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February 26, 2024

*Via Electronic Submission to the Federal eRulemaking Portal*

Internal Revenue Service
CC:PA:01:PR (REG–117631-23), Room 5203
P.O. Box 7604
Ben Franklin Station
Washington, DC 20044

**Re: REG-117631-23 | Notice of Proposed Rulemaking for the Clean Hydrogen Production Credit (Section 45V)**

To Whom It May Concern:

We write, on behalf of our client Dioxycle, to submit comments in response to the proposed regulations and request for comments published in the Federal Register by the Department of Treasury ("Treasury") and Internal Revenue Service ("IRS") on December 26, 2023, related to the section 45V credit for production of clean hydrogen.[1] We appreciate the work of the staff at Treasury and the IRS to issue these proposed regulations.

Dioxycle is developing a novel carbon monoxide ("CO") electrolyzer technology that can fully capture and utilize waste CO emissions from a variation of the steam-methane reforming of natural gas, the incumbent process to produce hydrogen. By using clean electricity, Dioxycle's electrolyzer transforms the captured CO into value-added chemicals such as ethylene along with producing additional green hydrogen as a co-product.

We appreciate your consideration of the recommendations discussed in the attached letter. If you have any questions, please do not hesitate to contact us at: N. Hunter Johnston, hjohnston@steptoe.com; Lisa M. Zarlenga, lzarlenga@steptoe.com; John E. Cobb, jcobb@steptoe.com; and Nicholas J. Sutter, nsutter@steptoe.com.

Sincerely,

N. Hunter Johnston

[1] Notice of Proposed Rulemaking, *Section 45V Credit for Production of Clean Hydrogen; Section 48(a)(15) Election To Treat Clean Hydrogen Production Facilities as Energy Property*, 88 Fed. Reg. 89,220 (Dec. 26, 2023).

cc: Aviva Aron-Dine, Acting Assistant Secretary (Tax Policy), Department of the Treasury
Shelley de Alth Leonard, Acting Deputy Assistant Secretary, Department of the Treasury
Krishna P. Vallabhaneni, Tax Legislative Counsel, Department of the Treasury
Kimberly A. Wojcik, Attorney-Advisor, Department of the Treasury
Jennifer C. Bernardini, Attorney-Advisor, Department of the Treasury
Daniel I. Werfel, Commissioner, Internal Revenue Service
William M. Paul, Principal Deputy Chief Counsel and Deputy Chief Counsel (Technical), Internal Revenue Service
Holly Porter, Associate Chief Counsel (Passthroughs & Special Industries), Internal Revenue Service
David Turk, Deputy Secretary, Department of Energy

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**Re: REG-117631-23 | Notice of Proposed Rulemaking for the Clean Hydrogen Production Credit (Section 45V)**

To Whom It May Concern:

Dioxycle submits this comment letter with respect to the proposed regulations (the "Proposed Regulations") from the Department of the Treasury and the Internal Revenue Service (collectively "Treasury") on the credit for the production of clean hydrogen under section 45V[1] of the Internal Revenue Code of 1986, as amended.[2]

## I. Executive Summary

Dioxycle generally supports the Proposed Regulations, which will be critical to scaling up the U.S. clean hydrogen industry while ensuring that federal funding in support of clean hydrogen projects will not contribute to significantly increasing overall greenhouse gas ("GHG") emissions. With the Proposed Regulations, the Department of Energy ("DOE") also issued a new Greenhouse gases, Regulated Emissions, and Energy use in Transportation ("GREET") model, the 45VH2-GREET Model, that is tailored for calculating lifecycle GHG emissions for the section 45V credit.[3] We are pleased to see Treasury and DOE use a technology-neutral approach that determines the section 45V credit value based upon a rigorous accounting of well-to-gate GHG emissions under the GREET model. This approach can support a wide range of technology pathways for clean hydrogen production. However, the Proposed Regulations and the accompanying 45VH2-GREET Model fail to account for some of the most innovative emerging technologies.

Dioxycle is developing a novel carbon monoxide ("CO") electrolyzer technology that can fully capture and utilize waste CO emissions from a variation of the steam-methane reforming ("SMR") of natural gas, the incumbent process to produce hydrogen. By using clean electricity, Dioxycle's electrolyzer transforms the captured CO into value-added chemicals such as ethylene along with producing additional green hydrogen as a co-product. By utilizing carbon emission

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[1] Unless otherwise indicated, all section references are to the Internal Revenue Code of 1986, as amended and all references to "Treas. Reg. §" are to the regulations promulgated (or in the case of proposed regulations, proposed) thereunder.

