22. Water security at the energy crossroads

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Water, sanitation, and energy are undoubtedly keystone components of civil infrastructure that enable cities to support populations; they are the foundations of civilisation. The growth of megacities is, however, rapidly depleting water resources and leading to declining levels of water security across the world. Failure of critical infrastructure services, such as water and energy, can cripple a city in a matter of hours and leave millions vulnerable.

Yet that which is most dear to us is now often subject to complex interactions before we are able to access it. Energy is used for pumping, transport and treatment of water and wastewater; water is used through most stages of energy production and generation. But most of the resources used are non-renewable, often involve pollution and bring us closer to the planetary boundaries defining the safe operating space of humanity (Rockström et al. 2009). Should we continue propagating the interdependencies between energy and water or should, in some cases at least, we be working to decouple these two crucial resources?

In the current system, increasing demands on one usually means increasing demands on the other. But there are alternatives and, hence, water security finds itself at the ‘energy crossroads’ through the multitude of options available for alleviating scarcity issues; options which may use disparate levels of energy. On the other hand, water security also meets energy at the crossroads in a future that is partly governed by the water-intensity of future energy systems.

Increasingly, the analysis of water supply options is conducted considering the energy intensity of exploiting that resource. A variety of capital-intensive options to meet marginal demands may be evaluated, including desalination, wastewater recycling, inter-basin transfers and increased storage capacity. The uncertainties in the performance and utility of each option may, however, be large. These variabilities are driven by the energy sector and stem from variation in demand growth, energy price fluctuation and dependency on climate-vulnerable water resources. These uncertainties, amongst others, present a challenge in predicting future operational expenditure, the majority of which is usually energy costs. In the United Kingdom, higher water-quality standards have resulted in a doubling of energy use since the 1990s, and this is set to rise (Council for Science and Technology (CST) 2009); lower river flows during
the more frequent droughts projected under climate change will require more stringent wastewater treatment as receiving bodies will have less capacity to dilute effluent (Hall et al. 2012).

<table>
<thead>
<tr>
<th>Supply</th>
<th>Energy intensity kWh/ML</th>
<th>Source and notes</th>
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</thead>
<tbody>
<tr>
<td>Water recycling</td>
<td>2,500-6,500</td>
<td>Water UK 2010; Perrone et al. 2011. Depends on level of treatment, Primary, Secondary, Advanced.</td>
</tr>
<tr>
<td>Desalination</td>
<td></td>
<td>Perrone et al. 2011; WRA (2011) Variable on water salinity and technology, and some of the energy demand can be met through waste heat or solar PV.</td>
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<tr>
<td>• Brackish</td>
<td>9,500-22,000</td>
<td></td>
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<tr>
<td>• Sea water</td>
<td>34,000/100,000</td>
<td></td>
</tr>
<tr>
<td>Imported water</td>
<td>0.04</td>
<td>Derived from Sampson et al. 2007, into kWh/ML/km distance/ Δm positive elevation from source to treatment.</td>
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</tbody>
</table>

*Figure 1: Ranges of energy intensity for different water supply options can vary by orders of magnitude. With depleted resources, however, energy intensive supply is increasingly competitive*

Source: See table.

There is, however, great benefit in decoupling this nexus of water and energy use. One irony is that wastewater has a chemical energy content higher than the energy required to treat it, the former just needs to be harnessed (Heidrich et al. 2011). Increasingly, anaerobic digestion (AD) is being deployed around the world in both high-tech and low-tech configurations. AD is the breakdown of biodegradeable matter in the absence of oxygen and can be used to treat both solid and liquid waste. Biogas is one of the main byproducts and consists mostly of methane, which can be burnt for electricity generation, heating or cooking. AD applications in developed countries will play a small part towards energy security and low carbon energy supply, whilst flipping the energy balance of wastewater treatment. In less developed countries, AD can provide a meaningful step towards proper sanitation and associated health benefits, whilst free biogas used for cooking drastically reduces indoor air pollution, a killer of 1.5 million women and children each year (World Health Organization (WHO) 2006). Conversely, seawater desalination and long-distance transport and pumping, such as the California State Water Project and the Central Arizona Project, result in roughly ten times the energy intensity of conventional treatment facilities (Water Reuse Association (WRA) 2011) due to the long distances, evaporation losses and changes in elevation.
In many countries, energy is produced by thermoelectric power stations on surface waters abstracting proportions of cooling water far exceeding those taken for public water supply and often matching agriculture (United Kingdom: 56 per cent, United States: 41 per cent, Europe: 45 per cent; see Figure 2 for further details on Europe). Most is returned, but evaporative losses from cooling towers can reduce this amount by 75 per cent. Energy demands are growing, thermal efficiencies are not improving rapidly enough, and power plants with carbon capture and storage (CCS) increase water consumption in the order of 80 per cent (National Energy Technology Laboratory (NETL) 2009). The strong prospects for shale gas and coal with CCS look set to lock electricity supply into another half-century of water-thirsty power plants. Even the fuels used require water for extraction and processing, leading to contamination. In recent years, thermoelectric nuclear and fossil fuel plants in the United States, Europe and China have faced output reduction and even shutdown due to low river flows and high water temperatures (Averyt et al. 2012; Pan et al. 2012 Economist 2013), a problem that is expected to worsen with climate change (van Vilet et al. 2012). Alternatives to water-intensive energy supply do exist, mostly in the form of some renewables and more strategic siting of power stations and grid balancing. But in order to play the crucial role of increasing both energy and water security, the benefits of the options need to be recognised in planning processes, alongside caveats that may include lower efficiencies and higher costs.
Capital investment projects in both sectors lock in decisions for decades that span considerable uncertainty. Short-term demand reductions and market mechanisms can ameliorate cross-sector risks, but the resource interdependencies will remain. Thus long-term planning that reduces critical resource interdependencies and improves performance under wide ranges of uncertainty, such as climatic changes or geo-political risks, is needed.

In its current state, the energy sector poses unacceptable risks to the public water supply and agriculture sectors that must be addressed with robust decisions encompassing sustainability, security of supply and affordability. Whilst the challenges facing each sector of the water–energy–food nexus are great in themselves, decision-makers must recognise the win-win-win opportunities that are presented by tackling them together, which are elegantly summed up by Wangari Maathai (2012), ‘Our planet is finite, our fates are intertwined, our choice is clear — stand together or fall divided.’

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References


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