

Urgency at the Nexus of Food, Energy, and Water Systems

Water shortages in California have recently attracted a lot of attention in the popular press, but the problem is much larger than a single state or even nation. The world population is growing, and an increase in both the number of people and the quality of life is resulting in an increased demand for more water, food, and energy. Of these three factors, water abundance and quality seems to be the central issue. Too little water, and crop yields decline. Too much water in the wrong places, and we have flooding and crop failure. In the past, water issues have generally been addressed by using more energy, allowing water redistribution over vast distances and (particularly in highly arid regions) extensive water production through seawater desalination. Most of this energy is currently derived from fossil fuels, which contributes to increased carbon dioxide emissions and climate change. To address these water issues on a local to global scale, we must therefore also consider these issues within the framework of climate change and understand how changes in the climate will alter the global availability and stability of water resources and food production. Clearly, we need a plan.

The U.S. National Science Foundation (NSF) recently announced a new effort in "Innovations at the Nexus of Food, Energy and Water Systems" (INFEWS). Whether or not we researchers wish to seek funding through this new effort, which is supported by a budget of \$75 million in 2016 (and more in future years), we need to carefully follow the issues raised in this program, and the technical and social studies that will be conducted. Previous efforts at NSF, such as the Science, Engineering and Education for Sustainability (SEES), have simultaneously addressed climate change, water, and energy issues within the framework of sustainability. Addressing issues related to food within the context of water and energy sustainability, however, is new for the NSF. It is a welcome and important new direction for the agency.

All states in the United States will have their unique issues. California has been highlighted because it is the top agricultural and food producer in the United States (for more than 50 years), and the agriculture industry in that state generates roughly \$37.5 billion annually. This state also uses more than twice as much energy as any other state, with an estimated 9–10% of all electricity used for water services. However, California is not the top western state percentage-wise in terms of electricity use for their water infrastructure: Idaho uses 34–49%, Montana 14–19%, and Arizona 12–16%. Approximately 25% of all electricity used for industrial purposes in the western states is for the water service sector. If climate change adversely impacts food production, as is expected in the near and long term, how will energy consumption be affected? How will food production across the United States, and the world, change in response to these water and energy issues? And what will be the environmental impacts of these changes?

To highlight the important issues related to INFEWS and climate change, we have assembled a list of papers published to date in *ES&T Letters* on these topics (http://pubs.acs.org/page/esthag/select/nexus_food_energy_water).

A total of 17 papers have been highlighted in a special virtual issue that focuses on the energy, water, and food intersecting topics. The largest number of these papers address energy–water issues, with several papers examining technologies for producing energy using water in noncombustion-based approaches, such as pressure-retarded osmosis, reverse electrodialysis, and microbial fuel cells. In other studies, the implications of energy production are evaluated from perspectives related to water quality, such as addressing radium in water, the treatment of hydraulic fracturing water, and possible recovery of energy from flare gas or CO₂ in flue gas. In food-related topics, there are several papers about recovery of nutrients such as phosphorus from water, chemicals in plants, and the relationship between animal manure and releases of steroid hormones.

ES&T Letters especially welcomes additional contributions in energy–water, energy–food, and water–food topics, or on the most difficult topic of all, the nexus of all three topics. While the current issues in the western United States revolve mostly around water scarcity, there will be other unique challenges related to water law and flow regulations, plans for groundwater recharge, toxicological issues tied to water supplies and food production, and many issues that arise from climate change. Elsewhere in the United States, for example in the Northeastern United States, key issues in the INFEWS are likely to focus more heavily on water quality, and food production from huge estuaries such as the Chesapeake Bay. In my own state of Pennsylvania, there could be a particular need to focus on technical as well as social/political issues related to water use for hydraulic fracturing. Other parts of the United States as well as other countries all over the world will face their own local, regional, national, and global challenges related to INFEWS, ranging from an increased reliance of potable water production from seawater desalination, and hydroelectric electricity production coupled to declining rainfall and runoff, to feeding concentrated populations living in water- and energy-poor regions of the world.

Part of the INFEWS activities involves studying and understanding the impacts of extreme events on different aspects of food production, water storage and delivery, and energy production. In cases where there are sudden and unexpected changes that have impacts on our environment and infrastructure due to disruptive events, such as storms, chemical releases, and food-borne outbreaks of new diseases, there is a particular need for urgent publication of research that addresses these topics. The short format of *ES&T Letters* is well-suited for rapid and high-quality peer review of manuscripts, and thus, it is a particularly useful venue for publication of the outcome of these studies on these important subjects. *ES&T Letters* has already published a number of papers in the INFEWS topics, and we hope to see more papers covering this field in the journal in the future.

Received: May 8, 2015

Published: June 2, 2015





Bruce Logan

■ AUTHOR INFORMATION

Notes

Views expressed in this editorial are those of the author and not necessarily the views of the ACS.