[2] Notice of Proposed Rulemaking, *Section 45V Credit for Production of Clean Hydrogen; Section 48(a)(15) Election To Treat Clean Hydrogen Production Facilities as Energy Property*, 88 Fed. Reg. 89,220 (Dec. 26, 2023).

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

from the SMR process, Dioxycle's innovative technology not only decarbonizes existing SMR hydrogen-production infrastructure but has the unique ability to additionally decarbonize some of the highest-emitting chemical manufacturing sectors.

While the most recent 45VH2-GREET Model includes the SMR + carbon capture and storage ("CCS") pathway, it does not consider the ability to instead valorize waste emissions through various carbon capture and utilization ("CCU") approaches.[4] Dioxycle respectfully requests that Treasury in consultation with the DOE provide functionality in the final regulations, 45VH2-GREET Model, accompanying user interface, and the Guidelines to Determine Well-to-Gate Greenhouse Gas Emissions of Hydrogen Production Pathways using 45VH2-GREET 2023 (the "Guidelines") that (1) reiterate the importance of CO utilization pathways for clean hydrogen production, and (2) do not exclude a taxpayer relying on a novel variation of an approved 45HV2-GREET Model pathway to produce hydrogen from obtaining a provisional emissions rate ("PER") to claim the section 45V credit and provide a timely resolution to determining the well-to-gate emissions rate for the production pathways further described below, whether through an update to the 45HV2-GREET Model or the determination of a PER.

## II. About Dioxycle

Dioxycle develops cost-effective electricity-driven pathways to convert waste carbon emissions into critical everyday feedstocks and chemicals. The core technology is a novel type of electrolyzer that utilizes captured carbon oxides emissions, in particular CO, and transforms them into energy-rich and useful molecules, usually produced from fossil fuels. As a low-temperature, fully electricity-driven process, Dioxycle's solution can be coupled with renewable electricity sources, unlocking pathways to turn carbon emissions into high-value decarbonized chemicals. With an unprecedented energy and cost efficiency outlook, this CO electrolysis technology offers a strategic solution for the decarbonization of the key chemicals, including ethylene. A pioneer in this field, Dioxycle is currently the only company in the marketplace developing an industrially-relevant CO electrolyzer to produce ethylene.

CCS technology continues to face practical implementation hurdles as well as policy and regulatory bottlenecks in the United States. Dioxycle's proprietary technology can serve as a promising alternative to CCS, where the captured carbon can be beneficially utilized for the on-site production of useful carbon-based products and/or where CCS implementation is not feasible. Dioxycle uses CCU technology to process captured CO as a feedstock to co-produce sustainable ethylene as the major product with green hydrogen.

One important use case of Dioxycle's technology is the decarbonization of hydrogen production. Dioxycle's electrolyzer is able to efficiently process CO originating from the SMR process, autothermal reforming ("ATR"), dry methane reforming ("DMR"), partial oxidation reactors ("POX") but also, gasification, or other hydrogen production pathways that produce syngas as an intermediate step (collectively the "Incumbent Pathways"). Through Dioxycle's process, captured CO can be valorized from a typical Incumbent Pathways without resorting to use of a water gas shift ("WGS").

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[4] *See* 88 Fed. Reg. at 89,225.

