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REPLY

Reply to 'A commentary on "US power sector carbon capture and storage under the Inflation Reduction Act could be costly with limited or negative abatement potential"'

Emily Grubert[1,*] and Frances Sawyer[2]

[1] Keough School of Global Affairs, University of Notre Dame, Notre Dame, United States of America
[2] Pleiades Strategy, San Francisco, United States of America
* Author to whom any correspondence should be addressed.

E-mail: egrubert@nd.edu

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Abstract

Here we reply to a comment by Dr. Robert Kennedy from the US Department of Energy (DOE) on our paper 'US power sector carbon capture and storage under the Inflation Reduction Act could be costly with limited or negative abatement potential,' which found that the 45Q carbon oxide sequestration tax credit incentivizes behaviors under profit-maximizing conditions that could increase rather than decrease GHG emissions in the power sector relative to a counterfactual without the tax credit. Our reply addresses claims that regulatory structures would prevent the negative outcomes we model in the original paper; that our cost and performance assumptions are inaccurate; and that other technologies will see growth. We show that the comment provides no evidence that our original analysis is incorrect and that information that has emerged since the March 2023 publication of our paper supports our assumptions, including public statements by carbon capture project proponents and new information about expected project costs. We agree with Dr. Kennedy that the incentives we highlight where 45Q might incentivize higher emissions at high cost are shocking; we disagree that we have incorrectly characterized these incentives. We share a belief that many of these loopholes can be closed, and disagree that they have already been closed.

1. Introduction

We thank Dr Kennedy from the US Department of Energy (DOE) for his comment on our 2023 paper in this journal, 'US power sector carbon capture and storage (CCS) under the Inflation Reduction Act could be costly with limited or negative abatement potential' (Grubert and Sawyer 2023), and the opportunity to respond. In our paper, we use a generator-level model of profit-maximizing rather than cost-minimizing behavior to illustrate that the Inflation Reduction Act's changes to the 45Q tax credit for carbon oxide sequestration incentivizes behaviors for existing US fossil power electric generating units (EGUs) that could increase life cycle greenhouse gas (GHG) emissions at high cost to the public (through subsidies) and rate payers (through capital expenditures). This outcome is largely due to the fact that 45Q (a short-term production tax credit for stored CO_2, with no requirements that such activities reduce GHG emissions) is law, while requirements to reduce or even stabilize GHG emissions are not. Although we understand the reaction expressed in the commentary that our results must be overlooking 'prohibitive external factors,' unfortunately, 45Q is essentially unconstrained, and Kennedy's commentary does not provide evidence otherwise. We agree with Kennedy that the outcomes we model are deeply worrying, and call on DOE, the Department of Treasury (which administers the credit), the Environmental Protection Agency (EPA), and legislative bodies to act swiftly to align the incentives under 45Q with climate benefits, including by strengthening and finalizing rules consistent with the now 14 year-old GHG Endangerment Finding. The critiques expressed in the commentary, as well as numerous developments since our paper was released in March 2023, reinforce our overall findings that incentives for the US power sector under 45Q are not aligned

with climate goals, and could actually cause substantial harm if power sector CCS proceeds in these settings. In the remainder of this reply, we briefly address Kennedy's core critiques.

2. Regulatory considerations

Kennedy claims that we make a 'dystopian assertion' in noting and incorporating the fact that based on current law, EGUs could be retrofit with CCS, claim the 45Q subsidy for the 12 years of eligibility, and then inactivate the equipment and run unabated when the subsidy is no longer available to cover the high operating cost of carbon dioxide capture. While we agree this is dystopian in the context of climate change, it is factual and widely acknowledged, even by project proponents. In relation to Project Tundra, a proposed CCS retrofit project at the Milton Young station in North Dakota, the *Bismarck Tribune* quoted Minnkota Power Cooperative spokesman Ben Fladhammer as saying: 'After the 12 year tax credit period, we have no obligation to continue to incur operating cost if the capture system is not beneficial to our operations and our membership we serve' (Standaert 2023). We agree with Kennedy that regulatory requirements *should* prevent this: to date, however, they do not.

