Research Summary: End Use Level Water and Energy Interactions: A Large Non-Residential Building Case Study

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The energy and water performances of buildings are two main legislations of European Union (EU). According to the European Commission, buildings constitute around 40% of the energy use and 36% of CO2 emissions in EU; its directive on energy performance of buildings requires all new buildings to be nearly zero-energy buildings (nZEB) by 2020. In Ireland, all new buildings will have to achieve a 60% improvement in energy performance by 2020 from current levels, and 20% of the primary energy use must be supplied by renewable energy sources. Space heating and heating water constitute 79% of total energy use in EU households. Reduced consumption of water, and hot water in particular, provides a significant opportunity to reduce energy consumption. While there have been numerous studies pertaining to the water-energy nexus of residential buildings, the complexity of water networks in larger buildings has meant that this area has been relatively unexplored. This study presents a comprehensive investigation of the hot water use profile, associated energy use, on-site pumping energy use, carbon emissions, and solar energy harvesting potential in an Irish university building over periods before and after water conservation efforts.

Research objectives and methodology

This study focused on the energy consumption associated with water end use in a large non-residential building with the following key objectives:

- Characterisation of hot water use and total water use in a large case-study building before and after implementation of water conservation measures
- Characterisation of energy use and CO_2 emissions associated with water heating and pumping
- Estimation of energy losses associated with water heating and pumping using comprehensive models

- Benchmarking of energy and CO_2 emissions
- Potential of a solar energy harvesting system as an energy source for water heating

Suitable models for were used to incorporate operational, distributional, standby and start up energy consumption for water heating and pumping. Simulations were also run for assessing the solar energy potential of the study site. This paper also accounted for the CO_2 emission intensities associated with water end uses at a building level. The engineering building at National University of Ireland, Galway (NUIG) was chosen as the site for the present case study as it was designed as a smart building

Summary of Results

The study found that water heating accounted for up to as 30% of the total energy use in the building (Figure 1). The implementation of demand-side water conservation measures indicated that around 9 m^3/day of hot water could be reduced and thus approximately 7 times less energy consumed (Figure 2). Using the comprehensive models, it was also found that water heating losses accounted for 20% of the total heating energy and pump start-ups attributed 10% of the total pumping energy. Another finding was that by reducing hot water use through conservation, most of the grid electricity supply could be replaced with solar energy (around 60%), and a significant amount of carbon emissions could be avoided.

Policy and industry relevance

The main contributions of this paper are therefore to increase the understanding of average energy consumption and associated CO_2 emission intensities of water-related activities across various time scales in a large non-residential building in a west European context. This study will further help in benchmarking water-related energy use (both pumping and heating), which is required for the design of renewable energy integration and demand side management strategies.

This research summary highlights key findings from recent paper: Nair, S., Hashim, H., Hannon, L. and Clifford, E. (2018). End Use Level Water and Energy Interactions: A Large Non-Residential Building Case Study. *Water*, 10(6), 810; doi: 10.3390/w10060810

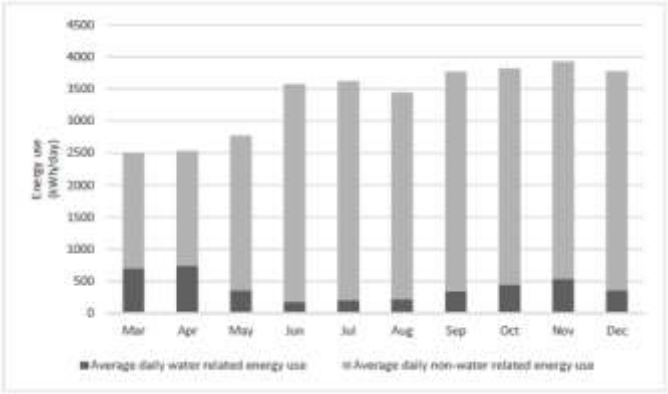

Figure 1. Average water related energy use and total energy use of the building

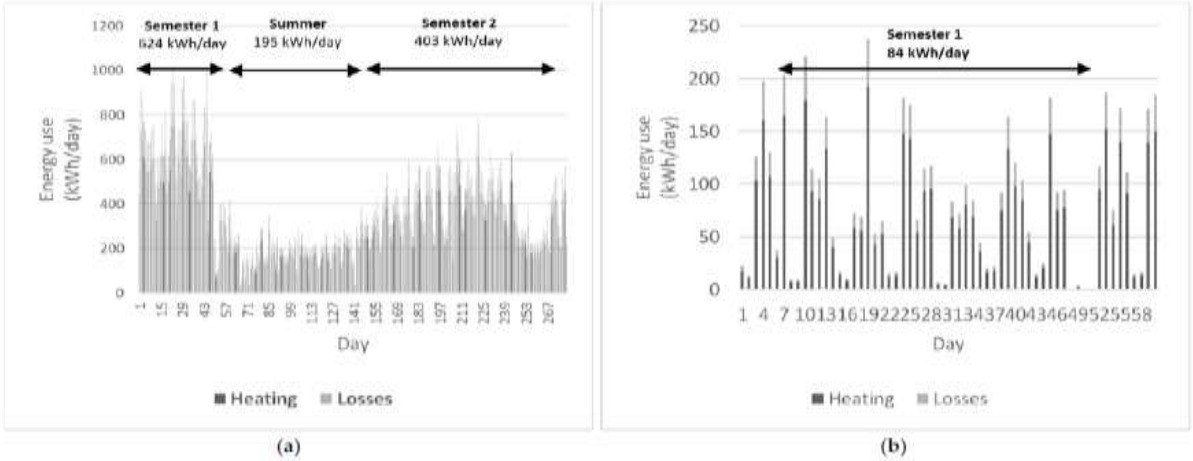

Figure 2. Energy used for water heating in the building (a) before and (b) after the water conservation measures