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Title: A temporally-dynamic and spatially-resolved comparison of life cycle greenhouse gas emissions from coal and natural gas-fired electricity in the United States

Abstract: The comparison of the life cycle greenhouse gas (GHG) emissions from natural gas and coal-fired electricity has yet to be resolved due to high levels of uncertainty in upstream emissions from the natural gas supply chain. In this analysis, we use (1) spatially-resolved datasets for natural gas infrastructure, (2) temporally-resolved power generation datasets, and (3) spatially-resolved emission factors for natural gas supply chain along with existing upstream coal emissions estimates.

Natural gas supply chain emissions across different drilling basins will be examined to understand regional variability in the emissions of natural gas. Estimated ultimate recovery (EUR), which has been shown to be a key factor in the life cycle assessment (LCA) of natural gas-fired electricity, will be calculated from a historic production dataset for over 1,000,000 wells. The analysis will thus account for differences in the production decline curves of conventional versus unconventional natural gas wells. Improved estimations of completion emissions will be calculated for the natural gas wells analyzed. Furthermore, actual power generation datasets will be used to inform a better understanding of how changes in heat rates and power plant efficiencies may influence overall life cycle emissions. The analysis will include three snapshot years to understand the changes in the electricity generation fleet and natural gas supply chain emissions (2005, 2010, and 2015). The fraction of natural gas combined cycle capacity has been increasing relative to simple cycle gas-fired and coal-fired capacity (surpassing the latter in 2018), suggesting that the life cycle emissions of U.S. natural gas-fired generation are decreasing over time. Spatially and temporally resolved estimates of upstream emissions of natural gas supply chain will support a greater understanding of the implications of the combined changes.

A sensitivity analysis will examine how replacing the EPA's methane emissions estimates with a spatially-resolved inventory of natural gas

supply chain emissions can influence the results of the comparison. Results for gas-fired electricity will be compared to existing estimates for coal-fired power, noting areas in need of data improvement.

Key words: Natural gas fired electricity, Greenhouse gas (GHG) emissions, Life cycle assessment (LCA), Spatiotemporal analysis, Estimated Ultimate Recovery (EUR)