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Abstract: Electricity and water are closely connected resources, with both resources necessary for sustaining urban built environments. Electric power generation depends on water resources, and piped treated water and wastewater systems depend on energy resources, representing aspects of the electricity-water nexus. A microcosm of this electricity-water nexus is the residential household, where consumers both directly and indirectly consume electricity and water resources. In this analysis, we quantify and visualize direct and indirect water and electricity consumption for households in the urban area of Chicago, Illinois, USA. As the third largest city in the United States, Chicago is a dense urban environment with interesting considerations regarding water and energy sustainability. While the area’s electricity provider has installed smart electricity meters, Chicago’s water sector has comparatively lagged in advances, struggling with challenges of limited drinking water withdrawals from Lake Michigan and massive gray infrastructure investment and overflow restrictions with a combined sewer system. To analyze the city as the sum of residents, we quantify the electricity-water nexus for the residential sector, conducting geographic analysis on a ZIP code scale. Using principles of embedded resource accounting with 30-minute electricity consumption, monthly drinking water flows, and daily wastewater flows, we quantify direct and indirect water and electricity consumption for Chicago households at both annual and monthly scales to reveal aspects of seasonality. We also demonstrate the 30-minute variations for residential customers with electric space heat, revealing the dominance of heating in winter electricity consumption. Results show that direct consumption exceeds indirect consumption of water and electricity due to 1) an electricity grid mix that relies on predominantly open-loop cooled power plants with low water consumption (yet high water withdrawals) for cooling, 2) a local surface water source for drinking water with low electricity consumption for treatment and pumping, and 3) energy recovery at local wastewater treatment facilities. Using a data-driven approach, we show that both water and electricity (and their respective embedded resources) are important for decision-making in the context of sustainable cities.

Keywords: electricity-water nexus; embedded resources; water and energy sustainability