

Air quality-Carbon-Water Nexus: Source prioritization of China's Natural Gas Development

Yue Qin

Air Quality and Greenhouse Gases (AIR) /Lena Höglund Isaksson, Zbigniew Klimont
Princeton University

Email: yq@princeton.edu

Introduction. Facing severe domestic air pollution primarily resulting from a coal-dominated energy structure, China has been actively pushing forward a higher penetration of natural gas from a variety of sources, i.e., shale gas, synthetic natural gas (SNG), imported pipeline gas from Central Asia and Russia East, and imported liquefied natural gas. Switching from coal to natural gas is usually advocated as beneficial for air quality and human health. However, various sources of natural gas may result in varying degrees of lifecycle impacts on air quality, human health, global climate, and regional water stress. This work aims to inform policy makers with prioritizing China's natural gas source choices based on systematic analysis of the air quality-climate-water impacts of its major potential gas sources.

Methodology. We use an integrated assessment model (GAINS) to evaluate the air quality and human health impacts of each gas source. Based on the EclipseV5a scenario built with the GAINS model for the year 2020, we construct five natural gas scenarios for the use of different potential gas sources. Combining changes in air pollutant emissions from both end uses and upstream stages, we obtain the changes in PM_{2.5} surface concentrations and the avoided premature mortality under each gas scenario using the GAINS model. In parallel, we estimate the lifecycle greenhouse gas emissions (GHGs) and water impacts of each gas scenario by integrating the GAINS scenarios with lifecycle assessments.

Results & Conclusions. We find that natural gas from all five potential sources brings net reductions in PM_{2.5} surface concentrations and PM_{2.5} associated premature mortality. Variations among gas sources are relatively small (~1.5 times) and are primarily resulted from differences in end uses. Under the same scenarios, SNG brings net increases in lifecycle GHGs using different global warming potentials (GWP₁₀₀ and GWP₂₀), primarily due to substantial upstream carbon emissions. Gas sources other than SNG all bring net decreases in lifecycle GHGs when assuming a mean upstream methane leakage rate, but have higher-than-coal upper bounds under potential high methane leakage rates. Similarly, the SNG scenario causes net increases in weighted water stress from water consumption, with all other gas sources bringing net decreases. Our study thus suggests that China should avoid developing large-scale SNG projects considering the overall air quality-climate-water impacts. Also, gas source choices other than SNG should be mainly based on methane leakage control and economic factors. Our study provides the scientific basis to China's policy makers on future natural gas source prioritization to maximize the potential air quality-climate-water benefits.

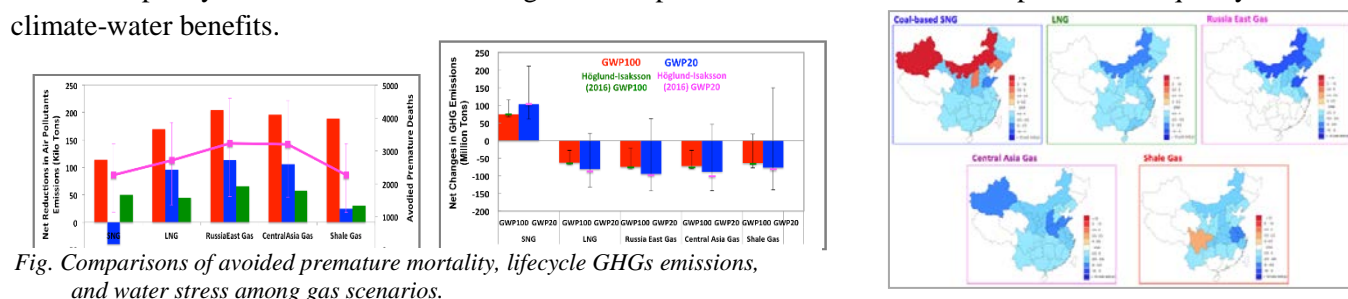


Fig. Comparisons of avoided premature mortality, lifecycle GHG emissions, and water stress among gas scenarios.