April 30, 2024

Via ePUC
Holly Anderson, PUC Clerk
Vermont Public Utility Commission
112 State Street
Montpelier, VT 05620-2701

Re: Case No. 23-2220-RULE, Proceeding to Design the Potential Clean Heat Standard, Scheduling – Tags 1 (advisory groups), 2 (measure characterization), 3 (credit creation), 4 (credit usage), and 5 (pacing)

Dear Clerk Anderson,

Conservation Law Foundation (CLF), Vermont Natural Resources Council (VNRC), and Vermont Public Interest Research Group (VPIRG) greatly appreciate all of the work that the Public Utility Commission (PUC), Clean Heat Standard (CHS) Technical Advisory Group (TAG), and CHS Equity Advisory Group (EAG) have been engaged in, particularly over the last few months, to best position the State of Vermont (State) to have a functioning, equitable, and effective CHS that helps Vermonters transition away from high-carbon, high-cost building heating practices and to lower-carbon alternatives. CLF, VNRC, and VPIRG have been especially encouraged by some of the recent work of the TAG related to ensuring that the PUC, the Department of Public Service (PSD), the TAG, and any subject matter consultants retained by the PUC and PSD—currently Opinion Dynamics and NV5/Energy and Environmental Economics, Inc. (E3)—are all working from the same assumptions so that there is consistency across all the moving pieces and less harmonization required before draft rules and decision support tools, such as the Technical Reference Manual, are finalized and/or ready for presentation to the General Assembly.

CLF, VNRC, and VPIRG were also very happy to see the Order Communicating Work Plan issued on April 19, 2024, which indicates that there will be more opportunity for members of the public to comment on actual language in the form of straw proposals.

CLF, VNRC, and VPIRG firmly believe that this is the start of the most important work that the PUC, TAG, EAG, PSD, retained consultants, anticipated CHS-market participants, advocates, members of the public, and others will need to do to ensure that Vermont designs a CHS that

aligns with Vermont statute, including the greenhouse gas emissions reduction requirements enacted through the Global Warming Solutions Act (GWSA). As indicated by the findings in the Affordable Heat Act (AHA), there is an opportunity and an obligation to design a CHS that not only works for heating providers today, but also paves the way for market diversification to create the energy system of the future, while efficiently, effectively, and equitably serving Vermonters.

To set up the process for success, CLF, VNRC, and VPIRG think there are some underlying assumptions and decisions that can and should be made before any straw proposals are drafted. Accordingly, CLF, VNRC, and VPIRG want to provide the PUC and TAG with preliminary comments on assumptions from Dr. Danny Cullenward, a climate economist and lawyer with expertise on market-based climate policies and their connection with greenhouse gas emissions accounting that CLF has retained. Those comments are enclosed, and we appreciate the PUC and TAG's consideration of this input as they make decisions to design the CHS.

While elaborated upon more fully in the enclosed comments themselves, CLF, VNRC, and VPIRG view the following as the key takeaways from Dr. Cullenward's expert analysis:

- **GREET is easily customizable**. The Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) Model, like any other spreadsheet-based decision support tool, has been, and can easily be, customized to best reflect both the policy goals of the State and the unique parameters of what a State-specific CHS needs to accomplish in order to meet the State's statutorily required greenhouse gas emissions reduction requirements, as enacted through the GWSA, within the thermal sector.

- **The PUC should customize a VT-GREET model**. The PUC, with the assistance of the TAG, DPS, and any retained consultants, should customize a State-specific GREET that deviates from the standard GREET by eliminating assumptions that yield perverse incentives and distortionary outcomes, such as anything that allows negative carbon intensity, and/or that are based on outdated scientific evidence. Customizing a VT-GREET model in such a way would also be consistent with legislative intent, which calls for an adaptation of GREET (or alternative comparable modeling) to fit the Vermont thermal sector context and the statutory greenhouse gas emission reduction requirements. *See* 30 V.S.A. § 8127(g)(1) ("The schedule shall be based on transparent, verifiable, and accurate emissions accounting adapting the Argonne National Laboratory GREET Model, Intergovernmental Panel on Climate Change (IPCC) modeling, or an alternative of comparable analytical rigor to fit the Vermont thermal sector context, and the requirements of 10 V.S.A. § 578(a)(2) and (3)."); *see also* 30 V.S.A. § 8127(g)(2) (Requires an accounting of "greenhouse gas emissions from biogenic and geologic sources, including fugitive emissions and loss of stored carbon[,]" for each fuel pathway and an adjustment to the baseline emission rates "as a result of [certain] local, State, or federal legal requirements . . .[,]" which would not be accomplished by using standard GREET without customization).

  An example of a way to eliminate an assumption that yields a perverse incentive and distortionary outcome in a way that is consistent with legislative intent is to require fuel

pathways that involve avoided methane emissions calculations to report no less than zero emissions as their assigned carbon intensity score, which would still allow the fuel pathway to receive credit as a clean heat measure that is preferred to fossil fuels. *See* 30 V.S.A. § 8127(d) (list of eligible measures) and (g) (requiring that the schedule of life cycle emissions be based on an accounting and the State's greenhouse gas emissions reduction requirements for 2030 and 2050 codified as 10 V.S.A. § 578(a)(2) and (3)); *see also* 2023 Acts and Resolves No. 18, Sec. 2(1) and (5) (Legislative findings for the AHA that incorporate all of the legislative findings from the GWSA, 2020 Acts and Resolves No. 153, Sec. 2, and include that "[t]o meet the greenhouse gas emission reductions required by the GWSA, Vermont needs to transition away from its current carbon-intensive building heating practices to lower-carbon alternatives.") and 30 V.S.A. §§ 8124(d)(2) (requiring minimum amounts of installed clean heat measures for customers with low or moderate income), 8127(c)(1) (allowing clean heat credits to be created for each year of the expected life of an installed measure), and 8128(a)(9) (requiring the TAG to coordinate "with the Agency of Natural Resources to ensure that greenhouse gas emissions reductions achieved in another sector through the implementation of the Clean Heat Standard are not double-counted in the Vermont Greenhouse Gas Emissions Inventory and Forecast[.]").

