RESEARCH BRIEF

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The impact of the proposed "first productive use" requirement for biogas for Inflation Reduction Act 45V tax credits

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SUMMARY

This brief assesses the greenhouse gas (GHG) emissions impact of diverting biogas from its current use and highlights the importance of the proposed "first productive use" requirement for biogas or biogas-derived renewable natural gas (RNG) in the Inflation Reduction Act (IRA) Section 45V tax credits. We provide an example where one type of biogas, landfill gas (LFG), is initially used for heat and power and compare that with when it is instead used to produce hydrogen to power fuel-cell electric trucks (FCETs). We find that when LFG is combusted for electricity and used to power a battery electric truck, a 76% emissions reduction would be achieved compared with a diesel truck. When that LFG is instead diverted to produce hydrogen to fuel FCETs, the FCET provides only 28% lower emissions relative to a diesel truck.

If the first productive use requirement is removed from the proposed Section 45V regulations, hydrogen producers could claim billions of dollars in tax credits even though the hydrogen production may induce more GHG emissions than would have occurred in absence of the tax incentive. In the case we illustrate, hydrogen producers would receive around $1.6 billion in tax incentives for hydrogen that would not have qualified for the tax credit if the GHG emissions associated with diverting the biogas from its first productive use were considered.

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BACKGROUND

The Inflation Reduction Act (IRA) provides funding to promote private-sector investment in clean energy, including incentives for low-carbon hydrogen within the Clean Hydrogen

Tax Credit under Section 45V.[1] In 2023, the U.S. Department of the Treasury and the Internal Revenue Service released proposed guidance for how hydrogen producers could qualify for the Clean Hydrogen Tax Credit.[2] A prior ICCT brief explained the IRA's provisions for hydrogen production and the proposed guidance in detail.[3] In short, producers can benefit from 45V tax credits if the life-cycle greenhouse gas (GHG) emissions from hydrogen production are below 4 kg carbon dioxide equivalent (CO_2e) per kg of hydrogen. There are four credit tiers, depending on the carbon intensity (CI) of a hydrogen pathway, and the lower the emissions, the greater the tax credit. The life-cycle CI of hydrogen production pathways can be calculated using the 45V version of the Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model (GREET), which was released alongside the proposed guidance.[4] If the hydrogen production pathway is not included in the 45V GREET model, the producer can request a provisional emissions rate from the U.S. Department of Energy.

Hydrogen produced from renewable natural gas (RNG) is potentially a low-CI hydrogen pathway, depending on the source of biogas and life-cycle assessment assumptions. In the 45V guidance, RNG refers to biogas that is upgraded via cleaning to have chemistry that is equivalent to fossil natural gas. Besides being upgraded to RNG, biogas could be used for multiple purposes, including combustion into electricity and direct use as fuel in boilers.[5] Although landfill gas (LFG) is currently the only biogas source in the 45V GREET model, Treasury has solicited comments on including non-landfill sources such as dairy manure in its proposed guidance.

Shifting biogas from its current use in the heating or power sectors could increase net GHG emissions due to indirect, or displacement emissions. Because the bio-based feedstocks needed to produce biogas are often in limited supply, biogas diverted from its current use to other uses is likely to be replaced with fossil energy, and if that happens, it would result in an increase in GHG emissions.[6] In order to limit displacement emissions, Treasury proposed a "first productive use" requirement for the biogas used during hydrogen production which specifies that the biogas should not have previously been used for another valuable application. First productive use is currently defined in the 45V guidance as "the time when a producer of that gas first begins using or selling it for productive use in the same taxable year as (or after) the relevant hydrogen production facility was placed in service." For example, if an existing facility producing electricity from LFG or supplying RNG to the power sector is diverted to hydrogen production, the first productive use requirement

1 Inflation Reduction Act of 2022, Pub L. No. 117-169, 136 Stat. 1818 (2022). https://www.congress.gov/bill/117th-congress/house-bill/5376?s=2&r=1.

