Urban Water Innovation Network

Transitioning toward sustainable urban water systems

National Science Foundation
WHERE DISCOVERIES BEGIN

Project A2-4

Assessment of Innovative Building Systems and Urban Infrastructure to Mediate Impacts on the Urban Water Cycle, Heat Island, and Regional Climate

Buildings are fundamental components of the urban environment host to many intersections between water, energy and people. Buildings must mediate the basic social demand for physical space and shelter with the basic living demands for water and energy.

Our research will help better understand the intersections of these demands through scientific modeling and experimentation to better characterize the nexus between energy and water experienced by society, which is often localized or originated in design and operation of buildings the their urban infrastructure.

Buildings act as a crux for the nexus between water, energy and materials. We research the most critical manifestations of these interactions related to buildings and their supporting urban infrastructure in three overarching themes:

1) The urban climate and its relationship to dissipation of water and energy through local urban form, infrastructure, and microclimates

2) The energy-water nexus and the role of buildings as the fulcrum connecting mutually dependent water and wastewater demands with energy and water supply

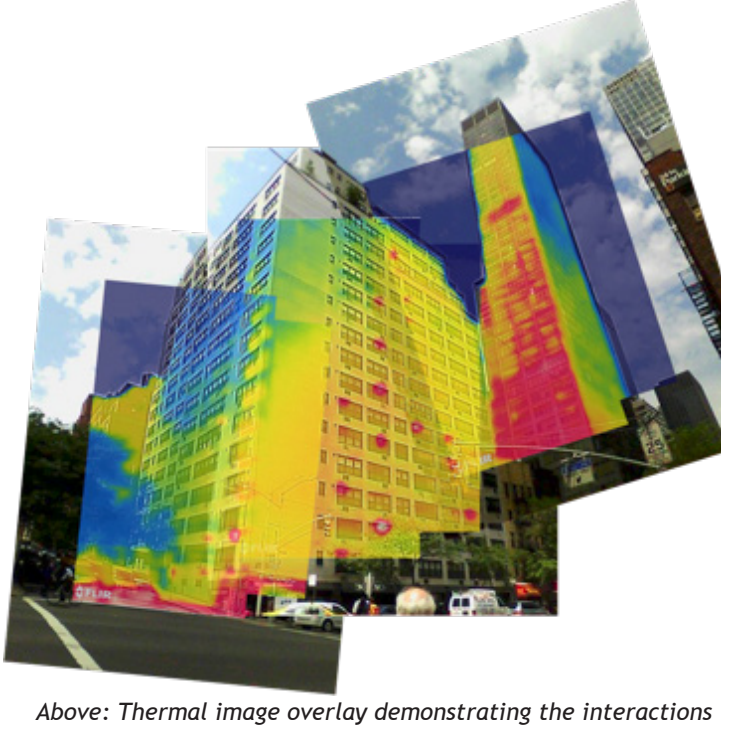
3) The design opportunities latent in architecture and the analysis of building systems and infrastructure for more sustainable water and energy solutions

This project will engage with water sustainability through study of energy, buildings, ecology and people, uncovering and bridging the gaps in knowledge that exist between disciplines of fundamental applied science and creative design research. As demonstrated by our thermal imaging research (pictured right) there is much information that can be represented through simple overlay of data onto the form of the city.

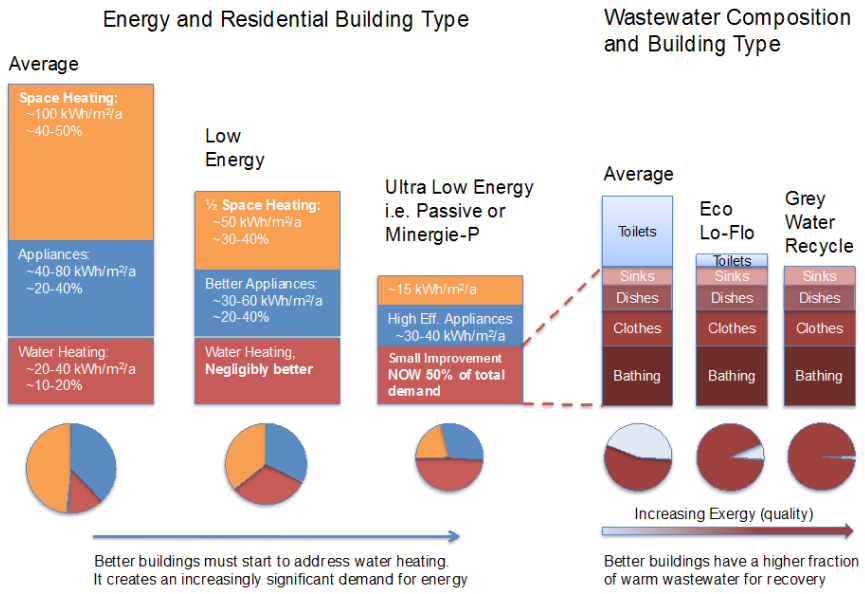
PROJECT OUTPUTS

Project A2-4 provides pragmatic context for the main component of the urban environment (buildings) in both scientific and design analysis. We are planning to setup models where input on region building typologies and water and energy demands can be checked.

We plan to output results from both models and experiments on the local effects of water cooling systems on climate and energy performance. We also plan to better characterize the value of thermal energy in



Above: Thermal image overlay demonstrating the interactions between buildings surfaces and the environment around them



Above: Illustration of the growing importance of hot water as we move toward more high performance buildings that first address space heating and cooling. In addition more high performance water systems separate grey and black water, leading to a concentration of higher potential warmer grey water sources.

Our research into the urban climate will include the development and utilization of new models as well as new sensors and field experiments to examine the relationship between climatic conditions and how water and energy dissipate in cities. We compare the role building air conditioning using dry versus wet heat exchange systems.

Dry heat exchangers, such as those used by common window air conditioners and small residential and rooftop units, have lower system efficiencies and are less expensive than larger water driven cooling towers that achieve lower heat rejection and temperatures and higher efficiency by exploiting the wet bulb temperature of the air through evaporative cooling.

There are questions that remain to be answered about the local climatic impact on humidity from cooling towers, which we will investigate with distributed sensor platforms measuring humidity variations due to evaporative cooling deployment and the placement of these devices within the geometry of the urban fabric.

We will also consider novel design opportunities for new systems that integrate the benefits of evaporative cooling into the building facade construction. Novel building simulations of the basic systems as well as the new concepts tools will be connected to data from the wider urban climate models being developed by UWIN colleagues to more broadly characterize the urban setting.

DATA

With the data developed for a specific building and for consideration of a neighborhood climate we can leverage tools for building facade thermal performance analysis to better characterize the heat transfer between people and their surroundings.

Data to be collected include:

- Statistics for percentage of built space using evaporative cooling towers
- Rate of water consumption
- Humidity levels around evaporative cooling systems
- Localized surface temperature data for mean radiant temperature mapping

PROJECT KEYWORDS

- Energy-Water Nexus
- Microclimate/Urban Climates
- Urban Infrastructure Design
- Thermal Imaging
- Evaporative Cooling Systems
- Heat Exchange Systems

PROJECT CONTACT

Forrest Meggers
Assistant Professor
Princeton University
(609) 258-7831
fmeggers@princeton.edu
https://erams.com/UWIN/a2-4/