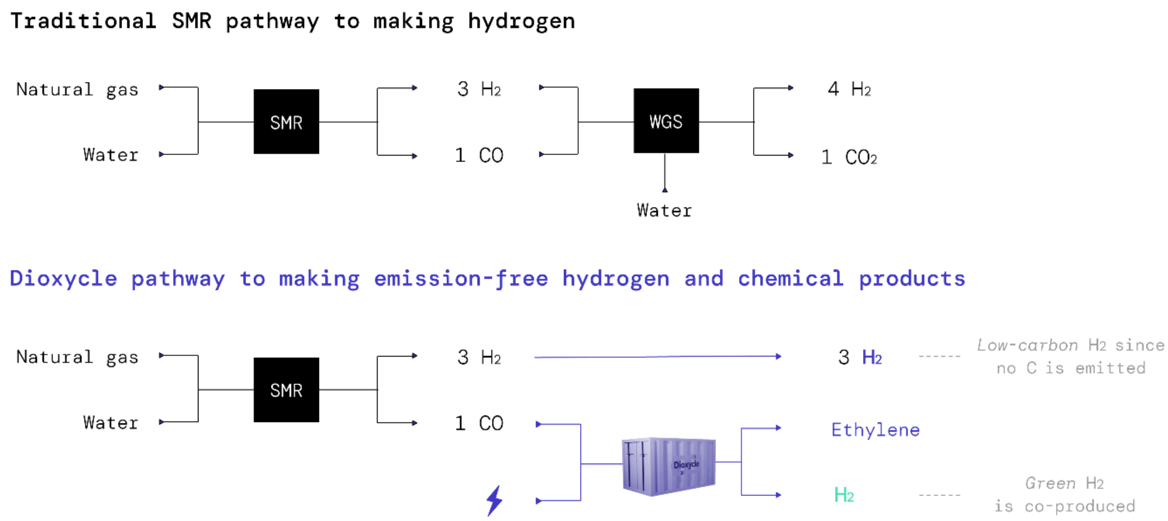


**Figure 1:** Dioxycle pathway to producing emission-free hydrogen and chemicals

All the most prominent Incumbent Pathways function by first producing syngas, which is predominantly a mixture of hydrogen and CO. For example, under the incumbent SMR process, methane reacts with steam in the presence of a catalyst to produce hydrogen, CO, and a relatively small amount of carbon dioxide ("$CO_2$"). In the SMR process, the reaction between 1 methane and 1 water molecule produces 3 di-hydrogen molecules and 1 CO molecule. Subsequently, in a water gas shift reaction, the CO molecule and steam are reacted using a catalyst to produce additional hydrogen while emitting $CO_2$. In the WGS reaction, each CO molecule, combined with a water molecule, produces 1 $CO_2$ molecule and one additional hydrogen molecule. As a result, in the combined SMR + WGS reaction, for each methane molecule, 1 $CO_2$ molecule and 4 hydrogen molecules (plus a small amount of additional impurities) are produced. Blue hydrogen can also be derived through this process if the resulting $CO_2$ molecule is captured and sequestered, but this sequestration process adds additional incompressible costs and drives up the price of blue hydrogen. Geological storage or $CO_2$ transportation network are also not always available limiting the feasibility of CCS in certain geographies.

Dioxycle's technology leverages Incumbent Pathways to produce low-carbon hydrogen in two steps. Dioxycle's technology first enables Incumbent Pathways to produce low-carbon (or 'blue') hydrogen through CCU and then uses the captured CO from the Incumbent Pathways to produce ethylene with green hydrogen as a co-product.

In the first step, the Incumbent Pathways produce hydrogen from a syngas stream. Dioxycle processes the syngas generated from the Incumbent Pathways and separates the CO from the hydrogen. Because the CO is captured and valorized, no WGS reaction is needed, and $CO_2$ is not produced from the CO.

In the second step, after the separation of the hydrogen from the CO in the syngas, the CO is utilized as a feedstock into Dioxycle's proprietary electrolyzer, along with water and electricity, to produce ethylene and hydrogen as a co-product, outside of the well-to-gate system boundaries of the hydrogen produced by the Incumbent Pathways. Dioxycle's electrolyzer uses an electric current to pass through a cell with bipolar plates, one half filled with the valorized CO and the other half filled with water. The electrolyzer draws out the hydrogen molecules from the water to produce green hydrogen and combines other hydrogen molecules with the carbon molecules from the valorized CO to produce decarbonized ethylene and oxygen as co-products.

Ethylene is the world's most used organic chemical and is present in everyday products, from short-life packaging to long-lasting building materials (*i.e.*, textiles and building materials to cars). Ethylene requires carbon as a raw material, as carbon atoms are "embedded", that is incorporated, into the molecule itself – ethylene's chemical formula being $C_2H_4$. The decarbonization of ethylene, therefore, replaces fossil carbon with the captured carbon emissions. In addition, ethylene is typically produced via the cracking of fossil fuels, a high-temperature process generating approximately 0.85 to 1.80 metric tons of $CO_2$ for every metric ton of ethylene produced.[5] In total, ethylene production therefore contributes globally to addition more than 800 million metric tons of carbon dioxide equivalent ("$CO_2e$") annually, with process emissions responsible for 260 million metric tons and the carbon embedded in ethylene molecules that can ultimately be released in the product's end-of-life responsible for 565 million metric tons.[6]

Dioxycle's electrolyzer replaces this highly emissive process while providing a cost-competitive option to decarbonize the SMR process for hydrogen production. On the one hand, it provides a zero-emission route to making ethylene. On the other hand, it provides an alternative for incumbent hydrogen producers to cut their emissions by repurposing them into value-added products.