2 Section 45V Credit for Production of Clean Hydrogen; Section 48(a)(15) Election to Treat Clean Hydrogen Production Facilities as Energy Property, 26 Fed. Reg. Part 1, December 26, 2023, https://www.federalregister.gov/documents/2023/12/26/2023-28359/section-45v-credit-for-production-of-clean-hydrogen-section-48a15-election-to-treat-clean-hydrogen.

3 Yifan Ding, Chelsea Baldino, and Yuanrong Zhou, *Understanding the Proposed Guidance for the Inflation Reduction Act's Section 45V Clean Hydrogen Production Tax Credit* (International Council on Clean Transportation, 2024), https://theicct.org/publication/proposed-guidance-for-the-inflation-reduction-act-45v-clean-hydrogen-tax-credit-mar29/.

4 U.S. Department of Energy, *Guidelines to Determine Well-to-Gate Greenhouse Gas (GHG) Emissions of Hydrogen Production Pathways Using 45VH2-GREET 2023 (2023)*, https://www.energy.gov/sites/default/files/2024-05/45vh2-greet-user-manual_may-2024.pdf.

5 Environmental Protection Agency, "Project Technology Options," in *Landfill Gas Energy Project Development Handbook*, 2024, 3–1, https://www.epa.gov/lmop/landfill-gas-energy-project-development-handbook; Environmental Protection Agency, "AgSTAR Data and Trends, Biogas Facts and Trends," accessed August 4, 2024, https://www.epa.gov/agstar/agstar-data-and-trends.

6 Jane O'Malley, Stephanie Searle, and Nikita Pavlenko, *Indirect Emissions from Waste and Residue Feedstocks: 10 Case Studies from the United States* (International Council on Clean Transportation, 2021), https://theicct.org/publication/indirect-emissions-from-waste-and-residue-feedstocks-10-case-studies-from-the-united-states/.

would not be satisfied. If this requirement is not met, Treasury proposes that the CI of fossil natural gas would be used for CI estimation of the hydrogen.

During the public comment period for 45V, comments critical of the first productive use requirement for biogas or biogas-derived RNG were submitted.[7] Some suggested that it would severely limit the eligible projects for the Section 45V crediting.[8] Others reasoned that regulations under the Environmental Protection Agency's Renewable Fuel Standard (RFS) already cover RNG and should continue to serve as the regulatory authority for RNG; this would mean that any RNG that is RFS-eligible would also be eligible for the 45V tax credit. Some stakeholders also argued that while the "three pillars" for crediting electricity in electrolysis hydrogen production are necessary to prevent displacement emissions, for RNG there is no corresponding concern about induced grid emissions.[9] However, relaxing the restrictions could make it likely that the biogas used for electricity production, heating, or RNG production today could be diverted to hydrogen production to exploit the full value of 45V tax credits at $3/kg.[10]

The analysis below demonstrates the GHG impact of diverting biogas from its first productive use to hydrogen production. We focus on LFG because it is the most abundant existing source of biogas in the United States and is currently the only source of biogas included in the GREET 45V model.[11] First, we estimate the fuel cycle GHG emissions of LFG-derived RNG, electricity, and hydrogen when used as fuel for trucks. We then analyze the GHG impact of diverting biogas from electricity production for powering a battery electric truck to hydrogen production to power a fuel-cell electric truck (FCET). This is illustrated in Figure 1.

7 Internal Revenue Service, "Rulemaking Docket, Section 45V Credit for Production of Clean Hydrogen; Section 48(a)(15) Election to Treat Clean Hydrogen Production Facilities as Energy Property (REG-117631-23)," https://www.regulations.gov/docket/IRS-2023-0066/comments.

8 Nextera Energy, "Comment from NextEra Energy, Re: Proposed Regulations Regarding the Section 45V Credit for Production of Clean Hydrogen (REG-117631-23)," February 26, 2024, https://www.regulations.gov/comment/IRS-2023-0066-28806.

