"Evaluating net life-cycle greenhouse gas emissions intensities from gas and coal at varying methane leakage rates," 2023
Review and Comments

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In July 2023, the *Environmental Research Letters* published "Evaluating net life-cycle greenhouse gas emissions intensities from gas and coal at varying methane leakage rates" (Gordon et al., July 2023).[1] The study seeks to introduce a novel analysis comparing the net climate impact of natural gas and coal life-cycle emissions, predicated on sulfur dioxide pollution emitted from coal-fired energy use, and assumptions related to methane emissions across the natural gas value chain and at the source of coal production. However, the study's headline conclusions are inadequately justified. The study inappropriately equates short-term cooling effects from coal-fired pollution with longer-term impacts related to carbon dioxide and methane, which is inappropriate given the scale and timeframes involved with global climate change. Moreover, the study appears to overlook critical factors such as the higher end-use efficiency of natural gas end-uses relative to coal. Finally, the study must be evaluated in the context of a vast body of other research that has concluded the climate benefits of natural gas use compared with coal.

Comment on Study Conclusions

- The study's principal claim is that coal and natural gas have equivalent levels over 20 years when considering sulfur dioxide emissions from coal, zero methane emissions from coal mines, and a 0.2% methane emissions rate from natural gas systems.

- Coal use can result in sulfur dioxide emissions, and the authors assert that the resulting sulfate aerosols can cause a cooling effect that can offset warming from methane and carbon dioxide released from coal.

- However, the authors discuss how atmospheric sulfur dioxide and sulfate aerosols impact air and water quality, ecosystem impacts, and human health.

[1] Gordon, Deborah[a,b], Frances Reuland[b], Daniel J Jacob[c], John R Worden[d], Drew T Shindell[e], and Mark Dyson[b]. 2023. "Evaluating net life-cycle greenhouse gas emissions intensities from gas and coal at varying methane leakage rates." Environmental Research Letters. https://iopscience.iop.org/article/10.1088/1748-9326/ace3db/pdf

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- The cooling effect of aerosols is localized and short-lived, given their relatively short atmospheric lifetime, as opposed to the long-lived warming impact of greenhouse gases like carbon dioxide. Therefore, their cooling effect is not a valid counterbalance to the warming effect of greenhouse gases.

- An assumption of near-zero methane emissions from coal mines does not represent the operational reality of the coal value chain in most circumstances. Coal mining activities such as production, processing, transportation, and use often release methane and can contribute significantly to its greenhouse gas footprint.

- The authors do not account for the end-use efficiency of coal and natural gas applications. Generally, natural gas end-uses will generally have a higher energy efficiency per unit output compared with coal, particularly in the electric power and industrial sectors.

- Finally, the study's findings must be evaluated in the broader context of research that indicates the benefits of transitioning from coal to natural gas. Numerous studies have concluded that natural gas results in lower greenhouse gas emissions than coal.

Further details

- The paper finds that natural gas and coal have comparable climate impacts when methane leakage from gas systems exceeds 4.7% over a 20-year timeframe or 7.6% over a 100-year timeframe. Inventories of greenhouse gas emissions and recent scientific studies show that natural gas system methane emissions are far below these levels; the study, therefore, confirms that when compared with coal, natural gas presents clear and immediate climate benefits when used as an energy source. [2]

- Coal combustion can produce sulfur dioxide (SO_2), which, when released into the atmosphere, can react to form sulfate aerosols that affect air quality, climate, and human and ecosystem health. Sulfate aerosols can also create a short-term cooling effect on the climate by reflecting sunlight into space.

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[2] See: Alvarez, Ramón A., Daniel Zavala-Araiza, David R. Lyon, David T. Allen, Zachary R. Barkley, Adam R. Brandt, Kenneth J. Davis, Scott C. Herndon, Daniel J. Jacob, et al. 2018. "Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain." Science 361, no. 6398: 186-188. https://doi.org/10.1126/science.aar7204.

American Gas Association. 2022. "Understanding Greenhouse Gas Emissions from Natural Gas (EPA Inventory)." Accessed month day, year. https://www.aga.org/wp-content/uploads/2021/05/ghg-report-10.04.22_updated.pdf.

- There is no discussion about the magnitude of the aerosol cooling effect and how its short-term impacts outweigh longer-term considerations from gases like methane and carbon dioxide. Further, it is unclear in the main paper what values for the direct radiative effect were used for sulfate aerosols or the corresponding negative global warming potential. This value is referenced as listed in the Supplemental Information, which was not available for download at the time of this comment.

- The authors assert that coal and natural gas have near-equivalent warming effects over 20 years under certain conditions and assumptions. The claim was covered in an associated New York Times article: "It takes as little as 0.2 percent of gas to leak to make natural gas as big a driver of climate change as coal."[3]

- The study finding is based on calculating greenhouse gas emissions and resulting time-integrated warming effects using a series of assumptions:

    - Accounting for sulfate aerosols produced from coal, which create a short-term cooling effect in the atmosphere.
    - Assuming near-zero methane emissions from coal mines, which would be an unusual and atypical assumption as applied to most coal mines.
    - Ignoring differences in end-use efficiency. Coal is typically much less efficient than natural gas at end-use, so this is a critical omission.
    - Using a 20-year global warming potential for all greenhouse gas emissions. This assumption places disproportionate short-term weight on methane-related warming relative to carbon dioxide.

