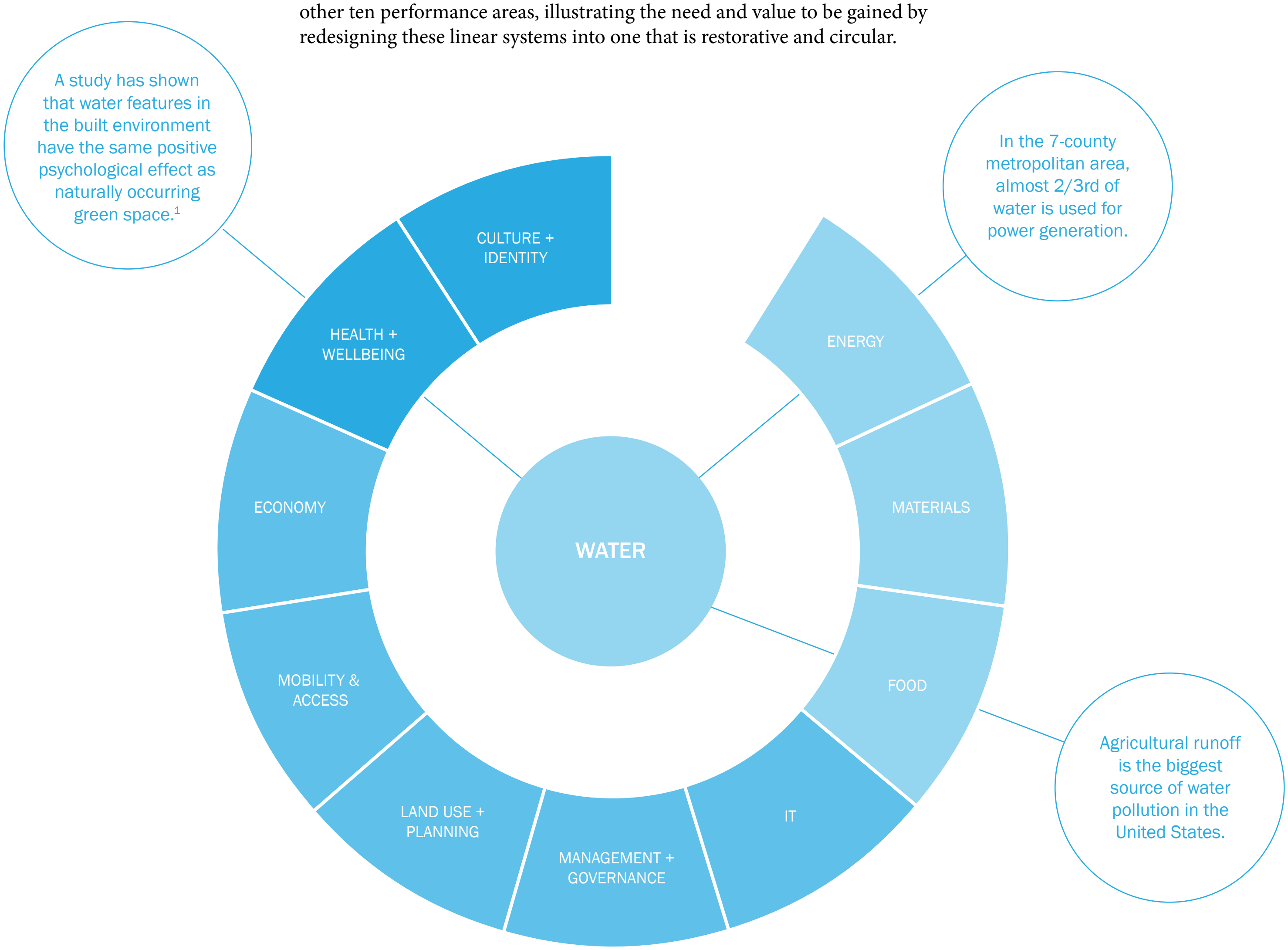
- Resilient and climate-proof infrastructure
- Zero-emission energy, water, materials and food infrastructure
- Energy, food and water security
- Resilient and green local economy with new jobs and career pathways
- Incentives for local developers and industries
- Increased economic, social and environmental equity across all sectors

CHAPTER SUMMARY

FROM
Water managed in silos in linear systems

TO
Closed-loop, one-water management that is integrated with energy, food and materials systems

The following overview shows the connectivity between water and the other ten performance areas, illustrating the need and value to be gained by redesigning these linear systems into one that is restorative and circular.