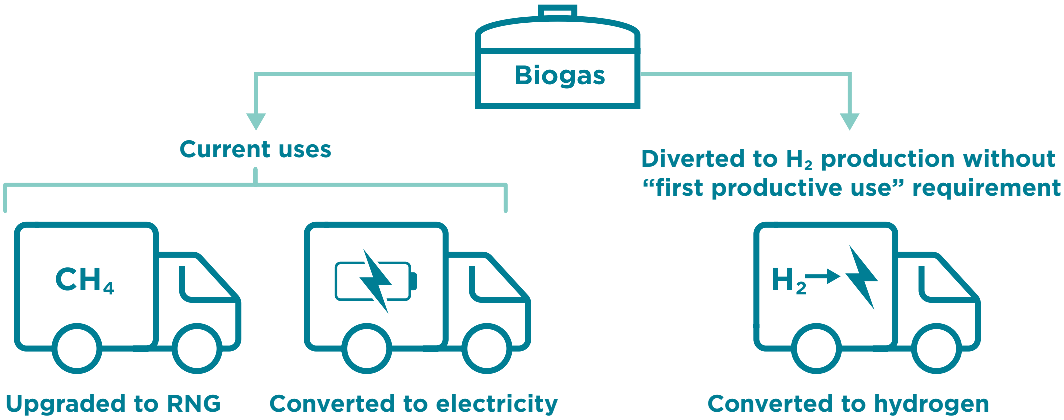
9 FuelCell Energy, "Comment from FuelCell Energy, Inc. (IRS-2023-0066-29506) Re: IRS and REG-117631-23-Notice of Proposed Rulemaking," February 26, 2024, https://www.regulations.gov/comment/IRS-2023-0066-29506.

10 International Council on Clean Transportation, "ICCT Comments on REG-117631-23: Proposed Regulations Relating to the Credit for Production of Clean Hydrogen (45V)," February 23, 2024, https://www.regulations.gov/comment/IRS-2023-0066-26007.

11 "Biogas Explained – Landfill Gas and Biogas," U.S. Energy Information Administration, accessed August 13, 2024, https://www.eia.gov/energyexplained/biomass/landfill-gas-and-biogas.php.

Figure 1

Diversion from the current uses of biogas as RNG or electricity to hydrogen to power trucks in the absence of a first productive use requirement



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METHODOLOGY

Our analysis estimates the well-to-wheel life-cycle GHG emissions of fuels derived from biogas for RNG-powered, battery electric, and fuel-cell electric trucks. The well-to-tank GHG emissions of RNG, electricity, and hydrogen production from LFG are assessed using GREET 2023.[12] The scope for LFG-derived electricity includes LFG upgrading to RNG, RNG distribution to power plants, and RNG conversion to electricity. For LFG-derived hydrogen, the scope includes LFG upgrading to RNG, RNG transmission, gaseous hydrogen production, hydrogen transmission and distribution, and compression.

Table 1 lists the well-to-tank emission factors for fuels derived from LFG used for this analysis. In addition to the scope described above for hydrogen, we considered the displacement emissions from replacing the electricity that would have been produced from LFG. If LFG is used instead for hydrogen production, then the previously LFG-derived electricity would be replaced by grid electricity. As displacement penalty, the difference between emissions from RNG-derived electricity and the grid electricity emissions used for transportation (CI: 122 gCO_2e/MJ Electricity) from GREET 2023 was taken. We calculate that the diverted energy generates displacement emissions of 40.2 gCO_2e per MJ of hydrogen (4.8 $kgCO_2e$/kg).

Table 1

Well-to-tank carbon intensity of fuels derived from landfill gas

Fuel	Carbon intensity (gCO_2e/MJ fuel)
RNG	20.0
Electricity	38.8
Hydrogen	25.9
Hydrogen with displacement impact	66.1

Note: Values estimated using the GREET model.

