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Simulating temporal variability in energy-water systems using the multi-commodity flow algorithm for robust operations and infrastructure planning.

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The inherent linkages between water and energy infrastructure systems are becoming widely-recognised. Efforts to better understand and model these linkages between the sectors have led to the creation of several different models and tools, which have been an important contribution to aid robust and sustainable long-term decision-making across the energy-water sectors. However, the nexus is poorly understood at an operational level, particularly in relation to temporal variations in energy demand and supply. It is necessary to identify the risks of system failures, as well as the opportunities for efficiency gains.

Recent evidence suggests significant efficiency gains could be made through the integration of demand-side management strategies of electricity usage into the water sector. That is, shifting electricity loads in water operations during times of peak energy demands or when flexibility is needed to accommodate renewables, which could alleviate pressures on the local power grid. The scale of this potential remains yet unknown given a lack of adequate modelling frameworks, which could simulate the two sectors at high temporal and spatial resolution for operations research.

In this work, we present an open-source modelling platform, which uses the multi-commodity flow method to simulate multi-sector systems at high spatial and temporal resolutions. The model is demonstrated through a case-study, in which the energy, water, and wastewater sectors in the United Kingdom are simulated at an asset-level. In doing so, we explore the potential for robust operations and infrastructure planning and specifically for: (i) electricity demand-side management schemes in the water and wastewater sectors to alleviate flexibility and the risks of peak-load pressures from the energy grid and (ii) achieving a guaranteed level of energy self-sufficiency in the water system.