KEY TAKEAWAYS

- Water is managed through three separate centralized systems, where it is either treated as an asset or a liability. Each system performs well on its own, but the siloed approach does not allow for localized, closed-loop use and reuse.
- Stormwater, seen as a liability, is one of the most overlooked assets of urban resource management. The current infrastructure is not fit to withstand future precipitation amounts.
- Cities have an opportunity to take a “one water” approach, where stormwater, drinking water, and wastewater are managed holistically within one system and are fully integrated with other resource flows.

WATER
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When it comes to water, Minneapolis is a city of superlatives. Built next to one of the world's largest rivers, the city is also not far from one of the world's largest freshwater lakes. Minneapolis—known as the "City of Lakes" because of its many urban lakes—has a deep connection with water. Whether it's an afternoon walk around a lake, a trip to the cabin, or ice-skating and skiing in the winter, residents flock to the water no matter the season.

Water has been referred to as an 'axis resource', meaning it is a resource that underlies all others. Virtually everything we interact with and utilize daily—energy, agriculture, building materials, electronics, technology, apparel—relies on water. But with increased use and subsequent contamination comes the danger of shortage, not just abroad, but in the United States, and even right here in Minnesota.

In urban areas, water has been managed through three separate systems: water supply, wastewater, and stormwater. The water supply system sees water as an asset, a resource to sell and consume. As such, governments are expected to supply it at the highest possible quality and the lowest possible cost. In the other two systems—wastewater and stormwater— water is seen as a liability, and the goal is to discard it as quickly and cheaply as possible.

While Minneapolis is a leader in drinking water purification, the surrounding metropolitan area is a leader in managing wastewater at the regional scale. However, as each system is optimized towards its singular definition of success, challenges loom as aquifers deplete at an unsustainable rate, even as surface waters swell with additional rain brought on by climate change. Governments at the city, county, and metropolitan levels acknowledge the need for a "one water" approach. While the magnitude of changing existing underground infrastructures seems daunting, no other city is better positioned to rethink and lead a different approach to managing water. Change can begin at the district scale with a closed-loop, restorative approach to water management, and then build outwards to the entire city and region over the next decades to come.

1. Water in Minneapolis and the Metropolitan Area

1.1 System Characteristics & Existing Infrastructure

Thanks to strong leadership and good governance, water has been managed well in Minneapolis and the surrounding region. For example, Minneapolis has been a national pioneer in separating its sewer and stormwater pipes, which ended the occurrence of combined sewer overflows into the Mississippi River during strong rain events.

