

# Water Efficiency:

A Key to Reducing Carbon Footprints



*Photo Credit Maksim Safaniuk*



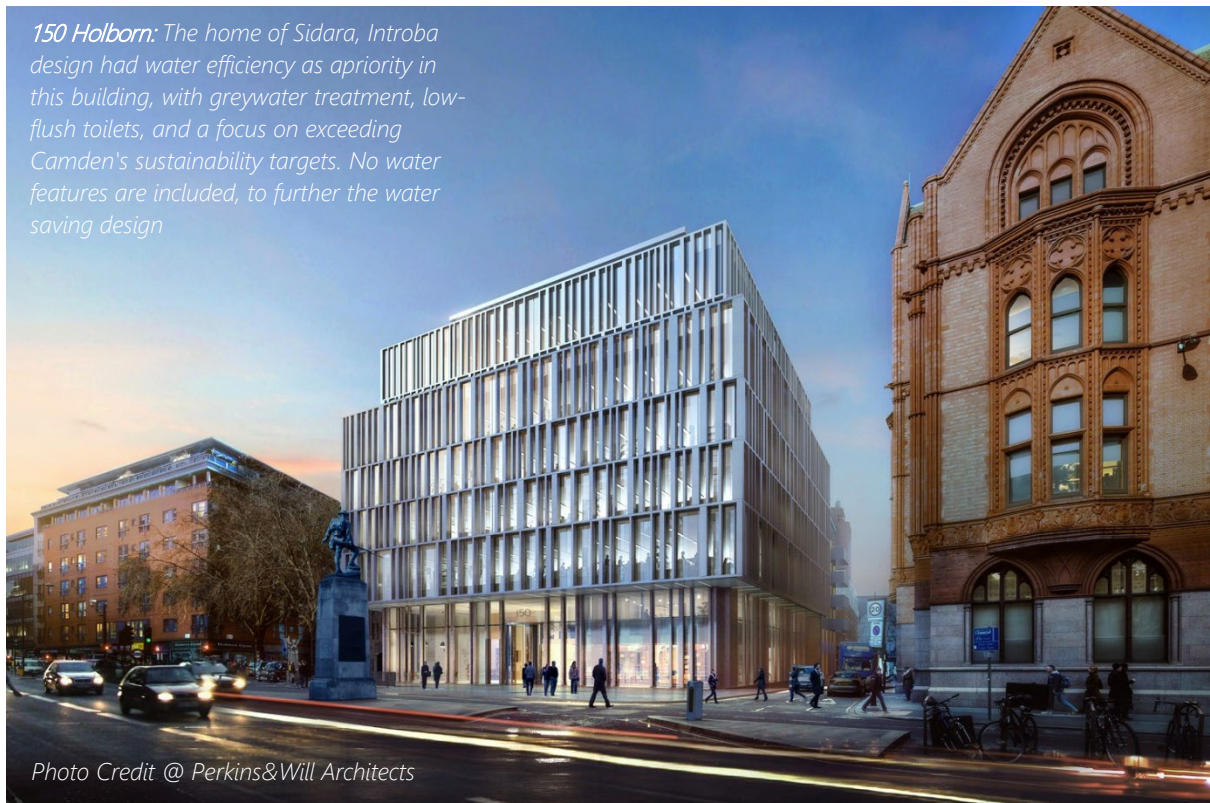
Written by  
Cristiano Michelena  
Associate Principal an Environmental Design  
Introba, part of the Sidara House of Brands

## Introduction

In the relentless pursuit of mitigating climate change, the spotlight often shines on reducing carbon emissions through energy conservation and sustainable practices. Yet, a vital component frequently escapes the limelight: water efficiency. Imagine a world where every drop of water saved translates into a tangible reduction in carbon footprints. This synergy between water conservation and carbon reduction holds immense potential for fostering a greener, more resilient planet. By delving into the intricate connection between water usage and carbon output, we uncover a powerful strategy that enhances sustainability on multiple fronts.

This connection is critical given the escalating challenges of water scarcity. For example, forecasts like those from Thames Water, predicting a daily shortfall of over 1 billion litres within 50 years, underscore the urgent need to integrate water efficiency into sustainable supply strategies, ecosystem protection, and holistic resource management. The energy required to treat and distribute potable water, often exceeding 5% of a city's total energy consumption and derived from carbon-intensive sources, directly links water usage to carbon footprints. Public health engineers, by championing water-efficient systems, can directly address this nexus. This article explores the impact of water conservation on carbon reduction, focusing on engineering solutions and their practical applications across key sectors.

