

**Title:** Integrated water, energy, and emissions trajectories and tradeoffs for the U.S.

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**Research Objective(s):**

The aim of this study is to explore the implications of future electricity supply scenarios for water consumption and withdrawals. The electricity generation sector is one of the largest water users in the U.S. Technology and fuels used in this sector are changing rapidly in response to economic and policy drivers; for example, natural gas-fired generation is increasingly displacing coal, and wind and solar are gaining ground. Integrated environmental assessments are needed to understand the tradeoffs of these changes for emissions of greenhouse gases, conventional air pollutants, and for impacts on water consumption and withdrawals.

**Methodology:**

This study applies the U.S. Environmental Protection Agency's 9-region (US9R) database and ANSWER-MARKAL energy supply model to explore future energy scenarios, focusing on water impacts of electricity generation alternatives. We update the water impact estimates for power generation in the US9R database and add impacts of upstream fuel production. We also add dry and hybrid cooling options for thermal power plants, in addition to the existing wet cooling tower (recirculating) and once-through technologies, and add new concentrated solar thermal technology options.

**Results:**

Results show that in 2035, direct water withdrawals for electricity generation decreases by 11% and 25% in the cheap gas and GHG fee scenarios, compared to the 2035 base case, and increase by 9% in the costly gas scenario. A scenario with water withdrawals and consumptions, each capped at 65% of the corresponding base case levels, drives a shift to natural gas combined cycle with dry cooling.

**Accomplishments:**

Presentation: The results were presented at a conference: Keshavarzmohammadian, A.; Milford, J.B; Cook, S.M. Impacts of Future Scenarios for Natural Gas Production and Use on Life Cycle Water Consumption. Poster Presentation at the Life Cycle Assessment XVIII, Fort Collins, CO, September, 2018.

Publications: The results have been disseminated as a conference proceeding: Keshavarzmohammadian, A.; Milford, J.B; Cook, S.M. Impacts of Power Generation Technology Choices on Life Cycle Water Consumption. Proceedings of the Life Cycle Assessment XVIII Conference, Fort Collins, CO, September, 2018.

**Conclusions/Next Steps:**

We hope to submit a collaborative NSF proposal in 2020 based on the preliminary data generated.