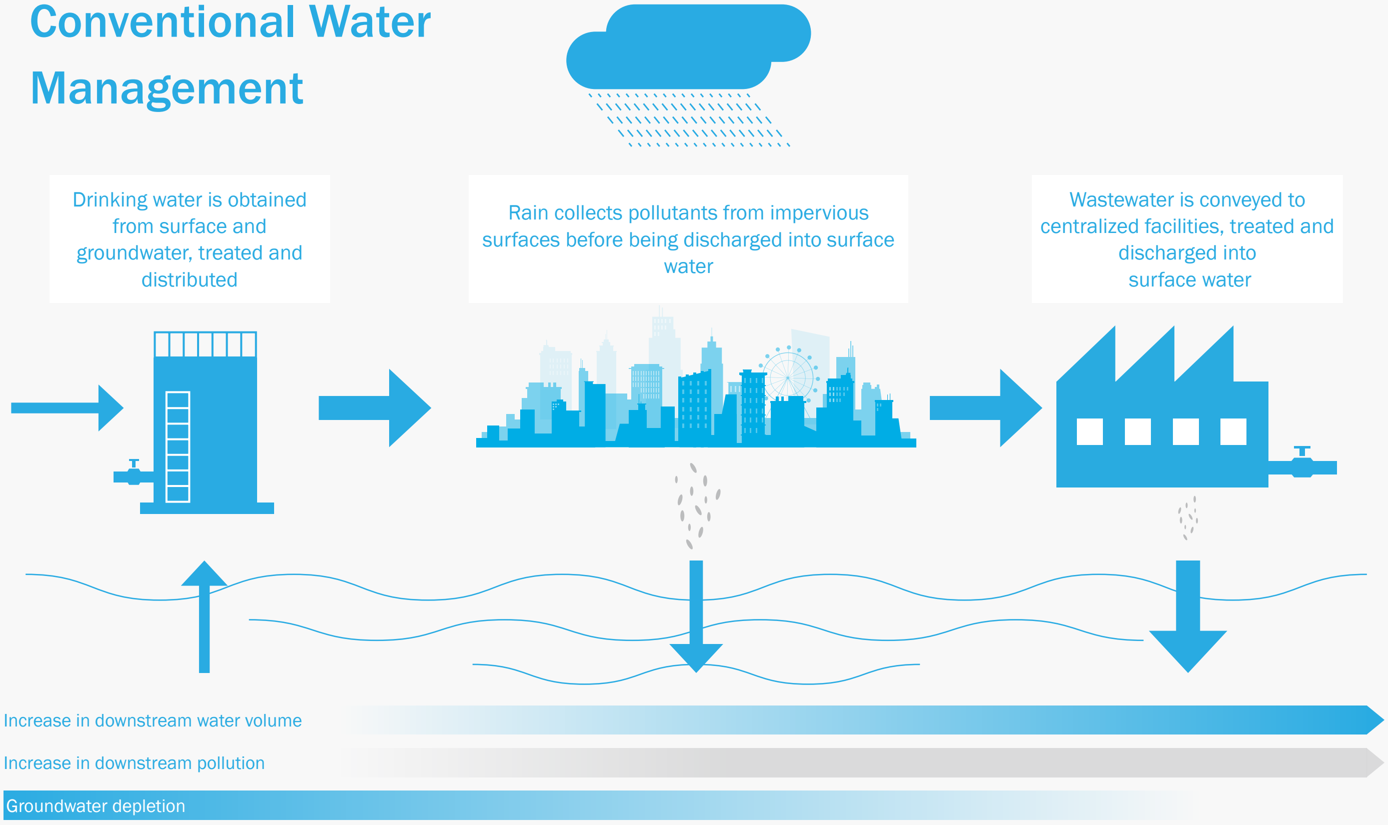
Each year, Minneapolis Public Works pumps and treats 21 billion gallons of water from the Mississippi River and delivers to its 500,000 customers at a rate of 57 million gallons a day.[2] In anticipation of stricter regulations and to hedge against the emergence of future microbes, Minneapolis upgraded one of its two treatment plants to a new membrane ultrafiltration plant, making it the largest potable water ultrafiltration plant in North America and the second-largest in the world when it was completed in 2005. The system produces some of the purest mass-produced drinking water in the United States, although it still relies on chemicals, such as chloramine, for routine disinfection.

Minneapolis' wastewater is managed by the Metropolitan Council as part of a regional management strategy. The average daily volume of wastewater generated within Minneapolis is approximately 17.2 million gallons.[3] Although most of the wastewater system is gravity fed, the Met Council system relies upon 61 pumping stations to convey wastewater to nine regional treatment plants. The Metro Plant receives sewage from 332 miles of interceptors, has a capacity of 251 million gallons, and treats an average of 175 million gallons of wastewater each day. It discharges water back into the Mississippi River, incinerates biosolids to capture some of its energy value, and collects nutrients to be used for regional agriculture. As part of its efforts to reduce stress on aquifers, the Met Council opened a zero-discharge wastewater treatment plant in East Bethel in 2014, which utilizes highly treated wastewater effluent to recharge groundwater instead of discharging it to the river.

Despite advanced technologies and innovations in treating water both before and after use, the regional water infrastructure comes with challenges that are common to any large city system.

First and foremost, managing water through three centralized systems requires separate pipe systems spanning the entire city and requiring constant updates and renewals. Finding themselves at the 'dawn of the replacement era' (a term coined by the American Water Works Association), in order to keep the system operational, authorities have little choice but to continue updating the conveyor systems that were established a century ago, even as future 21st-century demands would benefit from different approaches, such as treating stormwater on site.