12 Argonne National Laboratory, *R&D GREET Model 2023*, https://greet.anl.gov.

For tank-to-wheel emissions, we draw upon the methodology from a previous ICCT study and focus on a 40-t articulated truck (tractor-trailer) with gCO_2e/mi traveled as the functional unit.[13] We use fuel/electricity consumption values that correspond to real-world driving conditions instead of test-cycle vehicle efficiency. The fuel efficiency of a 40-t battery electric and fuel-cell tractor-trailer was obtained from another ICCT study and assumed to be 2.86 and 5.10 kWh/mi, respectively.[14] To compare our analysis with diesel-powered trucks we use the U.S. national average for the CI of diesel fuel from the RFS, 91.9 gCO_2e/MJ. This corresponds to 1,739 gCO_2e/mi for a truck where fuel efficiency is 0.53 L/mi. Non-CO_2 tailpipe emissions (CH_4 and N_2O) from GREET 2023 are included as equivalent amounts of CO_2 in the combustion emissions for diesel and RNG-powered trucks.

RESULTS

Figure 2 illustrates the differences in well-to-wheel GHG emissions for 40-t trucks, normalized per mile, for each fuel option analyzed. We find that when LFG is combusted for electricity and used to power a battery electric truck or upgraded to RNG to fuel a truck powered by compressed natural gas, emissions reductions of 76% and 73%, respectively, would be achieved relative to a diesel truck. When that LFG is diverted to produce hydrogen to fuel an FCET instead, the overall emissions benefits decrease to only 28% relative to a diesel truck. This illustrates how the first productive use requirement safeguards against unintended displacement emissions and ensures that eligible biogas pathways deliver the largest GHG savings possible.

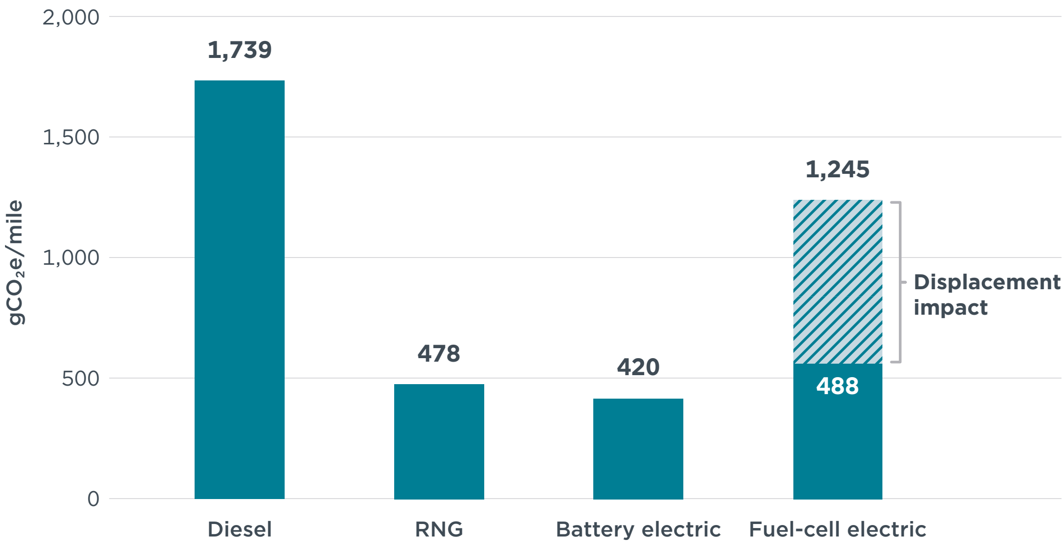
Displacement emissions are not accounted for in the GREET 45V model. This means that if the first productive use requirement is not retained in the guidance, a hydrogen producer using LFG that already has a current use would receive a low CI and qualify for a higher tax credit than is warranted by its GHG impact. For example, the well-to-gate CI of LFG-derived hydrogen corresponds to 1.4 gCO_2e/kg of hydrogen and qualifies for a tax credit of $1.0 per kg of hydrogen. When displacement emissions are considered, the LFG would not qualify for any credits because it would have a well-to-gate CI of 6.2 gCO_2e/kg of hydrogen.