- **The VT-GREET model should be incorporated into PUC's final rule**. A State-specific GREET should be incorporated into the PUC's final CHS rule and, as applicable, reflected in the CHS Technical Reference Manual and used to establish a schedule of lifecycle emission rates, as required under 30 V.S.A. § 8127(g) ("[T]he Commission shall, by rule or order, establish a schedule of lifecycle emission rates . . .."), and the values of clean heat credits, as required under 30 V.S.A. § 8127(a) ("By rule or order, the Commission shall establish or adopt a system of tradeable clean heat credits."). That same State-specific GREET can also then be further customized, under strict and transparent oversight within parameters adopted or ordered by the PUC, by obligated parties and entities that generate clean heat measure credits to be retired. *See* id. ("The Department of Public Service shall perform the verification of clean heat credit claims . . ..").

CLF, VNRC, and VPIRG believe that Dr. Cullenward can provide great perspective and valuable information that the TAG can use in the continued early stages of its work, especially related to bioenergy, pacing, measure characterization, lifecycle accounting, and how all of that inter-connected work can be reflected in a State-specific customization of GREET that can be used by the PUC, the TAG, obligated parties, and anyone who is generating clean heat measure credits. Dr. Cullenward's expertise, applied experience, and perspective would also fill some of the gap in the TAG's statutorily intended areas of expertise now that Dr. Michael Wang is no longer on the TAG and was the member with expertise in GREET. Given Dr. Cullenward's work in other states such as California, CLF, VNRC, and VPIRG believe that Dr. Cullenward is well situated to help Vermont in the iterative work that is necessary to design a CHS that works well, as envisioned by statute and measured to the nuances of Vermont as the implementing jurisdiction.

Dr. Cullenward has offered to make himself available to come to a TAG meeting to present, answer questions, participate in a subgroup meeting, etc. CLF, VNRC, and VPIRG hope that

members of the TAG will take Dr. Cullenward up on that offer, as is allowed pursuant to Procedure for the Clean Heat Standard Technical Advisory Group, Sec. III.D. CLF also looks forward to, as applicable, continuing to work with Dr. Cullenward through the balance of the development of the CHS and having him potentially provide comments on specific straw proposals and/or participate in future workshops.

CLF, VNRC, and VPIRG would like to thank the PUC and TAG in advance for their consideration of these comments from Dr. Cullenward and CLF, VNRC, and VPIRG look forward to continuing to engage in the development of the State's CHS and ensuring, consistent with legislative findings, that Vermont "transition[s] away from its current carbon-intensive building heating practices to lower-carbon alternatives [in a way that is] equitabl[e and] recogniz[es] economic effects on energy users, especially energy-burdened users[,] on the workforce currently providing these services[,] and on the overall economy." 2023 Acts and Resolves No. 18, Sec. 2(5).

Sincerely,

/s/ Anthea Dexter-Cooper
Anthea Dexter-Cooper
Senior Attorney
CLF Vermont

Ben Edgerly Walsh
Climate & Energy Program Director
Vermont Public Interest Research Group

/s/ Johanna Miller
Johanna Miller
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Enclosure

ENCLOSURE –

COMMENTS FROM
DR. DANNY CULLENWARD

Comments of Dr. Danny Cullenward to the Vermont Public Utility Commission and the Clean Heat Standard Technical Advisory Group on behalf of Conservation Law Foundation

April 30, 2024

Contents

1. Summary

Thank you for the opportunity to provide comments on Vermont's Clean Heat Standard. My name is Dr. Danny Cullenward. I am a climate economist and lawyer with expertise on market-based climate policies and their connection with greenhouse gas emissions accounting. I am currently a Senior Fellow with the Kleinman Center for Energy Policy at the University of Pennsylvania, a Research Fellow with the Institute for Responsible Carbon Removal at American University, and the Vice Chair of California's Independent Emissions Market Advisory Committee. I hold a JD and PhD from Stanford University. My academic publications, policy commentary, and public writing are available on my personal website.[1]

I have been retained by Conservation Law Foundation ("CLF") to provide comments to the Vermont Public Utility Commission and the Clean Heat Standard Technical Advisory Group ("Technical Advisory Group") on the initial discussions of the Clean Heat Standard design, specifically on the potential role and customization of the spreadsheet modeling tool known as the Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model (hereinafter "GREET" or "the GREET model").[2] My professional involvement with the GREET model dates back over a decade and includes recent commentary on its potential use in connection with uncapped federal tax credits that could lead to tens and possibly hundreds of billions of dollars in fiscal outlays.[3] Please note that my comments are offered in my individual capacity as an expert retained by CLF, and not on behalf of any other organizations with which I am affiliated.

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1 Available at: https://ghgpolicy.org.

2 Argonne National Laboratory, R&D GREET Model, https://greet.anl.gov/. As discussed below, the standard version of the GREET model released by Argonne National Laboratory is now called the "R&D" version to distinguish it from other implementations of the model as used in state and federal policy processes. All references to the "standard" or "R&D" version of the GREET model in these comments refer to the version of the model available at the link in this footnote.

3 Danny Cullenward and David Weiskopf (2013). Science Advocacy and the Legal System: Is Lifecycle Assessment Unconstitutional?, *in* New Trends in Earth-Science Outreach and Engagement (J.L. Drake et al., eds.), https://doi.org/10.1007/978-3-319-01821-8_4 (describing legal advocacy in support of the use of life cycle analysis and the GREET model in California's Low Carbon Fuel Standard); Emily Grubert and Danny Cullenward, The New Hydrogen Rules Risk Opening the Door to Methane Offsets, Heatmap News (Feb. 9, 2024), https://heatmap.news/climate/hydrogen-tax-credit-final-methane-offsets (criticism of the potential for negative carbon intensity scores in GREET to undermine the performance of the hydrogen production tax credit); Electric Power Research Institute, Impact of IRA's 45V Clean Hydrogen Production Tax Credit, https://www.epri.com/research/products/000000003002028407 (projecting potential fiscal outlays of $385-756 billion over the lifetime of the hydrogen production tax credit).