## III. Background

### A. Carbon Monoxide Produced by Incumbent Pathways as a Co-Product in a Syngas Stream and the Dioxycle Process

Most hydrogen production in the United States currently occurs through the Incumbent Pathways. Under these Incumbent Pathways, syngas, a mixture of predominantly hydrogen and CO is created by reacting natural gas and steam.[7] The high emissions associated with Incumbent Pathways originate from the subsequent WGS step. This step reacts the CO with steam to produce additional hydrogen, but also generates $CO_2$ emissions. Incorporating CCS technology into the Incumbent Pathways can reduce the hydrogen's lifecycle GHG emissions.[8]

In the case of the Dioxycle process, captured and separated CO from the syngas stream produced from the Incumbent Pathways is valorized in the electrolyzer by utilizing it as a raw

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[5] S&P Global Commodity Insights, *Net-zero carbon ethylene production via recovery of $CO_2$ from cracking furnace flue gas* (Jul. 2022) *available at* https://www.spglobal.com/commodityinsights/en/ci/products/net-zero-carbon-ethylene-production.html

[6] *Id*.

[7] Department of Energy, *Hydrogen Production and Distribution available at* https://afdc.energy.gov/fuels/hydrogen_production.html#:~:text=There%20are%20several%20pathways%20to,water%20to%20produce%20additional%20hydrogen.

[8] *Id*.

material to produce ethylene. This electrolysis process is emission-free; it uses only water and low-carbon electricity to produce green hydrogen as a co-product with ethylene. Dioxycle, therefore, leverages existing incumbent infrastructure while also not being subject to limitations in the lack of $CO_2$ pipeline/Class VI well infrastructure for transportation and storage.

B. Carbon Monoxide Utilization and the 45VH2-GREET Model

The 45VH2-GREET Model models only the permanent sequestration of $CO_2$ and does not model other forms of carbon oxide utilization, such as the production of feedstocks for sustainable chemicals. Under the 45VH2-GREET Model, a taxpayer that valorizes CO created during the SMR process in subsequent downstream processes cannot allocate emissions to this valorized co-product for the purposes of determining the hydrogen's lifecycle GHG emissions. Citing an EPA study regarding current practices in petroleum refining, the 45VH2-GREET Model assumes that all CO produced as a co-product is combusted inside the well-to-gate at the point of hydrogen production.[9] The Guidelines state:

> Additionally, to complete the accounting of carbon life cycle, 45VH2-GREET 2023 assumes that any carbon-containing impurities in the gas stream will be eventually converted by the end user(s) to form $CO_2$ emissions, and accounts for these $CO_2$ emissions in the well-to-gate GHG emissions of hydrogen production. (The assumption that carbon containing impurities will be converted to $CO_2$ is based on current practices at industrial facilities that consume hydrogen, such as petroleum refineries and ammonia plants, as well as expected practices at potential future industrial facilities such as iron and steel making plants.)[10]

As a result, the 45VH2-GREET Model and Guidelines appear to assume that almost all CO will be converted to $CO_2$ using the WGS reaction and require the taxpayer to treat any remaining CO co-product as an impurity under the 45VH2-GREET Model that is combusted at the point of hydrogen production inside the well-to-gate. This is an incorrect assumption in a case where the CO, rather than being transformed to $CO_2$ in a WGS reaction, is separated from the syngas stream and valorized to produce ethylene outside of the point of production.

In the context of valorized CO, the above assumptions are inconsistent with the treatment of co-products for the purpose of measuring well-to-gate emissions under GREET models, as is required under section 45V. As noted above, during the hydrogen production process, other commercially useful products—such as steam, oxygen, or nitrogen—may be generated and valorized. The 45VH2-GREET Model accounts for such co-products by allowing users to allocate emissions generated during the hydrogen production process to these co-products. The Guidelines are clear that valorized co-products should be accounted for when measuring lifecycle GHG emissions and state that:

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[9] Department of Energy, *Guidelines to Determine Well-to-Gate Greenhouse Gas (GHG) Emissions of Hydrogen Production Pathways using 45VH2-GREET 2023* (Dec. 2023) at 8 (citing US Environmental Protection Agency. (2015). Chapter 5.1: Petroleum Refining. In: AP 42, Compilation of Air Pollutant Emissions Factors, Volume 1, 5th Edition) *available at* https://www.energy.gov/sites/default/files/2023-12/greet-manual_2023-12-20.pdf.