*150 Holborn: The home of Sidara, Introba design had water efficiency as a priority in this building, with greywater treatment, low-flush toilets, and a focus on exceeding Camden's sustainability targets. No water features are included, to further the water saving design*



*Photo Credit @ Perkins&Will Architects*

## The Carbon-Water Nexus

Water and energy share a profound interdependency, forming a nexus that significantly influences our environmental impact. Extracting, treating, and distributing water demands considerable energy, often derived from carbon-intensive fossil fuels. Conversely, producing energy requires substantial water use. This dynamic interplay means that enhancing water efficiency can lead to notable reductions in carbon emissions.

The water-energy nexus is crucial for understanding carbon reduction. Every cubic meter of potable water requires energy for extraction, treatment, and distribution—typically amounting to 3-4 kWh per cubic meter. Similarly, energy production consumes large quantities of water; for instance, thermoelectric power plants can withdraw up to 190 Liters of water per kilowatt-hour produced. This interdependency implies that optimizing water efficiency directly translates to reduced energy demand and, consequently, lower carbon emissions. Engineers must consider this nexus when designing water systems, aiming for solutions that minimize both water and energy consumption.

## Efficient Water Use in Agriculture

Agriculture, a major global water consumer, presents a significant opportunity for carbon reduction. Drip irrigation systems, for example, have demonstrated water savings of up to 60% compared to traditional flood irrigation. This reduction in water demand translates to a 30-40% decrease in energy required for pumping and treatment, directly lowering carbon emissions. Moreover, rainwater harvesting systems, when designed with appropriate filtration and storage, can supplement or replace potable water use for irrigation, further reducing energy consumption. These systems must be designed to meet water quality standards, as defined by local regulations and industry best practices, to ensure safe and effective use.

Agriculture, as a major consumer of water globally, presents a prime opportunity for impactful conservation. Techniques like drip irrigation and rainwater harvesting emerge as game-changers, drastically reducing water usage while minimizing the energy required for pumping and treatment. These methods not only conserve precious water resources but also curtail carbon emissions, creating a win-win scenario for both agriculture and the environment.

## Household Water Conservation

In residences, simple actions can result in significant water savings. Using low-flow showerheads, repairing leaks quickly, and utilizing water-efficient appliances can contribute to substantial reductions in water usage, sometimes exceeding 50% depending on the choices made. Reducing hot water usage decreases the energy needed for heating, which impacts carbon emissions. Education and awareness campaigns can help households adopt these practices, contributing to carbon reduction efforts.

Additionally, advanced leak detection systems, utilizing ultrasonic sensors and data analytics, can identify leaks and prevent water and energy waste. For instance, a single leaking faucet can waste up to 20 Liters of water per day, leading to unnecessary energy use for water treatment. Engineers should also factor in the energy consumed during water heating and the efficiency of heat exchange systems to further optimize energy usage in residential settings.

## Industrial Water Efficiency

Industries can significantly reduce water consumption and energy costs by adopting water recycling and reuse systems. Closed-loop cooling systems for example, which cut water use by up to 90%, and water-efficient manufacturing processes lower carbon footprints and improve sustainability. These systems must meet strict water quality regulations like ISO 14001. Advanced filtration and disinfection technologies in recycling systems further decrease water demand and energy usage. Engineers must design these systems to fit specific industrial needs while minimizing energy consumption.



Photo Credit @ Iwan Baan

## Guides for Practical Solutions

**Slow-fill roof planters (gravity design):** Reduces stormwater runoff by up to 80%, decreasing the need for energy-intensive stormwater treatment. Utilizes gravity for water distribution, minimizing pumping energy.

**Drip irrigation systems (agricultural fields):** Reduces water consumption by up to 60% compared to flood irrigation, leading to a 30-40% decrease in pumping energy. Improves crop yields by delivering water directly to plant roots.

**Rainwater harvesting systems (residential/commercial):** Can reduce potable water demand by up to 50% for non-potable uses like toilet flushing and irrigation. Requires filtration and disinfection to meet local water quality standards.

