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Editorial: Preparing our water resource systems to the energy transition as well as climate change

Passed in 2019, the UK 2050 net zero emissions law mandates the transition to a low-carbon economy, a major socio-economic and technological challenge that requires a complete transformation of the energy systems that we collectively depend on. As illustrated by two of the five publications in this issue, part of the solution to this problem lies in using our water systems to supply more energy. Thus, Kocak et al. (2022) focus on energy recovery by using pumps as turbines in water supply systems, with a case-study in Napoli, Italy, and insights translatable to other places. Uses of water for hydropower also includes pumped storage, which stores excess energy (e.g., from intermittent renewables) to use it during times of peak demand. In this issue, Chen et al. (2022) focus on sediments in such structures, as they can limit water (and energy) storage capacity and damage the turbines. Yet, delivering energy from water alone is unlikely to be sufficient to keep our water systems functioning. The water sector's routemap for net zero by 2030 (UK Water 2020) includes the addition of on-site wind and solar farms by water companies. This is in line with expert knowledge that the transition will be renewable-led: falling costs mean renewables will become the largest source of electricity worldwide in this decade, and are the most feasible path to avert a climate catastrophe (IEA 2021).

Yet, renewable energy sources such as wind and solar are intermittent, which means that contrary to fossil sources, they cannot be produced on demand. Yet, the power grid's ability to "keep the lights on" is essentially its ability to match the demand with an equal supply at all times. This has implications for all electricity users, as an economically viable transition requires users to make their demand more flexible so it better matches availability on the grid (Heptonstall and Gross 2020). Yet, this need for greater flexibility in using power from the grid has yet to feature in the UK water sector's own climate plans. These currently assume business-as-usual provision from the grid, be it in a routemap to reach net zero emissions by 2030 (UK Water 2020), or in climate adaptation plans that focus on threats to supply from climate-enhanced drought risk, and on threats to demand from population growth (Hall et al. 2019). This focus is justified by the cost of droughts: £40 bn over the next 30 years according to two complementary appraisals (AECOM 2015; NIC 2018a), suggesting an even higher total. £21 bn in new water infrastructure are needed in response (NIC 2018b), and these investments must remain effective and cheap to operate in a low carbon future.

The consequences of business-as-usual modelling of flexibility in water sector adaptation plans have yet to be evaluated. The water sector represents 2-3% of national energy use (Majid et al. 2020), so ill-adapted infrastructure could hamper the energy transition. What is more, ill-adapted assets may become stranded (wasted) or require costly retrofitting, leaving the UK with impossible choices between affordable water, a drought-resilient supply, and a low-carbon economy. The current energy crisis is a cautionary tale on how supply volatility, coupled with inflexible demand, can lead to soaring energy prices with dramatic, cascading socio-economic impacts. Supply volatility is largely due to the global situation, but the crisis is a clear indication that each economic actor in the UK has a vested interest in adapting their electricity demand patterns in the future.

How do we then adapt the water sector's energy demands to a decarbonised power grid in a context of climate change? There is a fundamental technical gap to address this question, with a need for developing a new generation of water-energy models that can examine the value of a flexible energy demand by the water sector (Zohrabian et al. 2021).

To tackle this challenge, the UK's Engineering and Physical Sciences Research Council (EPSRC) recently funded a project titled "Flexible design and operation of water resource systems to tackle the triple challenge of climate change, the energy transition, and population growth" (Reference EP/X009459/1; EPSRC, 2022). The dual aim of this project is to develop a fast water-energy simulator to quantify the impacts of a decarbonised nationwide power grid on water resource systems, and to demonstrate its integration into state-of-the-art strategic water resource planning. This simulator will be the first to enable the exploration of the joint dynamics of water resource systems and low carbon energy systems at timescales ranging from hourly to multi-annual. This project will also promote an improved understanding of flexibility, which enables water resource systems to buffer against drought, as an opportunity to adapt to a decarbonised grid. Its outcomes will help the water sector (companies and regulators) to plan for the triple challenge of climate change, population growth, and the energy transition, and deliver a reliable water supply at affordable rates for water users.

Beyond its focus on water resource planning, this project will have broad relevance to the UK water sector, since the energy transition will affect all its facets. As the project's principal investigator, I am keen to engage with all interested stakeholders.

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