[10] *Id*. at 8.

> For those co-products that have actually been valorized, 45VH2-GREET 2023 allows for users to account for certain co-products in the well-to-gate GHG emissions of the hydrogen production facility. Users may only account for a co-product if it has been valorized in a process downstream of the hydrogen production facility; co-products that were produced but not valorized may not be allocated emissions in the well-to-gate GHG emissions calculation of produced hydrogen.[11]

The Guidelines further state, in a footnote, that "the allocation of emissions to valorized co-products is standard practice in a well-to-gate life cycle analysis, including in previously published GREET models and related publications."[12]

The 45VH2-GREET Model applies a "system expansion" approach to account for valorized co-products.[13] Despite the Guidelines clearly stating that valorized co-products should be afforded treatment under the system expansion co-product accounting system, the Guidelines only list three co-products for which taxpayers can currently allocate emissions under the model: steam, oxygen, and nitrogen.[14] The preamble to the Proposed Regulations requests comments on the system expansion approach, including if other co-product allocating methods such as the physical allocation approach would better ensure well-to-gate carbon intensity is accurately represented.[15]

C. The 45VH2-GREET Model and Provisional Emissions Rates

The 45VH2-GREET Model limits the model for testing qualified hydrogen's lifecycle GHG emissions to eight pathways.[16] For taxpayers who use a feedstock or other hydrogen production technology that is not a currently recognized pathway under the GREET model, the statute and Proposed Regulations allow the taxpayer to petition the DOE and Treasury to obtain a PER to claim the credit.[17]

Section 45V(c)(2)(C) provides:

> In the case of any hydrogen for which a lifecycle greenhouse gas emissions rate has not been determined for purposes of this section, a taxpayer producing such hydrogen may file a petition with the Secretary for determination of the lifecycle greenhouse gas emissions rate with respect to such hydrogen.

The Proposed Regulations implemented this statutory provision as follows:

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[11] *Id*.

[12] *Id*. at 18 n. 28.

[13] *Id*. at 18; *see also* 88 Fed. Reg. at 89,225.

[14] *Id*.

[15] 88 Fed. Reg. at 89,225.

[16] *Id*.

[17] *See* section 45V(c)(2)(C), Prop Treas. Reg. § 1.45V-4(c).

> Rate not determined—(i) In general. For purposes of section 45V(c)(2)(C), a taxpayer may not file a petition for a PER unless a lifecycle GHG emissions rate has not been determined under the most recent GREET model with respect to hydrogen produced by the taxpayer at a hydrogen production facility. A lifecycle GHG emissions rate has not been determined under the most recent GREET model with respect to hydrogen produced by the taxpayer at a hydrogen production facility if either the feedstock used by such facility or the facility's hydrogen production technology is not included in the most recent GREET model. A facility's hydrogen production pathway is not included in the most recent GREET model if the feedstock used by such facility or the facility's hydrogen production technology is not included in the most recent GREET model.[18]

The current 45VH2-GREET Model provides a pathway for SMR, ATR, and gasification pathways with potential CCS but variations of these pathways with CCU are not included.[19] In addition, low-temperature water electrolysis using electricity is a recognized 45VH2-GREET Model pathway but the electrolysis process using electricity and valorized CO as feedstocks is not included.[20]

## IV. Carbon Monoxide Produced in Syngas with Hydrogen and Subsequently Valorized to Produce Ethylene Should be Properly Accounted for under the 45VH2-GREET Model

CO that is separated from a syngas stream produced as a part of the Incumbent Pathways and is valorized to produce ethylene should be afforded co-product treatment under the 45VH2-GREET Model. Currently, the 45VH2-GREET Model treats the valorized CO as combusted within the well-to-gate even if the valorized CO is utilized in a valued-added co-product such as ethylene and not otherwise emitted as part of the hydrogen production process within the well-to-gate. Such treatment is inconsistent with the statutory requirement to consider well-to-gate emissions.