My comments focus on three key points. The first and most important is that the design of market-based policies that involve life cycle analysis requires many normative and highly consequential policy decisions. In my opinion, the Technical Advisory Group should explicitly discuss these options and make informed, calibrated choices, rather than defer to default assumptions in the GREET model. Second, when the GREET model is used in other policy settings it is often customized to reflect bespoke policy objectives and technical context. My third point is that customization is often straightforward — it can be as simple as changing a number in a spreadsheet cell.

At the end of the day, GREET is a decision support tool that can be helpful for applying consistent accounting across a complex policy program. Like any spreadsheet, it can be, and frequently is, easily modified to implement the goals of its users. I recommend that the Public Utility Commission, through the assistance of the Technical Advisory Group and within the allowances of the Affordable Heat Act, identify its policy design objectives and ensure that GREET helps implement those policy design objectives through customization, rather than assume the default instantiation of the GREET model makes the "right" call on questions that have significant policy implications.

As detailed below in Section 2, I also respectfully recommend that the Public Utility Commission and Technical Advisory Group:

- Prohibit fuel pathways from including avoided methane emissions in their carbon intensity calculations. The negative carbon intensity scores that would otherwise result will have distortionary impacts on the Clean Heat Standard and create a range of perverse incentives in the agricultural and energy sectors. (Section 2.1.)

- Review how life cycle accounting choices made in the Clean Heat Standard will affect what emissions get reported in Vermont's greenhouse gas emissions inventory and which credited activities under the Clean Heat Standard will count toward Vermont's greenhouse gas emission reduction requirements. (Section 2.2.)

- Update the default assumptions in the GREET model to incorporate the latest scientific evidence on methane leaks in fossil fuel supply chains, methane leaks in biogenic methane supply chains, and the climate impacts of hydrogen leaks in hydrogen supply chains. (Section 2.3.)

2. The Public Utility Commission and Technical Advisory Group should design the Clean Heat Standard based on Vermont's legal requirements and policy objectives, rather than uncritical deference to default assumptions in the GREET model that could conflict with those requirements and objectives.

Designing the Clean Heat Standard will require significant policy choices that will be reflected in adopted rules and technical assumptions made in the Clean Heat Standard Technical Reference Manual and other decision support tools. I respectfully recommend that the Technical Advisory Group and Public Utility Commission explicitly discuss these issues and make informed decisions based on Vermont's laws and policy objectives, rather than uncritically rely on default assumptions in the standard GREET model that were not created with Vermont's laws and goals in mind.

As explained below, several of the default model parameters make strong assumptions that will have significant policy consequences, notably the application of negative carbon intensity scores assigned to certain fuels as well as the exclusion of a potentially large amount of biogenic greenhouse gas emissions from the model's results. These issues raise important policy questions that will have bearing on Vermont's ability to meet its statutory requirements for greenhouse gas emission reductions. Finally, there are some aspects of the standard GREET model that are inconsistent with the best available science — a gap that helps emphasize why model users should make deliberate choices about how to use the model, rather than treat it as a crystal ball.

Because reliance on the default assumptions in the GREET model could lead to undesirable policy consequences that may be inconsistent with the state's long-term greenhouse gas emissions reduction requirements and because there is no reason to assume that these default assumptions were selected with the objectives of Vermont's program in mind, I respectfully recommend that the Technical Advisory Group and Public Utility Commission explicitly evaluate the choices they want to make with any use of the GREET model or similar decision support tools.

2.1. Some default assumptions in the standard GREET model make consequential and debatable policy choices, notably the assumption that certain "renewable natural gas" pathways should be assigned negative carbon intensity scores.

One of the more controversial questions involving the GREET model is whether certain fuel pathways should be able to claim credit for causing a third party to reduce or avoid greenhouse gas pollution, notably methane. This practice is effectively a form of offsetting. It is widespread in California's Low Carbon Fuel Standard, which relies on a bespoke version of GREET that, like the standard

version of GREET, includes avoided methane emissions in the carbon intensity score assigned to the production of renewable natural gas.

These fuels are assigned a negative carbon intensity score because they include the calculated effects of avoiding methane emissions that purportedly would have been vented to the atmosphere, such as from the anaerobic decomposition of uncontrolled animal manure from confined animal feedlots. Because methane is a potent greenhouse gas that has about 30 times the warming impact of carbon dioxide over its first 100 years, capturing even a small quantity of methane can lead to GREET assigning a fuel a negative carbon intensity[4] — indicating that the model deems the calculated benefit of capturing and avoiding methane emissions as more consequential than the carbon dioxide emissions from its combustion.[5]

Several lines of evidence indicate that assigning a negative carbon intensity to fuel pathways can lead to perverse incentives and distortionary outcomes. For one thing, when a fuel pathway is assigned a negative carbon intensity score, it becomes much more economically valuable than other decarbonization strategies; in a market-based policy setting, these negative numbers inevitably crowd out other climate strategies. For example, in California's Low Carbon Fuel Standard, negative carbon intensity scores led renewable natural gas to earn 17% of the low-carbon credits issued in the first three quarters of 2023, despite only contributing 1% to the state's transportation fuel supply.[6] The disconnect reflects two factors: first, that many renewable natural gas projects are located outside the state and do not deliver fuel that is used inside the state, and second, that the negative carbon intensity scores lead to renewable natural gas receiving more credits per unit of useful energy than other low-carbon fuels. When California market prices are high, dairy digesters can earn more than double the cost of operating their facilities, creating the potential for windfall

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4 Grubert and Cullenward (2024), *supra* note 3.

