Brief for GSDR 2015

Integrated resource policies for energy and water resources, with case studies of China and the UK

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Introduction

Because of economic development, increasing global population, and increased levels of affluence, future global demands for food, energy and water resources are expected to increase by 50%, 50% and 30% respectively (Beddington, 2009). However, with the world’s food, energy and water resources already experiencing shortfalls and stresses (Bizikova et al., 2013), there is an urgent need for nexus-oriented approaches to address unsustainable patterns of growth. The importance of these three resources has been highlighted in many publications, and they have been included in the Sustainable Development goals, which are to ensure the availability and sustainable management of water and sanitation for all, universal access to affordable, reliable and modern energy, and the achievement of food security and sustainable agriculture (United Nations, General Assembly, 2014).

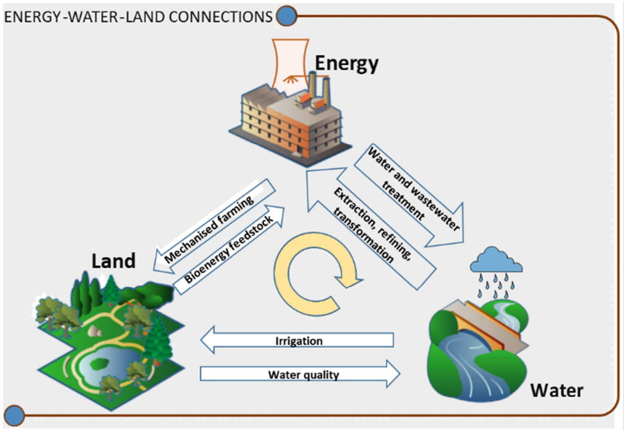

Figure 1. Connections between water, energy and land resources.

Water, energy and land resources are all interconnected (Figure 1) and should not be viewed in isolation. Agriculture and industry (including energy) account for 70% and 22% of global water withdrawals respectively (Howells et al., 2013); 7% of all energy is used for water supply; and 4% of energy is directly used in agriculture (Bazilian et al., 2011). The need for integrated resource planning for energy, water and land is becoming increasingly recognised by international institutions, national governments and businesses (Hoff, 2001). A policy that affects one resource can result in unexpected consequences for another. There is a need for policy makers, institutions and businesses to understand better the connections between these resources and to integrate them in future plans for a sustainable future. To be able to achieve this, the UN and other institutions should promote holistic analysis of the interconnections between resources.

The water-energy nexus

Energy and water resources are critical to the development of human society but policies regarding these two resources are still mostly developed in isolation from each other (Siddiqi et al., 2013). Howells et al., (2013) highlight that many national energy assessments fail to consider water at all, even though there are many examples where water constraints have affected energy production (Table 1).

Location (year)	**Description**
France (2003)	A sustained heat wave resulted in closure of nuclear reactors and a 50% reduction in electricity exports
Southeast US (2007)	Hydropower generation and output from nuclear and fossil fuel power plants were reduced by authorities as a result of drought
China (2008)	Dozens of planned coal-to-liquid (CTL) plants were abandoned due to concerns regarding local water scarcity
Vietnam, Philippines (2010)	The effects of El Nino caused a drought that resulted in reduced hydropower generation and power shortages
China (2011)	Drought limited hydropower generation along the Yangtze river, contributing to higher coal demand

Table 1: Examples of water constraints on energy production (adapted from IEA, 2012)

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Policy makers should consider the co-benefits and trade-offs between water and energy resources. To do so requires an understanding of how water is used in the energy system, and how technology and policy choices may affect the system. Figure 2 highlights the different energy processes that use water.

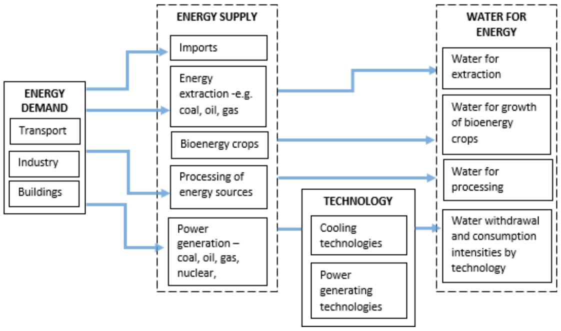

Figure 2: Diagram showing how water is used within the energy sector.

