Inseparability of Water and Energy

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With the increasing prices for fossil fuels as well as a concern for climate change resulting from the burning of these fuels, there has in recent years been a strategic focus on the development of or switching to alternative sources of energy. This includes wind, solar, wave, hydroelectric power, geothermal and not in the least, biomass. In Denmark, this can be seen in the current political debate, where the opposition parties released an energy plan for Denmark to be 100% fossil fuel free by 2050, with most of the energy being supplied by a combination of wind and biomass-based fuels (Socialedemokraterne et al. 2010). However, what is most often missing from this debate is how this change from fossil fuels will affect local water resources, both in terms of quantity and quality. Voinov and Cardwell (2009) correctly point out that water and energy are intimately intertwined. The water sector, including production, distribution and treatment, remain one of the largest users of energy, while water is required in production of almost all forms of energy (DOE 2006; Voinov and Cardwell 2009; Glassman *et al.* 2011). This relationship has been recently referred to as the "*Water-Energy Nexus*", which in essence describes the intertwined relationship between energy and water supply, two of the arguably most important components for modern society. It basically brings forth the questions: do we have enough water to support the conversion from fossil fuels to alternative fuels, and do we have the needed energy supply in order to provide the needed water for future generations?

Wind and wave based energy sources are the only two energy sources that do not have an impact on our freshwater resources (not including construction materials). All other forms of renewable energy do in some way or another. For example, hydroelectric power generation consumes up to 16,000 liters (depending on climate and dam construction) and geothermal consumes 4000 liters to produce 1MWh of electricity (Glassman *et al.* 2011). This is compared to 600 liters for natural gas and 800 liters for coal (Glassman *et al.* 2011).

The raising of crops for biofuels has been known to require significant water inputs, with evapotranspiration rates of 1000-3500 liters of water for every liter of ethanol (Varghese 2007). For many of the fuel-based crops, irrigation will be required. Algae provide an alternative source of biofuel that is outside of the food-crop vs. energy-crop debate. However, the growth of algal feed stocks still need a substantial water resource (Subhadra 2010). Open pond algal cultures contain a similar water footprint to that of standard irrigated fuel-based crops, however new innovations in water recycling in the open ponds can significantly reduce the water consumed (Subhadra 2010). In spite of the water recycling, the water consumption is still relatively high, equaling that of non-irrigated crops (Varghese 2007; Subhadra 2010).

Even production of solar power requires a significant input of water. Solar thermal requires much more water, as much as 3000 liters for 1MWh output (Glassman *et al.* 2011). Solar voltaic power does not require any water for actual electricity generation, however, the panels do need to be washed, other wise the dust accumulation on the panels will degrade the output potential. Washing consumes approximately 100-200 liters for every 1MWh output (Energy Matters 2009). However, the downside of solar photovoltaic power is that it is less efficient and much more expensive than solar thermal power production (Glassman *et al.* 2011).

The debate on the growing and use of biofuels has intensified over the last 10 years. Issues discussed not only have been focused on the use of irrigated crops, but also on the possible increase in food prices from the loss of land for food production as well as the increase in fertilizer and pesticide application in order to grow these additional energy crops (Varghese 2007). Particularly the increased application of fertilizers and pesticides that will be required to grow energy crops will undoubtedly have an impact on the quality of both surface and groundwater resources. In Denmark, more water supply wells polluted with pesticides are found every year, and as of 2008, 40% of all wells have traces of pesticides (GEUS 2009). Fertilizers are one of the primary causes for eutrophication in streams, lakes and seas. One of the primary goals of the European Water Framework Directive is to reduce the nutrient loads reaching these water bodies. Thus the expansion of the biofuel crops must also consider issues with regard to water quality.

The debate between water use and solar energy is increasing as well. Southern California, which has significant water scarcity problems, has already approved a number of large scale solar thermal plants. These include projects such as the Beacon Solar Energy Project, which will consume nearly 2 million m^3 of water per year in order to provide an operational capacity of 250MW. However, concerns by both citizens, municipalities and environmental groups about the large water consumption from these projects has led to heated debates over whether or not future projects should be approved (Woody 2009). In one case, a solar thermal power project has been abandoned because the water district refused to supply the 3 million m^3 of water per year the plant required, and several others have been put on hold pending further review (Woody 2009). Often times, the countries and regions with the highest potential for solar power also are in the regions with the least available fresh water (Glassman *et al.* 2011), and thus careful consideration with respect to the availability of water must be taken prior to approval of these projects.

The other side to the water-energy nexus is the fact that energy is also required to obtain and distribute fresh water for drinking and industrial production. In order to achieve the Millennium Development Goal of halving the number of people without access to clean water by 2015, energy will play an important part in achieving this goal. There is required energy to transport drinking water to users from lakes, rivers, and groundwater – as much as 1kWh for every 2000 liters of water (Webber 2008). Many areas with little surface and sustainable groundwater resources are turning towards an even more energy intensive process to supply the needed fresh water: desalination of seawater. Although the desalination process has become more efficient over the last decade, it remains by far the most energy intensive water supply system, using 1kWh for every 230-370 liters of water, depending on the desalination process used and water salinity (Webber 2008).

There is very little discussion that society will be required to change from a fossil fuel-based society in the short and medium term. The fact remains that fossil fuels are a limited, non-renewable resource, and will only become more expensive in the future. However, we are currently at a point, where we can determine what fuels will be switched for with respect to transportation, heating and electricity. Before significant investments are made in the research and development of these different fuels, a full assessment should be made on how these will impact our water resources, both in terms of quality and quantity. In addition, the energy consumption in our water supply must also be taken into consideration. The link between water and energy will only become more important as the economies and water infrastructure in the developing world continue to improve. As Webber (2008) put it, "*as the worlds population and energy consumption continues to increase, will our development be limited by lack of energy or lack of water?*" Therefore, the editors from TES welcome the submission of articles dealing with the issue of water management and energy production.

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