5 Technically, the full lifecycle emissions calculation includes avoided methane emissions as well as incurred methane emissions associated with the production and transportation of renewable natural gas to its end-user. When GREET assigns a negative carbon intensity score to a pathway involving avoided methane emissions, this negative number indicates that the calculated benefit of the avoided methane emissions, net of gross emissions incurred, is deemed to be more consequential than the carbon dioxide emissions produced by the fuel's combustion.

6 Jeremy Martin, Something Stinks: California Must End Manure Biomethane Accounting Gimmicks in its Low Carbon Fuel Standard, Union of Concerned Scientists (Feb. 15, 2024), https://blog.ucsusa.org/jeremy-martin/something-stinks-california-must-end-manure-biomethane-accounting-gimmicks-in-its-low-carbon-fuel-standard/.

profits and, unfortunately, the incentive to expand methane production to earn more money from capturing it.[7]

Pipeline-quality methane produced from anthropogenic sources, like dairy manure ponds or landfills, can contribute to lower emissions relative to fossil fuel alternatives, but even in these contexts it is important to properly account for methane leakage. Unfortunately, academic studies suggest that these emissions can be even higher than methane emissions from fossil fuel systems[8] — which GREET likely undercounts already, as explained below in Section 2.3. (Furthermore, it is well established in the scientific literature that justifying ongoing carbon dioxide emissions based on methane emission reductions necessarily increases global warming because methane is a short-lived greenhouse gas and carbon dioxide has effectively permanent consequences.[9])

The distortionary effects of negative carbon intensity scores have an even broader reach.[10] Because only some kinds of intensive animal agriculture practices are amenable to the anaerobic digester capture technologies used to generate renewable natural gas from animal manure, the incentives from California's Low Carbon Fuel Standard appear to be encouraging consolidation of large-scale dairy production and contributing to economic pressures on smaller farms that use practices that have lower environmental impacts, but are unsuitable for large-scale manure collection.[11]

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7 Emily Grubert (2020). At scale, renewable natural gas systems could be climate intensive: the influence of methane feedstock and leakage rates, *Environmental Research Letters* 15(8), 084041, https://doi.org/10.1088/1748-9326/ab9335; Aaron Smith, Cow Poop is Now a Big Part of California Fuel Policy, Energy Institute at Haas, University of California, Berkeley (Jan. 22, 2024), https://energyathaas.wordpress.com/2024/01/22/cow-poop-is-now-a-big-part-of-california-fuel-policy/.

8 Semra Bakkaloglu et al. (2022). Methane emissions along biomethane and biogas supply chains are underestimated, *One Earth* 5(6), 724-736, https://doi.org/10.1016/j.oneear.2022.05.012.

9 Raymond T. Pierrehumbert (2014). Short-Lived Climate Pollution, *Annual Review of Earth and Planetary Sciences* 42(1), 341-379, https://doi.org/10.1146/annurev-earth-060313-054843; *id*. at 373 ("*any* amount of substitution of [methane] abatement for [carbon dioxide] abatement results in a situation in which a temporary and modest reduction in near-term temperature is bought at the expense of a permanent increase in the long-term temperature") (emphasis in original).

10 For context on how extensively California's policy incentives are affecting the U.S. dairy industry, *see* Phred Dvorak, California's Green-Energy Subsidies Spur a Gold Rush in Cow Manure, *The Wall Street Journal* (Feb. 19, 2022), https://www.wsj.com/articles/californias-green-energy-subsidies-spur-a-gold-rush-in-cow-manure-11645279200.

11 Ruthie Lazenby (2024). Mitigating Emissions from California's Dairies: Considering the Role of Anaerobic Digesters, UCLA School of Law, Emmett Institute on Climate Change & the Environment, https://law.ucla.edu/news/mitigating-emissions-californias-dairies-considering-role-anaerobic-digesters; Martin (2024), *supra* note 6; Smith (2024), *supra* note 7.

Meanwhile, even though biomethane captured from dairies has the same direct combustion and greenhouse gas emissions as methane captured from landfills, only agricultural sources receive negative carbon intensity scores because landfills are typically required to capture and flare methane. Thus, while putting biomethane captured from landfills to productive use can help reduce emissions, it is disfavored relative to a fuel that produces the same emissions byproducts solely because of the preferential regulatory treatment of agricultural emissions. Worse yet, including avoided methane emissions in a fuel pathway's carbon intensity score creates a dedicated constituency to oppose any future regulatory efforts, as projects that include avoided methane emissions in their carbon intensity scores would no long be able to do so if avoiding their methane emissions were ever required by law. Thus, paying for methane reductions in unregulated sectors through valuable credits creates a direct incentive to lobby against future environmental regulation that would even the playing field between sources of biogenic methane.[12]

Fundamentally, it is a policy choice to let some fuel production pathways use what are effectively methane offsets to outcompete other low-carbon fuels. It is also a policy choice to prohibit those outcomes and calculate the carbon intensity of fuels like renewable natural gas not on the basis of what emissions a dairy purportedly avoids, but what happens when these fuels are combusted in Vermont in place of higher-emitting fossil fuels. I respectfully suggest that policymakers discuss their options and come to a decision about the right way to proceed, rather than defer to an opaque but highly consequential assumption in a spreadsheet model adopted in another jurisdiction for another purpose.

For the reasons above, I respectfully recommend that the Clean Heat Standard prohibit fuel pathways from including avoided methane emissions in their carbon intensity calculations. The negative carbon intensity scores that would otherwise result will have distortionary impacts on the Clean Heat Standard and create a range of perverse incentives in the agricultural and energy sectors. The negative carbon intensity scores these calculations would otherwise produce will have distortionary impacts on the Clean Heat Standard and create a range of perverse incentives in the agricultural and energy sectors.