Dioxycle's technology relies on variations of the Incumbent Pathways that are recognized pathways under the 45VH-2 GREET Model, such as the SMR process of natural gas, but instead of the WGS reaction used in the Incumbent Pathways, Dioxycle relies on a CCU process that separates the syngas created by the SMR process into hydrogen and CO streams and valorizes the captured CO to produce ethylene and green hydrogen as a co-product.

As described in more detail below, Dioxycle requests that Treasury provide functionality in final regulations, 45VH2-GREET Model, accompanying user interface, and Guidelines to ensure that all valorized or productively utilized COs that are not emitted within the well-to-gate scope at the point of production of hydrogen are disregarded or otherwise treated the same as sequestered carbon for purposes of determining lifecycle GHG emissions. Alternatively, final regulations could allow taxpayers to allocate emissions to valorized CO co-products under the 45VH2-GREET Model.

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[18] Prop. Treas. Reg. § 1.45V-4(c).

[19] 88 Fed. Reg. at 89,225.

[20] *Id*.

A. Final Regulations Should Treat Carbon Monoxide Utilization Similarly to Carbon Dioxide Sequestration under the 45VH2-GREET Model, Accompanying User Interface, and the Guidelines

For hydrogen generation from the Incumbent Pathways, CO and $CO_2$ products are essentially interchangeable, with the potential conversion from CO to $CO_2$ during the WGS reaction occurring at the end of the production process.[21] This observation is consistent with the Proposed Regulations' cross-reference to section 45Q, which applies to equipment used in "the capture of carbon oxides" – not just carbon dioxide.[22] Indeed, section 45Q applies to captured CO and is not limited to captured $CO_2$. Moreover, both carbon sequestration in secure geologic storage and carbon utilization are recognized section 45Q credit pathways. The DOE's Clean Hydrogen Production Standard ("CHPS") guidance discusses downstream hydrogen production processes and a footnote explains that "[w]here $CO_2$ utilization is conducted, the $CO_2$ may be treated as a co-product of hydrogen production, and the emissions attributed to the hydrogen may be adjusted accordingly."[23] This CHPS guidance supports the conclusion that carbon oxides should be treated as co-products within the 45VH2-GREET Model, reducing the emissions of the hydrogen production process to the extent the carbon oxides are actually valorized for productive use. With that in mind, the treatment of the Incumbent Pathways under the 45VH2-GREET Model, accompanying user interface, and Guidelines should be revised to take into account the capture of either CO or $CO_2$ and to model both carbon sequestration and carbon utilization pathways.

The preamble to the Proposed Regulations provides that the 45VH2-GREET Model allows users to input the quantity of valorized co-products and allocates emissions to those co-products (rather than to the hydrogen production).[24] The Guidelines add that the 45VH2-GREET Model can be used to model thermal reformation and gasification pathways with and without CCS.[25] However, in a footnote, the Guidelines provide that the 45VH2-GREET Model is only capable of modeling permanent sequestration of $CO_2$, as in Class II or Class VI injection wells.[26] The 45VH2-GREET Model does not model other forms of CO or $CO_2$ utilization (e.g., production of synthetic fuels).[27]

The 45VH2-GREET Model's accompanying user interface relies on the hydrogen producer's data inputs into the model to determine the lifecycle GHG emissions, including the

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[21] National Energy Technology Laboratory, § 6.2.6 Water Gas Shift & Hydrogen Production *available at* https://netl.doe.gov/research/coal/energy-systems/gasification/gasifipedia/water-gas-shift

[22] Prop. Treas. Reg. § 1.45V-1(a)(7)(iv).

[23] Department of Energy, *U.S. Department of Energy Clean Hydrogen Production Standard (CHPS) Guidance* (Jun. 2023) at 3 n.12 *available at* https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/clean-hydrogen-production-standard-guidance.pdf.

[24] 88 Fed. Reg. at 89,225.

[25] Department of Energy, *Guidelines to Determine Well-to-Gate Greenhouse Gas (GHG) Emissions of Hydrogen Production Pathways using 45VH2-GREET 2023* (Dec. 2023) at 11 *available at* https://www.energy.gov/sites/default/files/2023-12/greet-manual_2023-12-20.pdf.

[26] *Id*. at 11 n. 12.