As Kennedy points out, EPA has been obligated to regulate GHG emissions from stationary sources, including existing fossil EGUs, for over a decade. However, EPA has not yet done so. The endangerment finding has been in place for longer than the time remaining between now and 2035, the date by which executive order 14008 targets 'carbon pollution free' electricity (White House 2021), which technically excludes fossil CCS below 100% mitigative capture, with no implementation so far. One attempt (the Clean Power Plan) was proposed in 2014 and ultimately repealed in 2019 without ever taking effect (for background, see Ha and Grubert 2023). In Summer 2023, EPA issued a new proposed rulemaking under Clean Air Act Section 111 that directly addresses GHG emissions behind the fenceline and includes, under some circumstances, long-term CCS operations (Environmental Protection Agency 2023a). As we noted in our original paper, such a mechanism to ensure capture and storage continues for the life of the facility could close this alarming loophole under 45Q incentives, and we applaud EPA for moving forward with a rulemaking. We stress, however, that the proposed rulemaking is not yet law, remains politically vulnerable, and contains numerous serious flaws with respect to actually regulating GHGs, including a severe undercoverage of emitting EGUs. In the context of 45Q, potentially the most relevant flaw—as one of us (Grubert) pointed out in a public comment on the proposed rulemaking—is that EPA intends to determine compliance based *on capture alone*, not on the fate of the CO_2: the implication is that if the proposed rulemaking is finalized and goes into effect, after the 12 years of eligibility for the 45Q tax credit expires, EGUs would not be able to turn off capture equipment, but they would be able to divert captured CO_2 in ways that would not sequester it outside the atmosphere (Grubert *et al* 2023). Bluntly, in the proposed rulemaking as written, nothing explicitly prevents a plant from capturing CO_2 and venting it (although selling the CO_2 for uses that would result in re-release is the more likely pathway to ongoing emissions).

3. Modeling and technical considerations

Kennedy's comment notes in its introduction that our 'cost and performance assumptions are not representative of carbon capture retrofits' but provides no support for this claim in the body of the text, so we address it here. Carbon capture retrofit costs (and new build costs) are highly uncertain precisely because almost none of them have been performed, so empirical data are not available. As such, as described in our paper, we use data provided by the DOE for cost differentials between new build plants with and without CCS to estimate retrofit costs on a per-capacity basis, with the caveat that these new build-based estimates are likely too low for retrofit contexts. We invite Kennedy to clarify what alternate data might be available if the values from his agency are unacceptable. We can also compare our modeled data to project estimates as demonstration projects are planned and release more project details. For example, our model projects that a retrofit of the Milton R. Young power station (for 90% capture on the full 680 MW capacity) in North Dakota would cost $1.87 billion. Documents associated with Project Tundra, the proposed CCS retrofit of this plant, show currently estimated costs (as presented to DOE) of $1.94 billion (note that this estimate is for capture rate variably claimed as 90% versus 74%, which reinforces our caution that our cost estimates are likely too low) (Smyth 2023).

Kennedy's direct critiques of our model appear to reflect a lack of engagement with the model itself. As Kennedy points out, our model is not a system-level capacity expansion model. Rather, we investigate profitability at a generator level to conduct a fit-for-purpose analysis of incentives introduced by a specific policy to evaluate where and to what extent CCS retrofits are financially incentivized in the US power sector, introducing policy awareness of 45Q to a base model structure that has been demonstrated in the open literature (Grubert 2020, 2021, Grubert *et al* 2020). Kennedy highlights values from the EIA's Annual Energy

Outlook (AEO) that suggest IRA will contribute to lower fossil generation in 2050 to claim that our work does not sufficiently account for fossil energy decline, apparently without realizing that our model's highest fossil generation scenarios are roughly in line with AEO IRA projections, and most of our scenarios suggest fossil generation will be much lower. Based on Kennedy's numbers, AEO's IRA case suggests 1200 billion kWh of coal and natural gas generation in 2050; our model's 20 year lifespan extension cases suggest 1360 billion kWh of coal and natural gas generation in 2050, a very similar value. Our 0 year and 12 year lifespan extension scenarios suggest fossil generation of 170 billion kWh and 640 billion kWh in 2050, respectively[3]. As such, we do not find the argument that we fail to consider declines in fossil generation to be compelling. We also note that the model underlying the AEO is well known for not capturing decarbonization dynamics well (see, e.g. Zacarias and Grubert 2021) and that the EIA announced in July 2023 that it will be canceling the 2024 edition of the AEO in part due to much-needed updates to the underlying model to correct some of these problems (EIA 2023b).

Kennedy also critiques our assumption that fossil EGUs retrofitting with CCS could increase their capacity factors, claiming that it is 'dubious' to assume that capacity factor increases could clear environmental regulatory requirements or be allowed by system operators, but does not provide evidence of barriers to increased capacity factors. Under CFR 40(1)(C)(60)(A) § 60.14, emissions increases resulting from an increase in hours of operation are explicitly exempted from consideration as a modification triggering regulatory action under Section 111 (Code of Federal Regulations 2023).