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[12] Barbara Haya et al. (2020). Managing uncertainty in carbon offsets: insights from California's standardized approach, *Climate Policy* 20(9), 1112-26, at 1118-21, https://doi.org/10.1080/14693062.2020.1781035.

2.2. Relying on default assumptions in the standard GREET model could "disappear" biogenic greenhouse gas emissions that should be included in policy deliberations to ensure consistency with Vermont's greenhouse gas emission reduction requirements.

One of the most challenging issues in greenhouse gas emissions accounting is how to deal with biogenic emissions, particularly biogenic emissions of carbon dioxide. Many greenhouse gas emissions inventory systems exclude biogenic carbon dioxide emissions by accounting convention. The typical reasoning for excluding biogenic carbon dioxide emissions from inventory accounts is that the carbon found in plant tissue was originally sequestered from the atmosphere, implying that there is a one-for-one equivalence between the carbon dioxide that plants remove from the atmosphere and the emissions that arise when biomass decomposes or is combusted or otherwise emitted in an energy system. However, researchers have long understood that these assumptions are scientifically inaccurate oversimplifications of much more complex and context-dependent systems.[13]

This complexity is magnified when, as is the case in Vermont, a policy instrument uses life cycle methods but the overall state climate policy framework is based on territorial emissions accounting conventions. In a life cycle analysis framework, greenhouse gas emissions, emission reductions, and atmospheric removals are included no matter their location; in contrast, most governments only track emissions, reductions, and removals in their territorial jurisdiction. These differences can lead to significant inconsistencies. Suppose a biomass resource is grown, processed, and combusted all in the state of Vermont. In that case, there will be no difference between what is reported under a territorial accounting convention and what a life cycle analysis would show. But if the biomass resource is grown or collected outside of Vermont and used in the state, then there is a potentially significant disconnect between geography-agnostic life cycle analysis and the territorial emissions accounting used by states like Vermont to track their progress toward climate goals and greenhouse gas emissions reduction requirements. In that case, the carbon dioxide sequestration would be located outside the state, while the carbon dioxide emissions from combusting biogenic fuels would occur in Vermont.

Vermont's statutory framework illustrates why it is important to carefully account for the location of life cycle emissions. The state's greenhouse gas emission reduction requirements are based on the sum of in-state emissions and

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[13] Timothy D. Searchinger et al. (2009). Fixing a Critical Climate Accounting Error, *Science* 326, 527-528, https://doi.org/10.1126/science.1178797.

"emissions outside the boundaries of the State that are caused by the use of energy in Vermont."[14] This indicates that Vermont's emission reduction requirements include territorial emissions as well as so-called "upstream" emissions that occur outside the state due to in-state fuel consumption. But because the Clean Heat Standard relies on life cycle assessment calculations,[15] there is a potential for conflicts between the accounting conventions used in Vermont's greenhouse gas emissions inventory and decisions made in the Clean Heat Standard.

Because of the potential for conflict between life cycle analysis and territorial greenhouse gas emissions inventories, it is important to carefully consider how the design of a life cycle policy mechanism interacts with the state's emissions inventory. I was heartened to see the proposed analytical methodology from the consultancy NV5, which indicated it would report emissions from low-carbon fuels across three different methodological approaches:

- A territorial emissions accounting approach ("IPCC-style");
- A life cycle analysis approach that (a) excludes biogenic carbon dioxide emissions and (b) excludes avoided counterfactual credits for animal waste, renewable natural gas, and other applications; and
- A life cycle analysis approach that (a) includes biogenic carbon dioxide emissions and (b) includes avoided counterfactual credits for animal waste, renewable natural gas, and other applications.[16]

Reporting results across these three approaches will help the Public Utility Commission and Technical Advisory Group to understand the implications of key policy design decisions. To provide a complete assessment, I recommend adding three more options:

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[14] 10 V.S.A. § 578(a); *see also id.* at § 582(a) (requiring the Secretary of Natural Resources to "include a supplemental accounting" in the state's greenhouse gas inventory "that measures the upstream and lifecycle greenhouse gas emissions of liquid, gaseous, solid geologic and biogenic fuels combusted in Vermont").

[15] 30 V.S.A. § 8123(1) (defining "carbon intensity value" in terms of life cycle greenhouse gas emissions); *id*. at § 8127(g) (obligating the Public Utility Commission to establish life cycle greenhouse gas emissions for each fuel pathway); *id*. at § 8128(a)(1) (obligating the Public Utility Commission to establish obligated parties' annual compliance requirements based on life cycle greenhouse gas emissions).

[16] Clean Heat Standard Technical Advisory Group Agenda (March 7, 2024), NV5 slide 8, https://puc.vermont.gov/sites/psbnew/files/documents/UPDATED%203.6%20Combined%20Materials.pdf#page=16.

- A territorial emissions accounting approach that includes biogenic carbon dioxide emissions.
- A life cycle analysis approach that (a) excludes biogenic carbon dioxide emissions and (b) includes avoided counterfactual credits for animal waste, renewable natural gas, and other applications.
- A life cycle analysis approach that (a) includes biogenic carbon dioxide emissions and (b) excludes avoided counterfactual credits for animal waste, renewable natural gas, and other applications.

Including multiple frameworks for reporting metrics is important to show the interaction between key policy design choices. There are three key questions for the life cycle analysis methods: (a) whether to include biogenic carbon dioxide emissions; (b) whether to include avoided methane emissions; and (c) if avoided methane emissions are included, whether to limit that treatment to in-state sources only or allow it for all projects. To illustrate all combinations of those three choices, six sets of results are needed (see Table 1).