Conventional Water Management



The same constraints of an outdated design encumber efforts to more effectively harness stormwater, which is perhaps the most overlooked resource of urban water management. Until recently, stormwater was seen as a liability that needed to be discharged as efficiently as possible, creating a myriad of enduring problems, even as localized urban flooding was mitigated. First, as a result of increased urbanization, more impervious surface carries larger amounts of pollution into rivers and lakes whenever it rains. A typical downtown block in Minneapolis produces about nine times more runoff than a wooded area of the same size. The city uses different methods to treat the pollutants that stormwater collects, which include among others vehicle oil and grease, construction site sediment, bacteria from animal waste, and excess lawn fertilizer and pesticides. Second, as the climate changes, rain events in Minneapolis are becoming both more frequent and more intense, leading to more frequent flooding of an infrastructure that was built for last century's rainfalls. According to Minneapolis Public Works, a 2018 study on flooding in Southwest Minneapolis estimates that $72 million in infrastructure improvements are needed to address localized flooding in that area of the city alone. This estimate represents a small portion of the investment needed to address these challenges across the entire City of Minneapolis.

1.2 Vulnerabilities

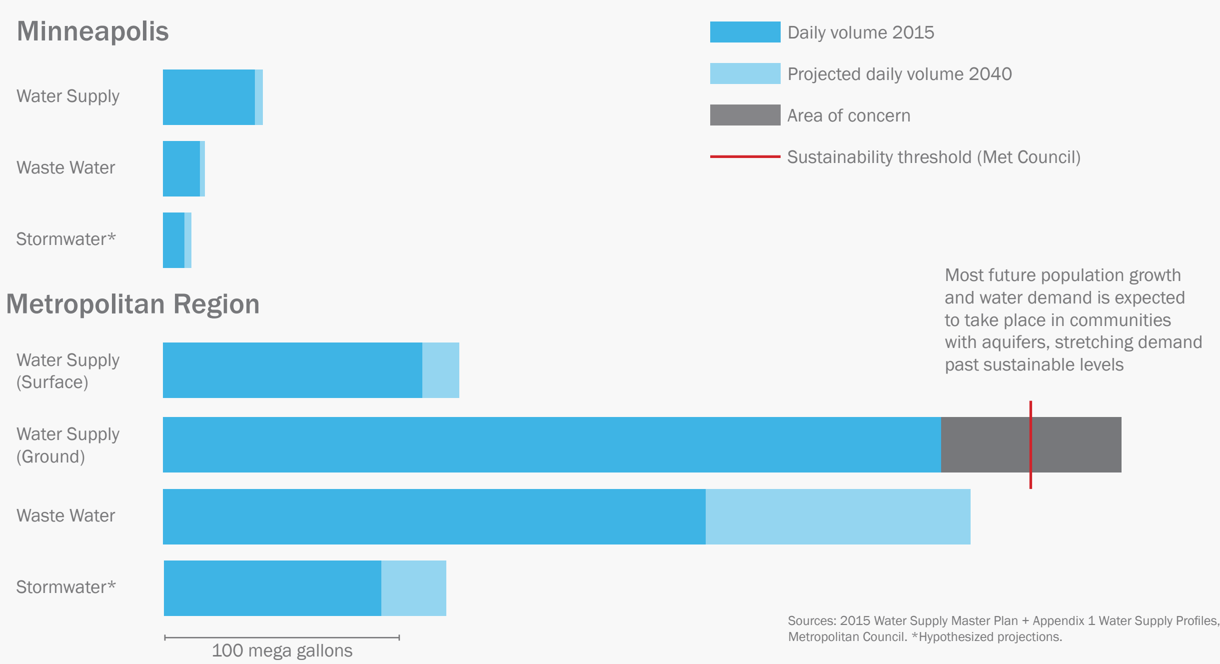
Although drinking water in the City of Minneapolis is supplied by an abundant resource, the Mississippi River, if a severe drought were to happen upstream, or if surrounding communities had to draw from it as well, the water supply in Minneapolis could be at risk.

When zooming out of the Minneapolis city limits to the entire metropolitan region, the risk to water supply takes on an added dimension, as most communities draw drinking water from aquifers that are depleting at unsustainable levels. What's more, 75% of the metro area's future population growth is expected to occur in communities where these aquifers supply municipal systems.[4] To meet future demand, the Met Council recognizes that all sources of water, including reclaimed wastewater and stormwater, must be considered as a resource.

Besides substantial aquifer decline, there is also a risk of significant water contamination. Drinking water in Minneapolis is susceptible to any contamination spills entering the Mississippi River. In addition, industrial activity has created plumes of contamination in the metro area, and nitrates and other run-off from farms are significantly impacting some metro counties. This is a story that plays out in the entire United States, where agricultural runoff is now the biggest source of water pollution.