4. Relevant energy system factors

Kennedy's final major area of critique focuses on the idea that other technologies also exist. The core claims are that low-cost renewable energy will continue to grow, and that CCS will potentially develop outside the power sector. Although these claims are true, neither of these points has any bearing on our core point that 45Q incentivizes behavior among existing US fossil EGUs that is not aligned with climate goals. We agree and hope that renewables will continue to be built, but flag also that under net-zero compatible model profiles, US installed generation capacity will likely need to increase by a factor of 5–8 (Browning *et al* 2023). Particularly given that new build wind and solar are already cheaper than operational costs alone for US coal plants (Gearino 2023), the existence of some incentives to build zero-carbon electricity (which as we note in our paper, are much lower on a kWh basis than the 45Q credits are for coal and natural gas) does not assure displacement of fossil power.

Similarly, the notion that other industries might use carbon management is correct, but irrelevant to our point that 45Q creates bad incentives for power sector CCS. The claim that infrastructure built to support fossil EGUs can spur 'development of systems with more favorable carbon lifecycle estimates' acknowledges that the life cycle profile of fossil power CCS is poor. A recent GHG-oriented life cycle analysis issued by the DOE for Project Tundra, the proposed coal CCS retrofit mentioned above, concluded that the project would emit more than 3 times as much GHG pollution as was captured but still recommended proceeding (DOE 2023): although much of this value was driven by serious analytical errors (Grubert 2023), the recommendation for moving ahead reinforces the point that there are essentially no guardrails preventing CCS projects from increasing GHG emissions. (Based on our paper, we agree the Tundra retrofit would increase GHG emissions, but largely due to the fact that the plant is at retirement age.) Kennedy's claim about development of these bad-for-climate power sector CCS projects enabling better projects in other contexts is questionable, largely because it relies on the argument that economy of scale is beneficial for non-power sector activities without investigating the real infrastructure needs. Industrial activities where CCS is effectively required as a mitigative strategy are limited in scope (e.g. US cement plant process emissions account for only about 40 million tonnes of CO_2/year (Environmental Protection Agency 2023b), roughly equal to the 2021 emissions from the country's two largest coal-fired power plants (EIA 2023a)) and may not be colocated with power. As such, having large pipelines optimized around power plant locations has limited benefits for these sectors. For carbon dioxide removal through processes like direct air capture with storage that could share infrastructure with mitigative CCS, the capture plants are not yet sited: in theory, capture and storage could be colocated, essentially eliminating the need for controversial and costly pipeline infrastructure. In neither of these cases is it clear that investing in long-lived linear infrastructure like pipelines optimized around the locations of aging fossil EGUs would be beneficial, and it might in fact be harmful (e.g. by further burdening already-overburdened communities with infrastructure that lowers costs of extending fossil EGU lifespans and incentivizes further development along pipeline routes rather than alternative site selection mechanisms). In any case, our analysis focuses on the fact that 45Q does not include

[3] We note that due to a copy-paste error, generation values for Scenario 1a were reported as too high in the model as released. We regret the error and note that users can enter the Scenario 1a conditions as the 'Active Scenario' to correct this.

guardrails to ensure that any carbon management activities rewarded with the subsidy are actually creating climate benefits: although we looked only at the power sector, and the structure of the power sector means the behaviors and risks are likely different, the point also applies to other applications. For example, 45Q has no guardrails to prevent natural gas-based direct air capture with high methane emissions from being awarded \$180/tonne of CO_2 stored even if the life cycle GHG balance results in net emissions rather than net removal.

5. Conclusion

We appreciate the opportunity to respond to Dr Kennedy's comment on our paper. We emphasize that this comment provides no evidence that our paper incorrectly characterizes the incentive structure presented to fossil EGUs considering CCS to obtain subsidies through 45Q. In fact, information that has emerged since publication of our paper—including details on specific projects; project proponent statements about intended behaviors; and the proposed EPA rulemaking on power sector GHGs—reinforces our claim that 45Q alone, as currently enshrined in law, creates incentives that are not aligned with climate goals and needs, with few to no guardrails. As we describe in the original paper, our work is not a deterministic view of what *will* happen under the IRA modification of 45Q in the US power sector, but rather what *could* happen given generator-level incentives. This perspective adds to more common capacity expansion and cost optimization models that provide very optimistic views of what might happen under cost-optimal conditions by focusing on profit optimization as the other end of a range of possibilities. Where we end up depends strongly on choices we make now. We agree with Kennedy that preventing negative outcomes relies on regulatory guardrails, likely including requirements for high quality GHG accounting and a demand for climate benefits; we disagree that such guardrails already exist.