[27] *Id*.

user's sequestered emissions. Treasury should provide functionality in the final regulations, the 45VH2-GREET Model, the accompanying user interface, and Guidelines to allow the user to input both sequestered and utilized emissions. For clarity, to the extent CO is emitted, it would be included in the determination of lifecycle GHG emissions. However, because lifecycle GHG emissions are based on well-to-gate emissions, if COs are valorized or used productively and not emitted through the point of production (e.g., COs used in the production of chemicals or fuels), for purposes of determining lifecycle GHG emissions, such CO should be treated in the same manner as sequestered carbon and not increase the lifecycle GHG emissions rate. Such a result will also encourage taxpayers to reduce their lifecycle GHG emissions rate for hydrogen production by utilizing captured carbon oxides in a valorized product or selling the captured carbon oxides to another taxpayer where such carbon oxides will be utilized in a valorized product.

B. Treasury Should Alternatively Allow Taxpayers to Allocate Emissions to Valorized Syngas Co-Products Using a Physical Allocation Method

If the treatment of carbon utilization is not allowed to be treated similarly to carbon sequestration under the 45VH2-GREET Model, taxpayers should be able to allocate co-products using a physical allocation method.

The Guidelines currently treat all CO as an "impurity" that is combusted within the production process and fail to distinguish between CO converted to $CO_2$ through a WGS and CO that is valorized for the production of sustainable chemicals, such as ethylene. For the reasons described above, this treatment is contrary to the well-to-gate analysis required under section 45V for measuring lifecycle GHG emissions through the point of hydrogen production.[28]

The primary and most expansive version of the GREET model is the iterative "R&D GREET" model, which has been updated regularly since its creation in 1995 by Argonne National Laboratory. Section 45V requires a taxpayer to measure the hydrogen's lifecycle GHG emissions using the GREET model or a "successor" model.[29] When section 45V was enacted in the Inflation Reduction Act ("IRA") in 2022, the most recent publicly available version of the model was R&D GREET 2021. Since then, two more versions of R&D GREET have been released, with the latest release in October 2023.[30] R&D GREET 2023 is intended to be flexible, allowing users to reduce their calculated emissions by accounting for any co-products created during production processes. For taxpayers with mixed streams like syngas, R&D GREET properly allows system allocation of valorized carbon co-products and calculates the emissions rates of integrated processes that valorize carbon oxides in downstream processes. R&D GREET 2022 provided functionality to

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[28] *See* section 45V(c)(1)(B) ("The term 'lifecycle greenhouse gas emissions' shall only include emissions through the point of production (well-to-gate), as determined under the most recent Greenhouse gases, Regulated Emissions, and Energy use in Transportation model (commonly referred to as the "GREET model") developed by Argonne National Laboratory, or a successor model (as determined by the Secretary)") (emphasis added).

[29] *Id*.

[30] *See* U.S. Department of Energy Office of Scientific and Technical Information, *Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model* ® (2023 .Net), *available at* https://www.osti.gov/doecode/biblio/113208

treat co-products such as CO under the system allocation approach, including mass or energy allocation methods.

Consistent with the approach described in the preamble to the Proposed Regulations, each valorized co-product in the hydrogen production process should have emissions allocated to such co-products and be afforded system-allocation treatment on a consistent basis. The preamble provides that all valorized co-products will have emissions allocated to such co-products "if possible."[31] However, the amount of steam co-product that reformers can claim is restricted because, as explained in the preamble, it avoids improper incentives that could arise from the inefficient overproduction of co-products like steam. Nonetheless, no such issue arises with respect to the treatment of mixed stream co-products.[32]

The preamble to the Proposed Regulations specifically requests comments on whether alternative co-product accounting methods, "such as physical allocation (for example, energy allocation or mass allocation) or allocation based on other characteristics, would better ensure well-to-gate carbon intensity of hydrogen production is accurately represented."[33] Dioxycle recommends physical allocation accounting of carbon co-products because the system expansion method utilized in the 45VH2-GREET Model for co-products creates unnecessary uncertainty in the case of syngas where the comparison system for reference is not easily identifiable. Valorized and productively used carbon oxides may be treated as co-products of hydrogen production, and both R&D GREET and independent third-party consultants are able to allocate emissions to the co-products consistent with the system allocation approach that the preamble to the Proposed Regulations state is used in the 45VH2-GREET Model. Accordingly, it is indeed "possible" to allocate emissions to co-products other than steam, oxygen, and nitrogen in the clean hydrogen production process – in this case carbon oxides – and the final regulations and Table 4 of the Guidelines should reflect that approach with physical system allocation on either a mass, energy, or economic allocation basis.