Table 1: Summary of accounting framework options

Approach	**Method**	**Biogenic CO_2**	**Avoided Emissions**
1	Territorial	Excluded	Included in-state Excluded outside
2 (new)	Territorial	Included	Included in-state Excluded outside
3	Life cycle analysis	Excluded	Excluded
4	Life cycle analysis	Included	Included
5 (new)	Life cycle analysis	Excluded	Included
6 (new)	Life cycle analysis	Included	Excluded

While these accounting choices might seem obscure, they are actually highly consequential. When a climate policy encourages substantial new biomass resources, the effects on reported emissions can be highly distortionary depending on what emissions are included or excluded in the jurisdictions' official accounting. For example, California's Low Carbon Fuel Standard has primarily encouraged the expansion of various biofuels — such as ethanol,

renewable diesel, and renewable natural gas — with biofuels receiving more than 80% of valuable low-carbon credits from the program's inception through 2022.[17] Although the California climate regulator calculates that biofuels like ethanol reduce emissions by about 40% relative to conventional gasoline, the statewide greenhouse gas inventory excludes the biogenic carbon dioxide emissions associated with combusting ethanol and therefore reports ethanol use as a 100% reduction in emissions — an exaggeration by a factor of 2.5 relative to the regulator's own life cycle results.[18] The exclusion of biogenic carbon dioxide emissions from California's major climate policies has led to a substantial reduction in reported, "included," emissions and almost a doubling of unreported, "excluded," emissions from about 25 to about 48 million tons of carbon-dioxide-equivalent[19] — essentially disappearing tens of millions of tons of carbon dioxide emissions off the state's books.

To summarize, the Public Utility Commission and Technical Advisory Group will need to consider several important and overlapping questions. Because answers to these questions depend on one another, it is necessary to report the consultants' analytical results across the six combinations in Table 1.

- What quantity of biogenic carbon dioxide emissions would be excluded (such that they "disappear") from Vermont's greenhouse gas emissions inventory, despite the fact that they contribute to climate change? (Compare options 1 and 2 or 3 and 4)

- Should avoided methane emissions be included in the calculation of life cycle emissions of fuels credited under the Clean Heat Standard? (Compare options 3 and 5 or 4 and 6)

- If methane emissions are included in the calculation of life cycle emissions of fuels credited under the Clean Heat Standard, should they be limited to in-state projects only? If not, what fraction of the credited climate benefits would count toward Vermont's greenhouse gas emission reduction requirements and what fraction would be paid for by Vermonters but accrue

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17 California Air Resources Board, LCFS Data Dashboard at Figure 2, https://ww2.arb.ca.gov/resources/documents/lcfs-data-dashboard.

18 California Independent Emissions Market Advisory Committee, 2023 Annual Report at 8, https://calepa.ca.gov/2023-iemac-annual-report/.

19 California Air Resources Board, California Greenhouse Gas Inventory for 2000-2021 — by IPCC category (Dec. 13, 2023) (reporting 2000 and 2021 biogenic carbon dioxide emissions of 24.8 and 47.7 million tons, respectively), https://ww2.arb.ca.gov/sites/default/files/2023-12/ghg_inventory_ipcc_sum_2000-21.pdf.

to out-of-state parties?
(Compare options 1 and 5 or 2 and 4)

Increasingly, scholars are documenting how the decisions over which emissions to include or exclude from climate policy analysis is becoming increasingly political and arbitrary,[20] which is why I was glad to see NV5 propose to report results across a set of accounting frameworks that will allow the Technical Advisory Group and Public Utility Commission to explore the consequences of their decisions. Showing the implications of carbon accounting choices across a fuller set of options would be a critical step forward, and one that a consultant can easily perform with a simple spreadsheet calculation.

2.3. Some default assumptions in the standard GREET model are inconsistent with the best available scientific evidence.

Finally, it is worth observing that several important assumptions in the standard R&D version of the GREET model are not consistent with the best available scientific evidence.

For example, GREET does not adequately account for methane emissions from natural gas systems. It has been widely documented in the scientific literature that the U.S. Environmental Protection Agency's ("EPA") official greenhouse gas emissions inventory undercounts methane emissions from oil and gas production.[21] The 2023 version of the R&D GREET model makes several assumptions that increase the methane emissions GREET assumes, resulting in an increase of about 35–38% more emissions than what EPA assumes.[22] In contrast, a high-profile study published earlier this year in *Nature* found that methane emissions detected via satellite data were about three times higher than what EPA reports[23] — a substantially larger number than what the 2023 R&D GREET model assumes. (Unfortunately, methane leakage from renewable natural gas supply chains may be even higher.[24])

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20 *See*, *e.g.*, Leehi Yona, Emissions Omissions: Greenhouse Gas Accounting Gaps, SSRN (Dec. 1, 2023), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4436504.

21 *See*, *e.g.*, Ramón A. Alvarez et al. (2018). Assessment of methane emissions from the U.S. oil and gas supply chain, *Science* 361, 186-188, https://doi.org/10.1126/science.aar7204.

22 *See* Table 4 in Andrew Burnham, Updated Natural Gas Pathways in GREET 2023, Argonne National Laboratory, https://greet.anl.gov/publication-update_ng_2023.

23 Evan D. Sherwin et al. (2024). US oil and gas system emissions from nearly one million aerial site measurements, *Nature* 627, 328-334, https://doi.org/10.1038/s41586-024-07117-5.

24 Bakkalogu et al. (2022), *supra* note 8.

Similarly, when it comes to hydrogen production and use, GREET does not account for the fact that hydrogen itself is an indirect greenhouse gas that contributes to global warming by inhibiting the destruction of methane, a potent greenhouse gas that is responsible for almost half of observed warming to date.[25] Just as methane leaks in its supply chains, so too should we expect hydrogen to leak as well. Because it does not include hydrogen emissions, GREET undercounts the total climate impacts of hydrogen-related pathways.[26]

My point in raising these issues is not to focus critical attention on the Argonne National Laboratory team. After all, their work is being used far more widely than I expect anyone thought likely when they first developed these spreadsheet tools, and some of the latest scientific findings emerged since their most recent model update. Rather, my goal is to document that the 2023 version of the standard R&D GREET model has objective shortcomings relative to the best available science. That gap indicates that policymakers can and should customize the standard GREET model with different assumptions as warranted by scientific evidence, or where legal requirements or policy objectives counsel a different outcome. It also illustrates that calls to rely on the GREET model as an objective measure of truth in all applications are overbroad.