Foreseer – a new platform for assessing the nexus

The Foreseer tool is a scenario generation tool which includes natural resource supply, transformation and use, emphasising the connections and trade-offs amongst resources - particularly energy, land and water. The uniqueness of the tool is that it visualises resource futures through a set of Sankey diagrams which show the flows of basic resource (e.g. coal and surface water) through transformations (e.g. oil refining and desalination) to final services (e.g. sustenance and transportation) (www.foreseer.org). The tool has been developed for several case studies including California (Curmi et al., 2013a), China and the United Kingdom, as well as global water (Curmi et al., 2013b).

Case study - China

The interaction between water and energy resources is particularly important in China, where there is an uneven distribution of water, with limited availability in the majority of coal and gas-rich regions. To tackle growing concerns over water scarcity and pollution, the Chinese government has developed a water management plan known as the "3 Red Lines" water policies which aim to control total water use, increase water use efficiency and improve the quality of water. One of the policies aims to reduce industrial water use, of which the energy sector is a component. To meet growing energy needs, China is planning on diversifying its energy mix through an increase in renewables, nuclear and gas whilst also sustaining its use of coal. Given the interdependence between energy and water, growing demands for both, and the lack of integration between future plans, it is not clear how the energy sector will be able to comply with the industrial water policy.

Even though most water policies target withdrawals, as is the case with the industrial water policy, it is still important to assess both water withdrawals and consumption, especially when assessing water used by the power sector. Water used in power generation depends on the type of plant, the fuel, and also on the cooling technology (Macknick et al., 2012). There are three main types of cooling technologies, these include once-through, wet-tower and dry cooling. The main difference between these technologies is the amount of water withdrawn and consumed, with once-through cooling requiring large amounts of water (although most returns to the freshwater system), wet-tower cooling withdraws less water but consumes more, and dry cooling requires little or no water but incurs an energy penalty, is more costly and has higher in-plant electricity usage.

In 2010, the energy sector withdrew a total of 70km^3 but only consumed 8km^3 (Qin et al. under review). Coal-fired power generation accounted for 84% of the total water withdrawn. However, 91% of this withdrawn water returned to the system (albeit at a higher temperature) and only 7% was actually consumed (Qin et al. under review). Coal extraction was the second largest water user responsible for 8% of the total water withdrawn, and is often polluted with chemical and impurities.

It is estimated that in 2035 the energy sector will withdraw 90 km^3 which is approximately 80% of the total industrial water use target in 2030, leaving only 20% (~25 km^3) for other water-intensive industries. This assumes an improvement in the energy efficiency of power plants, the use of wet-tower cooling for new inland nuclear power plants and an increase in dry cooling in certain regions (30% of power generated).

Case study – United Kingdom

An integrated analysis of the energy and water nexus in the UK has been carried out to assess the impacts on the water system from the national low-carbon energy pathways proposed by the Carbon Plan (HM Government, 2011). These ensure 80% GHG emissions reduction to 2050, relative to 1990 levels. However, the pathway involving increased nuclear power that seems most sustainable in energy emission terms also requires bioenergy at levels that are likely to limit the amount of freshwater available to other water use sectors in the UK.

Future climate variability and change, population growth, increased water demand for food and energy crops and the water abstractions for cooling in the energy system thus have the potential to cause competition for freshwater resources amongst different water services. This could lead to a delay in the timelines of GHG emissions reduction targets as well as potential “lock-in” to long term energy infrastructure which may not be able to cope with future changes in the water system.

This study has shown that energy system pathways with high shares of large scale thermal generation and CCS technologies could also have high impacts on water resources, while those pathways with high shares of renewable generation, in combination with ambitious targets for energy demand reduction, are more likely to have low impacts on the water system.

Issues to take into consideration

Water and energy policies should be developed together and not in isolation. Managing water and energy resources together enables anticipation of unintended consequences arising from resource inter-dependences. Water policies aimed at the energy sector should also encourage the use of different technologies (e.g., for cooling), but their appropriate deployment must depend on plant locations (and local water availability). Energy efficiency improvements should enable saving of *both* water and energy resources, as should policies to control demand and increase the fraction of electricity supplied by renewables. However, some policies made to relieve stress on one resource may have unintended impacts on other resources, e.g. dry cooling technology may be enforced to relieve local water stress but at the same time it also increases the consumption of coal. It is also important to consider other water users including agriculture and domestic water demands and environmental flows to provide a holistic assessment of the water sector and assess the trade-offs between different sectors’ water use. Another key consideration is the quality of water used in the energy sector; high withdrawals with low consumption may be acceptable, but for return flows not to count as consumption, their quality must be fit for further use.

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