Conflict of interest

While Deputy Assistant Secretary for Carbon Management at the US DOE in 2021-2022, Grubert was in a supervisory role over Kennedy, the author of the commentary to which this piece replies.

ORCID iD

Emily Grubert https://orcid.org/0000-0003-2196-7571

References

Browning M *et al* 2023 Net-zero CO_2 by 2050 scenarios for the united states in the energy modeling forum 37 study *Energy Clim. Change* **4** 100104

Code of Federal Regulations 2023 40 CFR 60.14—modification (available at: www.ecfr.gov/current/title-40/part-60/section-60.14)

DOE 2023 DOE/EA-2197: draft environmental assessment *Energy.gov* (available at: www.energy.gov/nepa/articles/doeea-2197-draft-environmental-assessment)

EIA 2023a Emissions by plant and by region (available at: www.eia.gov/electricity/data/emissions/)

EIA 2023b Statement on the annual energy outlook and EIA's plan to enhance long-term modeling capabilities (available at: www.eia.gov/pressroom/releases/press537.php)

Environmental Protection Agency 2023a Greenhouse gas standards and guidelines for fossil fuel-fired power plants (available at: www.epa.gov/stationary-sources-air-pollution/greenhouse-gas-standards-and-guidelines-fossil-fuel-fired-power)

Environmental Protection Agency 2023b Inventory of U.S. greenhouse gas emissions and sinks (available at: www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks)

Gearino D 2023 New wind and solar are cheaper than the costs to operate all but one coal-fired power plant in the United States *Inside Climate News* (available at: https://insideclimatenews.org/news/30012023/wind-solar-coal-power-plant-costs/)

Grubert E 2020 Fossil electricity retirement deadlines for a just transition *Science* **370** 1171–3

Grubert E 2021 Emissions projections for US utilities through 2050 *Environ. Res. Lett.* **16** 084049

Grubert E 2023 DOE's error-ridden analysis on coal CCS project threatens climate and engagement goals *Utility Dive* (available at: www.utilitydive.com/news/department-of-energy-doe-coal-carbon-capture-and-storage-ccs-project-threatens-climate/692705/)

Grubert E, Buonocore J J and Polka E 2023 Comment submitted by emily grubert, jonathan buonocore and erin polka *Regulations.gov* (available at: www.regulations.gov/comment/EPA-HQ-OAR-2023-0072–0783)

Grubert E and Sawyer F 2023 US power sector carbon capture and storage under the inflation reduction act could be costly with limited or negative abatement potential *Environ. Res.: Infrastruct. Sustain.* **3** 015008

Grubert E, Stokes-Draut J, Horvath A and Eisenstein W 2020 Utility-specific projections of electricity sector greenhouse gas emissions: a committed emissions model-based case study of California through 2050 *Environ. Res. Lett.* **15** 1040a4

Ha S and Grubert E 2023 Hybridizing qualitative coding with natural language processing and deep learning to assess public comments: a case study of the clean power plan *Energy Res. Soc. Sci.* **98** 103016

Smyth J 2023 Department of energy analysis says coal carbon capture project would emit more greenhouse gases than it stores. *Energy and Policy Institute* (available at: https://energyandpolicy.org/department-of-energy-analysis-says-coal-carbon-capture-project-would-emit-more-greenhouse-gases-than-it-stores/)

Standaert M 2023 Experts say Project Tundra carbon capture plans may not be worth climate, financial risks *The Bismarck Tribune* (available at: https://bismarcktribune.com/news/state-regional/business/experts-say-project-tundra-carbon-capture-plans-may-not-be-worth-climate-financial-risks/article_cfa437f2-24b6-11ee-9769-2f63d327da25.html)

White House 2021 Executive order 14008: tackling the climate crisis at home and abroad (available at: www.regulations.gov/document/EPA-HQ-OPPT-2021-0202–0012)

Zacarias L M and Grubert E 2021 Effects of implausible power plant lifetime assumptions on US federal energy system projected costs, greenhouse gas emissions, air pollution, and water use *Environ. Res.: Infrastruct. Sustain.* **1** 011001