**Low-flow showerheads and faucets:** Reduces water consumption by up to 50%, decreasing hot water demand and associated energy use. Flow rates reduced from 12 Liters/minute to 6 Liters/minute.

**Water-efficient appliances:** Washing machines and dishwashers with energy-efficient cycles can reduce water and energy consumption by up to 40%. Design must ensure water quality and hardness for energy efficiency.

**Leak detection and repair systems:** Ultrasonic sensors and data analytics can identify and mitigate leaks, preventing water and energy waste. A single leaking faucet can waste up to 20 Liters of water per day.

**Closed-loop cooling systems (commercial/industrial):** Reduces water consumption by up to 90% compared to once-through cooling systems.

**Water recycling/reuse systems:** Reduces water demand and associated energy costs by up to 70%. Requires filtration, disinfection, and monitoring to meet industrial water quality standards.

## Innovations on Water Conservation

### Digital Water Management and Smart Sensors:

**Real-time Monitoring:** Smart sensors and IoT devices can monitor water usage, pressure, and quality in real-time, enabling proactive leak detection and optimized system performance. This data-driven approach allows for precise water management, minimizing waste and energy consumption.

**AI and Machine Learning:** AI algorithms can analyse water usage patterns and predict future demand, enabling more efficient water distribution and treatment. Machine learning can optimize pumping schedules and identify anomalies that indicate leaks or system inefficiencies.

**Digital Twins:** Digital twins of water systems can simulate various scenarios, allowing engineers to optimize designs and predict the impact of different water conservation measures.

### Advanced Water Treatment Technologies:

**Advanced Oxidation Processes (AOPs):** AOPs, such as UV/H<sub>2</sub>O<sub>2</sub> and ozone treatment, can remove persistent organic pollutants and pathogens, enabling the reuse of highly treated wastewater for various applications. These processes are becoming more energy efficient.

**Decentralised Water Treatment:** Onsite water treatment systems, that treat water at the point of use, can reduce the energy used to transport water to centralized treatment plants.

### **Nature-Based Solutions (NBS):**

The UK Green Building Council (UKGBC) in Manchester has been a pioneer in promoting nature-based solutions (NBS) for sustainable urban development. Their initiatives highlight the importance of integrating natural systems into urban planning to enhance water management and reduce environmental impact. By implementing constructed wetlands and green infrastructure, UKGBC projects not only improve water quality but also provide additional benefits such as urban cooling, biodiversity enhancement, and carbon sequestration. These solutions showcase the potential for cities to create resilient and sustainable environments through the utilization of natural processes.

**Constructed Wetlands:** Constructed wetlands can treat wastewater naturally, reducing the need for energy-intensive treatment processes. These systems also provide ecosystem services, such as carbon sequestration and habitat creation.

**Green Infrastructure:** Green roofs, rain gardens, and permeable pavements can reduce stormwater runoff and improve water quality, minimizing the need for energy-intensive stormwater management. These systems also help with urban cooling, which reduces energy usage.

**Aquifer Recharge:** Managed Aquifer Recharge (MAR) can replenish groundwater supplies, reducing reliance on energy-intensive surface water extraction.

### **Energy Recovery from Wastewater:**

**Anaerobic Digestion:** Anaerobic digestion of wastewater sludge can produce biogas, a renewable energy source that can be used to power wastewater treatment plants. This process can significantly reduce the carbon footprint of wastewater treatment.

**Thermal Energy Recovery:** Heat exchangers can recover thermal energy from wastewater, which can be used for heating buildings or other industrial processes.

### **Material Innovation:**

**Low Embodied Carbon Materials:** Using piping and building materials with a low embodied carbon footprint can reduce the overall environmental impact of water infrastructure.

**Smart Materials:** Self-healing concrete, and other smart materials, that increase the life span of water infrastructure, reducing the carbon footprint associated with repair and replacement.

## The Broader Impact & Conclusions

The benefits of water efficiency extend beyond direct carbon reduction. It alleviates stress on water sources, promotes biodiversity, and enhances ecosystem resilience. Integrating water conservation into broader sustainability strategies allows communities to adopt a holistic approach to environmental stewardship, fostering a balanced and thriving natural world.

As public health engineers, you must champion water-efficient design and advocate for policies that promote sustainable water management. By quantifying the carbon reduction potential of water conservation and implementing engineering solutions, we can contribute significantly to a Net-Zero future.