Allowing taxpayers to allocate emissions to hydrogen co-products is a critical issue for developing sustainable chemicals due to the array of products produced during the hydrogen production process, including CO used to produce sustainable ethylene. Co-production allows for the development of different types of feedstocks at different points in the production process that would otherwise have no productive value. Co-production drives both economic and environmental efficiencies by maximizing the use of energy-intensive operations, minimizing process emissions and waste, and conserving feedstocks. The section 45V credit and accompanying 45VH2-GREET Model should avoid discouraging co-product development by allowing taxpayers to calculate their lifecycle GHG emissions at a level appropriate for each product produced during the hydrogen production process.

Recognizing the production of a co-product as valorized outside the well-to-gate is key to the decarbonization of ethylene, the production of which, as noted above, is one of the most carbon-intensive processes within the chemicals industry.

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[31] 88 Fed. Reg. at 89,225.

[32] *Id.*

[33] *Id*.

## V. Final Regulations Should Clarify that Taxpayers Utilizing CO Produced in a Syngas Stream That is Not an Established Pathway Can Obtain a Provisional Emissions Rate

If the final regulations do not account for CO co-product utilization or CO co-product allocation under the 45VH-2 GREET Model, Dioxycle requests that Treasury clarify in the final regulations that taxpayers producing hydrogen through novel variations of the Incumbent Pathways are not excluded from the statutory PER petition process even if the generic Incumbent Pathways' technology and feedstock are already covered under the existing GREET model.

Section 45V(c)(2)(C) allows taxpayers who do not produce hydrogen under a pathway recognized under the 45VH2-GREET Model to petition the DOE and Treasury for a PER determination to use to claim the section 45V tax credit. This statutory provision broadly applies to "any hydrogen for which a lifecycle greenhouse gas emissions rate has not been determined."[34] This statutory language implies that a taxpayer should always have some mechanism for determining the lifecycle GHG emissions rate of hydrogen that they have produced, either because the lifecycle GHG emissions rate is already included within the GREET model's approved pathways or because the taxpayer has a right to petition the government to obtain a PER. To the extent that the Proposed Regulations are meant to restrict a taxpayer's right to petition for a PER in circumstances where a lifecycle GHG emissions rate cannot already be determined under the 45VH2-GREET Model, they appear to be inconsistent with the statutory language of section 45V(c)(2)(C).

The Proposed Regulations provide that a lifecycle GHG emissions rate has not been determined under the most recent GREET model if the taxpayer's production method uses a hydrogen production pathway that is not included in the most recent GREET model—that is, "if either the feedstock used by such facility or the facility's hydrogen production technology is not included in the most recent GREET model."[35] On their face, it seems that the Proposed Regulations could create a situation where taxpayers are unable to determine a lifecycle GHG emissions rate under the most recent GREET model and yet are also unable to obtain a PER. For example, a taxpayer may not be able to obtain a PER if the reason that the lifecycle GHG emissions rate cannot be determined is deemed to not be attributable to the failure of the model to include the feedstock or production pathway.

As noted above, the SMR of natural gas with CCS and low-temperature water electrolysis using electricity are approved pathways under the 45VH2-GREET Model. However, Dioxycle's technology relies on variations of these pathways to produce hydrogen, ethylene, and other co-products.

To avoid potential uncertainty, the final regulations should clarify that taxpayers will not be excluded from obtaining a PER to claim the section 45V credit for: (a) hydrogen produced from a variation of the SMR, ATR, or other incumbent pathways where valorized CO separated from syngas is utilized to produce ethylene rather than converted to $CO_2$ using a WGS reaction; and (b)

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[34] Section 45V(c)(2)(C).

[35] Prop Treas. Reg. § 1.45V-4(c)(2)(i).

hydrogen produced from a variation of the low-temperature water electrolysis pathway where the hydrogen is produced as a co-product to ethylene produced from an electrolyzer that uses valorized CO, water, and electricity.

## VI. Conclusion

For the reasons discussed above, we believe that final regulations should modify the 45VH2-GREET Model to properly account for CO utilization or should at least permit taxpayers utilizing variations of the Incumbent Pathways that utilize valorized CO to obtain a PER under the statutory petition process.

We appreciate your consideration of these comments. If you have any questions, please do not hesitate to contact me at: Lamaison@dioxycle.com.

Sincerely,

LAMAISON Sarah