To account for these issues, I recommend that the Public Utility Commission and Technical Advisory Group consider updating the GREET model's default assumptions to reflect the latest scientific evidence on:

- Methane leaks in fossil fuel supply chains;
- Methane leaks in biogenic methane supply chains, including whether these leaks are likely to be similar to or different than methane emissions from fossil fuel supply chains; and
- The climate impacts of hydrogen leaks in hydrogen supply chains.

3. Customizing the GREET model is common in policy settings.

The GREET model is widely used in different policy settings, where it is frequently customized to meet the specific policy objectives and technical needs. As the U.S.

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25 Ilissa B. Ocko and Steven P. Hamburg (2022). Climate consequences of hydrogen emissions, *Atmospheric Chemistry and Physics* 22(14), 9349-9368, https://doi.org/10.5194/acp-22-9349-2022.

26 Tianyi Sun et al. (2024). Climate Impacts of Hydrogen and Methane Emissions Can Considerably Reduce the Climate Benefits across Key Hydrogen Use Cases and Time Scales. *Environmental Science & Technology* 58, 5299-5309, https://doi.org/10.1021/acs.est.3c09030.

Department of Energy notes on a website that lists many of the prominent versions of the GREET model in use in state, federal, and international policy:

> "GREET models are developed for specific use cases. Users are responsible for ensuring they have selected the correct model for their intended purpose. For instance, annual releases of R&D GREET are comprehensive in order to inform the life cycle analysis technical community and elicit stakeholder feedback. R&D GREET may not be the version of GREET adopted in independent regulatory programs (e.g., tax credits). Stakeholders seeking a GREET model for purposes of compliance with a given regulatory program should review guidance specific to that program to ascertain the appropriate version of GREET to use."[27]

The standard, or "R&D," version of GREET is published by Argonne National Laboratory and updated on an approximately annual basis. The current version is the 2023 R&D GREET model.[28]

Customized versions of the model have been developed for a variety of policy applications. For example, the U.S. Department of Energy and other federal government entities are developing a bespoke version of the model for use under the Treasury Department's implementation of Section 40B tax credits for sustainable aviation fuels ("40BSAF-GREET")[29] and have developed a bespoke version of the model for use under the Treasury Department's implementation of Section 45V tax credits for hydrogen production ("45VH2-GREET").[30] Similarly, the California Air Resources Board has developed its own implementation of the GREET model for use under its Low Carbon Fuel Standard program for transportation fuels ("CA-GREET3.0") and is in the process of updating its model in an active regulatory process ("CA-GREET4.0").[31] Finally, the International Civil Aviation Organization has adopted a bespoke version of the model for use under its Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) program ("ICAO-GREET").[32]

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27 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, GREET, https://www.energy.gov/eere/greet.

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

29 Internal Revenue Service, Notice 2024-6, Sustainable Aviation Fuel Credit; Lifecycle Greenhouse Gas Emissions Reduction Percentage and Certification of Sustainability Requirements Related to the Clean Air Act; Safe Harbors, https://www.irs.gov/pub/irs-drop/n-24-06.pdf.

30 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, GREET, 45VH2-GREET, https://www.energy.gov/eere/greet.

31 California Air Resources Board, LCFS Life Cycle Analysis Models and Documentation, https://ww2.arb.ca.gov/resources/documents/lcfs-life-cycle-analysis-models-and-documentation.

32 Argonne National Laboratories, ICAO-GREET Model, https://greet.anl.gov/greet_icao.

The Public Utility Commission and Technical Advisory Group should follow the lead of other policymakers in adapting any use of the GREET model under the Clean Heat Standard according to Vermont's legal requirements and policy goals. Vermont law requires the Commission to establish life cycle emissions rates for heating fuels based on "transparent, verifiable, and accurate emissions accounting *adapting* the Argonne National Laboratory GREET Model, Intergovernmental Panel on Climate Change (IPCC) modeling, or an alternative of comparable rigor to fit the Vermont thermal sector context, and the requirements of [Vermont's 2030 and 2050 greenhouse gas emission reduction requirements]."[33] Because Vermont's 2030 and 2050 greenhouse gas emission reduction requirements are measured based on the state's official greenhouse gas inventory,[34] it may be necessary to "adapt[]" the use of the GREET model (as contemplated by the Affordable Heat Act's instructions[35]) to avoid potential conflicts with the greenhouse gas emissions inventory, as discussed above in Section 2. Furthermore, to the extent that any adaptions or extensions of the standard GREET modeling framework are required for consistency with Vermont law, the Affordable Heat Act authorizes the Commission to use "alternative" modeling to that end.[36]

4. Customizing the GREET model can be simple.

Although some of the custom versions of GREET require extensive modifications — for example, to include brand new "pathways" for fuels that are not already part of the underlying R&D GREET model — many customization options are straightforward.

For example, the Minnesota Public Utilities Commission ordered the use of the GREET model in its implementation of the state's Natural Gas Innovation Act.[37] Although the Commission's Order requires the use of the latest R&D version of the GREET model that is available, it also authorizes utilities to customize the assumptions and/or inputs used in that model according to direction and with oversight from the Commission.[38]

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33 30 V.S.A. § 8127(g)(1) (emphasis added) (citing Vermont's 2030 and 2050 greenhouse gas reduction requirements in 10 V.S.A. §§ 578(a)(2), (3)).

34 10 V.S.A. § 578(a) (citing the greenhouse gas emissions inventory in 10 V.S.A. § 582).