Like any large centralized system, water supply is vulnerable to catastrophic events, such as terrorist attacks, or a prolonged power outage, which would disrupt the flow of water. There are few redundancies in the system, threatening the city's resilience to such disruptions.

Daily Volume Projections for Water Supply, Waste Water and Stormwater



Sources: 2015 Water Supply Master Plan + Appendix 1 Water Supply Profiles, Metropolitan Council. *Hypothesized projections.

In 2019, Minneapolis residents paid an average of $30.41 a month for using around 5,000 gallons of water.[5] For 2020, such cost is expected to increase 2.8% to $31.26 and to $35.78 by 2024. For wastewater, Minneapolis residents paid an average of $31.06 a month in 2019 for using around 4,500 gallons of sanitary sewer. For 2020 such cost is expected to increase 8% to $33.54 and to $39.86 by 2024.

Minneapolis Public Works and the Metropolitan Council operate under a definition of success that is common for utilities of any type or size. Their mandate is to provide high-quality service at competitive costs, which is often defined as at or below the national average. This definition of success is accepted—and even demanded—by the public, who has grown accustomed to paying relatively little for their water, energy, and waste management.

This means that certain trade-offs are widely accepted by most stakeholders as the "cost of doing business." For example, with more than 700 new chemicals entering the market every year, there are insufficient resources—and a lack of political pressure on agencies such as the EPA—to study the effects of these so-called "emerging contaminants" that end up in our water supply. Likewise, after the point of consumption, federal rules allow for a certain amount of pollution to remain in treated wastewater that is discharged back into rivers and other water bodies. As water becomes a scarcer resource, even in water-abundant states such as Minnesota, public scrutiny is likely to increase, prompting, perhaps, a rethinking of the value of clean water, and the legal framework and investments needed to obtain it.

Water supply and wastewater infrastructures are costly to build and to maintain. For example, the Metropolitan Council's current investment in wastewater infrastructure is $7 billion. To accommodate projected population growth in the Twin Cities, the region will need to invest another $3.7 billion to maintain, replace, and expand the system in the next 25 years.

Spotlight: Stormwater and Restorative Development

Good governance at various levels of accountability has led to regional water systems that are relatively well-funded compared to the rest of the country. However, concerns exist for the adequacy of the region's stormwater system to meet future needs. Built for rainfall predictions devised as far back as the 1960s, the system is ill-equipped to handle the increased rainfall volume now and into the future. This is partially due to the challenging economics of the stormwater infrastructure, which is expensive to build and maintain, has unclear payoffs, and functions in a siloed system where water is considered a liability to be disposed of quickly and cheaply. The siloed approach to water management leads to unaccounted externalities, such as increasing amounts of run-off pollution from stormwater that ends up in lakes and in drinking water supplies, thus making treatment more costly. Further complicating the "business case" for stormwater investments is the fact that in Minneapolis, as in many places, the cost of flooding is not systematically tracked because such costs are mostly carried by private parties, such as businesses, residents and insurers.

Arguably, the key to increasing the resilience of the regional water system is to take a "one water" perspective, with a focus on rethinking stormwater. Instead of considering it as a liability it should be treated as a valuable resource with a clear financial benefit when taking into account its potential to reduce the strain on aquifers, its value as a public realm asset, and its ability to become a carrier of renewable energy in the form of hydrogen.