- The authors state that "Recent aerial measurement surveys of U.S. oil and gas production basins find wide-ranging natural gas leak rates 0.65% to 66.2%." However, this value of "66.2%" is not supported by the references provided by the authors.
    - "The "66.2%" may be a misinterpreted reference to a 2022 study table cited by the authors that show that oil and gas methane emissions from production from the San Joaquin basin account for a 66% share of the various supply chain components.[4]
    - The "66.2%" may reference Ayasse et al. 2022, which reported the results of methane remote sensing and emissions quantification of offshore water oil and gas platforms. This reference is not included in the Gordon et al. 2023 study.

[3] Tabuchi, Hiroko. "Leaks Can Make Natural Gas as Bad for the Climate as Coal, a Study Says." The New York Times, July 13, 2023. https://www.nytimes.com/2023/07/13/climate/natural-gas-leaks-coal-climate-change.html.
[4] See Table 2: Cusworth, Daniel H., Andrew K. Thorpe, Alana K. Ayasse, et al. 2022. "Strong Methane Point Sources Contribute a Disproportionate Fraction of Total Emissions Across Multiple Basins in the United States." Proceedings of the National Academy of Sciences 119, no. 38: e2202338119. https://doi.org/10.1073/pnas.2202338119.

- If this reference were included, the authors would want to indicate the significant statistical uncertainty associated with this reported value (+/- 33.8%)
- Ayasee notes, "The cause of the exceptionally high loss rate for this set of platforms at this time is unknown."
- The reported findings may be influenced by temporal or operational biases (e.g., daytime aerial flyovers during well blowdowns that are unrepresentative of 24/7 average emissions).
- An oil and gas offshore data point may not be relevant to considering natural gas value chain emissions in general.

- The study proposes that its comparison method—based on energy content (BTU) rather than energy output (e.g., kWh)—is valid because of the extensive use of natural gas in the industrial, commercial and residential sectors. However, this approach is not applicable in the U.S. context since coal is not used in the residential and commercial sectors. In the U.S. industrial sector, coal represents less than nine percent of the primary energy requirements, predominantly cement and lime manufacturing, food milling, manufacturing process heat, and paper milling. A comprehensive understanding of the relative greenhouse gas impacts of these two fuels necessitates an assessment of the efficiency of coal compared to natural gas in these specific end uses.[5]

- The study findings, inclusive of any new considerations with regard to sulfate aerosols, need to be evaluated in the context of the significant body of research that indicates clear and immediate climate benefits of natural gas relative to coal. See:

    - "We found that the coal-to-gas shift is consistent with climate stabilization objectives for the next 50–100 years."

      Tanaka, Katsumasa, Otávio Cavalett, William J. Collins, and Francesco Cherubini. 2019. "Asserting the climate benefits of the coal-to-gas shift across temporal and spatial scales." Nature Climate Change 9: 389-396. https://www.nature.com/articles/s41558-019-0457-1.

    - "The GHG emissions of Canadian LNG to China for power and heat generation were found to be 427–556 g CO2-eq/kWh and 81–92 g CO2-eq/M.J. Compared with Chinese coal for power generation, 291–687 g CO2-eq (34%–62%) reduction can be achieved per kWh of power generated."

[5] Energy Information Administration. *2018 Manufacturing Energy Consumption Survey*. Table 1.2. https://www.eia.gov/consumption/manufacturing/.

Nie, Yuhao, Siduo Zhang, Ryan Edward Liu, Daniel Javier Roda-Stuart, Arvind P. Ravikumar, Alex Bradley, Mohammad S. Masnadi, Adam R. Brandt, Joule Bergerson, and Xiaotao Tony Bi. 2020. "Greenhouse-gas Emissions of Canadian Liquefied Natural Gas for Use in China: Comparison and Synthesis of Three Independent Life Cycle Assessments." Journal of Cleaner Production 258 (June): 120701. https://www.sciencedirect.com/science/article/abs/pii/S0959652620307484.

- "This analysis has determined that the use of U.S. LNG exports for power production in European and Asian markets will not increase GHG emissions from a life cycle perspective, when compared to regional coal extraction and consumption for power production."

  Roman-White, Selina, Srijana Rai, James Littlefield, Gregory Cooney, and Timothy J. Skone. 2019. "Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States: 2019 Update." National Energy Technology Laboratory, DOE/NETL-2019/2041, September 12. https://www.energy.gov/sites/prod/files/2019/09/f66/2019%20NETL%20LCA-GHG%20Report.pdf.

- "We find that, during the period of plant operation, if there is substantial methane leakage, natural gas plants can produce greater near-term warming than coal plants with the same power output. However, if methane leakage rates are low and power plant efficiency is high, natural gas plants can produce some reduction in near-term warming. In the long term, natural gas power plants produce less warming than would occur with coal power plants."

  Zhang, Xiaochun, Nathan P. Myhrvold, and Ken Caldeira. 2014. "Key Factors for Assessing Climate Benefits of Natural Gas versus Coal Electricity Generation." Environmental Research Letters 9, no. 11. https://doi.org/10.1088/1748-9326/9/11/114022.

- NREL finds that published total life cycle emissions factors for electricity generation technologies from natural gas are 51% lower than coal in terms of g CO_2e/kWh.

  National Renewable Energy Laboratory. 2021. "Life Cycle Greenhouse Gas Emissions from Electricity Generation: Update." Accessed July 17, 2023. https://www.nrel.gov/docs/fy21osti/80580.pdf.

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