35 30 V.S.A. § 8127(g)(1).

36 *Id*.

37 Minnesota Public Utilities Commission, Order Establishing Frameworks for Implementing Minnesota's Natural Gas Innovation Act, Docket No. G-999/CI-21-566, Document 20226-186267-01 (June 1, 2022).

38 *Id*. at 17, Order ¶ 4 (authorizing utilities to submit utility-specific methane leakage data in place of default assumptions, when "reliable data become available"); *id*. at 17, Order ¶ 7 (authorizing utilities to submit facility-specific electricity consumption data in place of default assumptions, "for approval on a case-by-case basis"); *id*. at 18, Order ¶ 16 (requiring utilities to use new default assumptions for calculating the greenhouse gas emissions associated with electricity consumption and authorizing utilities to develop additional utility-specific customizations, subject to "review and approval" by the utility regulator).

These changes are straightforward, as they only require the model user to enter different numbers in place of default assumptions in the spreadsheet model. Furthermore, as the Minnesota order makes clear, specific technical decisions about how to use or change default assumptions in the R&D version of the GREET model can be delegated to a program's Technical Reference Manual, which can provide additional instructions about when flexibility is allowed and under what conditions.[39]

As the Minnesota proceeding helpfully illustrates, a utility commission can order parties to use or modify default GREET assumptions without engaging in resource- or time-intensive efforts to build new model elements. Here, the Vermont Public Utility Commission, with the assistance of the Technical Advisory Group, should modify default GREET assumptions in ways that are consistent with Vermont law and policy goals and, as applicable, include in rule, order, or the Technical Reference Manual that those modifications are to be employed consistently in any instances where obligated parties and/or entities that generate credits are permitted to customize other aspects of GREET.

Critically, these changes can be as simple as directing users to change certain assumptions in the model via standardized instructions in the Clean Heat Standard's Technical Reference Manual. For example, the Clean Heat Standard could require that the carbon intensity of renewable natural gas be calculated without including avoided methane emissions, rather than a negative number that primarily reflects avoided methane emissions from a fossil fuel producer or agricultural emitter. Similarly, the Technical Advisory Group might decide that biogenic greenhouse gasses that are excluded from GREET's emissions accounting framework or Vermont's official greenhouse gas inventory should be explicitly accounted for in the design of the Clean Heat Standard, and provide standardized guidance on how to account for these emissions in a technical handbook for program implementation.

It is also straightforward for policymakers to prohibit the use of a certain model pathway that they deem inconsistent with their goals. For example, in the proposed Treasury regulations for implementing the Section 45V hydrogen production tax credit, the initial 45VH2-GREET model was released with only some of the pathways found in the R&D version of GREET included.[40] Again, such a change can be implemented in a bespoke version of the model and/or standardized instructions in a program handbook.

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39 *Id*. at 19, Order ¶ 17 (authorizing utilities to rely on a "Technical Reference Manual or other methods approved by the [Minnesota] Department [of Commerce]").

40 U.S. Department of Energy, Guidelines to Determine Well-to-Gate Greenhouse Gas (GHG) Emissions of Hydrogen Production Pathways using 45VH2-GREET 2023 (Dec. 2023) at 25, https://www.energy.gov/sites/default/files/2023-12/greet-manual_2023-12-20.pdf.

5. Conclusion

Life cycle analysis is an important methodology for considering the suite of impacts associated with different energy technologies and fuels. Because of the complexity of life cycle analysis and greenhouse gas emissions accounting, it can be helpful to standardize assumptions and methodologies using a decision support tool. The GREET model is one of the most common decision support tools used in policy regimes to calculate life cycle greenhouse gas emissions, but it would be a mistake to consider the model's use in these programs a purely technical or even an objective function.

Life cycle analysis models necessarily make a range of assumptions, many of which involve or at least imply highly normative and consequential policy decisions. Several of the most important decisions in the context of Vermont's Clean Heat Standard concern whether to assign negative carbon intensity scores to certain fuel pathways that effectively involve methane offsets, such as renewable natural gas production, as well as how to account for biogenic emissions that contribute to global warming but are frequently excluded from greenhouse gas inventories by abstract accounting conventions. Policymakers have several options for addressing these issues, and in my opinion should not presume that the choices implemented in the standard R&D version of the GREET model resolve matters in ways that are consistent with the statutory framework or with Vermont's long-term greenhouse gas emissions reduction requirements. To improve the decision-making process, I recommend that the Public Utility Commission and Technical Advisory Group engage with these questions explicitly, rather than defer to default assumptions in a spreadsheet modeling tool.

For the reasons explained above in Section 2, I respectfully recommend that the Public Utility Commission and Technical Advisory Group:

- Prohibit fuel pathways from including avoided methane emissions in their carbon intensity calculations. The negative carbon intensity scores that would otherwise result will have distortionary impacts on the Clean Heat Standard and create a range of perverse incentives in the agricultural and energy sectors. (Section 2.1.)

- Review how life cycle accounting choices made in the Clean Heat Standard will affect what emissions get reported in Vermont's greenhouse gas emissions inventory and which credited activities under the Clean Heat Standard will count toward Vermont's greenhouse gas emission reduction requirements. (Section 2.2.)

- Update the default assumptions in the GREET model to incorporate the latest scientific evidence on methane leaks in fossil fuel supply chains, methane leaks in biogenic methane supply chains, and the climate impacts of hydrogen leaks in hydrogen supply chains. (Section 2.3.)

Finally, it is important to emphasize that part of what makes GREET an appealing framework for policymakers at the state, federal, and international levels is the fact that the model can be customized to suit the needs of a particular user or application. Customization is commonplace across many of the policy systems that use GREET, and often is as simple as directing model users to replace default assumptions in a spreadsheet cell. Many such changes can be implemented with minor modifications to the spreadsheet file or via direction in a technical support manual.

Thank you for the opportunity to submit comments.

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