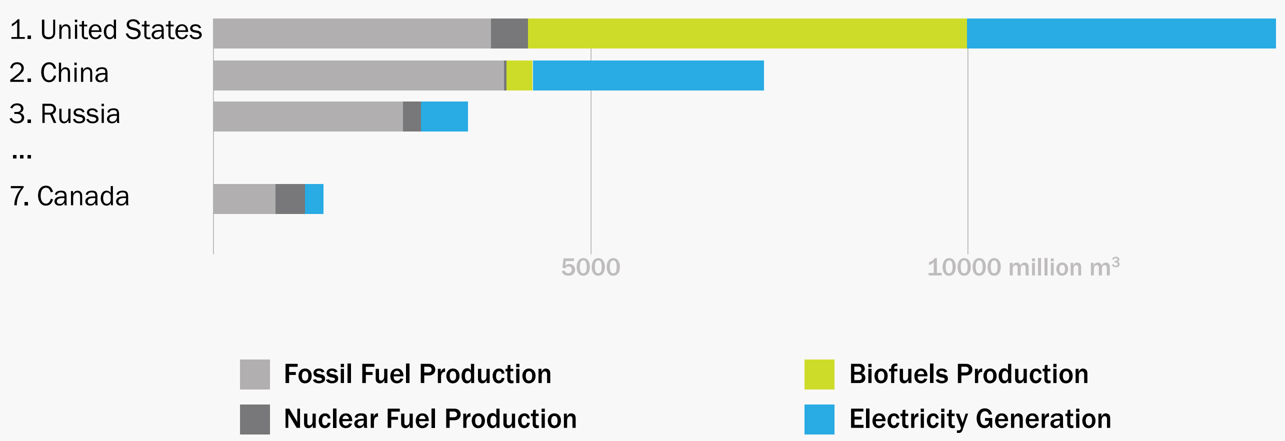
2. The Water-Energy Nexus

Minneapolis is born out of the nexus of energy and water. Built next to St. Anthony Falls, the highest waterfall on the Mississippi River, water powered the development of the initial industry that gave rise to the city.

Water and energy are inextricably linked. Electricity is needed to treat and move water, and water is needed to produce electricity. In the 7-county metropolitan area, almost two-thirds of water is used for power generation.[6] Much of this water is used for steam generation and cooling in thermoelectric power plants.

Worldwide, the United States is by far the biggest consumer of water for energy production. This is due in part to the country's high consumption of energy, only second to China, and in part to its large biofuel production to supplement oil and petroleum products in the transportation sector. The environmental benefits of biofuels are subject to much debate. Adding the amount of water used to the equation—along with fertilizer and pesticides that pollute ground and surface waters—further weakens the case of biofuels as a "green" alternative. Seen through this wider lens, the rapid rise of biofuels is a pointed example of the danger of pursuing singular goals, such as emission reductions, without taking into account systemic effects on other resource flows, such as water.

Total Water Consumption for Energy Production (WCEP) by Country[7]



Given its prominent position as a biofuels producer, this U.S. chart can be considered a strong indicator of how water is used for biofuels production and electricity generation in Minnesota, even if the water used to produce fossil fuels and nuclear fuels and its negative impacts are "externalized" to production outside the state.

In the current system, when water is used to generate energy, it is often left in a degraded state, whether through chemical pollutants introduced through fracking and industrialized agricultural practices, or thermal pollution from power plants, where warm water released back into rivers reduces oxygen and increases algae growth. What's more, the interdependence between water and energy is largely unknown to the broad public. They may be unaware that their electricity comes at a cost of water pollution, and vice versa, that turning on their faucets produces greenhouse gas emissions from the electricity used to pump it to their homes.

In restorative development, circular and closed-loop logic is applied to water. This means first and foremost, taking a "one water" approach, where stormwater, drinking water, and wastewater are managed holistically within one system. Secondly, it means water is integrated with other resource flows, including energy, food, and materials, in a way that not only produces no harm, but maximizes synergies and use.

Stormwater and wastewater can be captured, treated, and used for the creation and irrigation of blue and green habitat, for industrial applications, and for urban agriculture. The heat energy embedded in wastewater can be used for greenhouses, snowmelt of sidewalks, and other applications where heat may be needed. With an anaerobic digester on-site to treat organic waste (food and yard waste), sludge from wastewater could be used to create energy and fertilizer. Last but not least, hydrogen made from water plays an important role as a carrier of clean energy.

While all these processes happen "under the hood", public realm serves an important integrative function in restorative development. Blue and green infrastructure captures and sequesters air and water pollution, noise, and heat. District-and city-scale stormwater systems can be redesigned to integrate public pools, streams, and water ponds that support a thriving habitat, and a desired place for work and play. This can act as an important creator of regional cultural identity and become the core of a city's brand.

The key is situating all these functions close to one another, where waste from one system can serve as an input to another and be recycled multiple times over. Ultimately, this means operators need to deploy smart city technologies in a way that allows them to monitor all resource flows, including energy, water, food, and materials. It also means that cities have an opportunity to be more intentional when they zone for mixed-use and light manufacturing, prioritizing sites where such closed-loop infrastructures can be built for public and private benefit.

Endnotes

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3 Internal Information Request Sheet, Public Works

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7 E S Spang, W R Moomaw, K S Gallagher, P H Kirshen and D H Marks (2014). The water consumption of energy production: an international comparison. Environmental Research Letters, Volume 9, Number 10. Retrieved from: https://iopscience.iop.org/article/10.1088/1748-9326/9/10/105002