13 Adrian O'Connell et al., *A Comparison of the Life-Cycle Greenhouse Gas Emissions of European Heavy-Duty Vehicles and Fuels* (International Council on Clean Transportation, 2023), https://theicct.org/publication/lca-ghg-emissions-hdv-fuels-europe-feb23/.

14 Hussein Basma et al., *Total Cost of Ownership of Alternative Powertrains Technologies for Class 8 Long-Haul Trucks in the United States* (International Council on Clean Transportation, 2023), https://theicct.org/publication/tco-alt-powertrain-long-haul-trucks-us-apr23/.

Figure 2

Life-cycle greenhouse gas emissions from fuel cycle of a 40-t tractor-trailer for various fuels



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According to energy project data from the Landfill Methane Outreach Program, there are 664 LFG projects in the United States collecting 1,631 million cubic feet of LFG per day after accounting for the flared gas.[15] Of the collected gas, 67% is used for electricity production and 23% is upgraded to RNG. The remaining 10% is used as direct fuel in boilers. If the LFG used for electricity generation were diverted for hydrogen, 1.6 million MT of hydrogen could be produced per year.[16] The producers could claim around $1.6 billion in tax credits from the IRA for the low-CI hydrogen when our estimates are that this hydrogen induces 7.8 kt of GHG emissions from the diversion of biogas from its first productive use.

Note, too, that emissions due to the diversion of LFG from electricity production would be expected to vary by region and biogas source. In a region where the CI of the electricity mix is higher (e.g., the percentage of coal in the electricity mix is higher), these indirect emissions would increase. The opposite would be true in an area where more renewable sources are used in electricity production.

If manure-derived biogas is used as feedstock for hydrogen production, the value of IRA credits would increase due to the highly negative CI of manure-derived RNG and hydrogen pathways.[17] No life-cycle GHG value is currently assigned to the manure biogas pathways under the RFS.[18] If manure-biogas were displaced from its first productive use, much more federal funding could be spent on tax credits for hydrogen that may bring little-to-no emissions reduction benefits. Furthermore, as most of the

15 "Landfill Methane Outreach Program (LMOP) Landfill Gas Energy Project Data," U.S. Environmental Protection Agency, accessed July 19, 2024, https://www.epa.gov/lmop/landfill-gas-energy-project-data.

16 Landfill gas is assumed to consist of 50% of methane and is upgraded into RNG at a facility working at 90% capacity to calculate the amount of RNG produced per year. RNG is assumed to be converted into hydrogen with a 42% yield (wt%) using assumptions from GREET.

17 California Air Resources Board, "Current Fuel Pathways," accessed August 14, 2024, https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/current-pathways_all.xlsx.

18 "Lifecycle Greenhouse Gas Results," U.S. Environmental Protection Agency, accessed August 4, 2024, https://www.epa.gov/fuels-registration-reporting-and-compliance-help/lifecycle-greenhouse-gas-results;

manure biogas is already used for heat and electricity purposes, the additional GHG emissions due to displacement would also be expected to be high.[19]

CONCLUSION

This analysis illustrates how diverting existing biogas from electricity production to hydrogen production could induce indirect emissions that reduce the overall GHG savings of that hydrogen. We estimate that diverting biogas from existing uses for heat and power generates approximately 4.8 kg CO_2e per kg of hydrogen of displacement emissions. The proposed first production use rule is a critical component of the Section 45V guidance and is important for ensuring that the tax credits incentivize new, additional hydrogen production rather than promote the diversion of existing resources.

19 "AgSTAR Data and Trends, Biogas Facts and Trends," U.S. Environmental Protection Agency, updated June 16, 2024, https://www.epa.gov/agstar/agstar-data-and-trends.

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