Allocation Methods in Section 45V

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Date: 3 December 2022

IRS Notice 2022-58 *provides questions on the treatment of co-products*

.01 Credit for Production of Clean Hydrogen.
(b)(i) How should lifecycle greenhouse gas emissions be allocated to co-products from the clean hydrogen production process? For example, a clean hydrogen producer may valorize steam, electricity, elemental carbon, or oxygen produced alongside clean hydrogen.
(ii) How should emissions be allocated to the co-products (for example, system expansion, energy-based approach, mass-based approach)?
(c)(i) How should lifecycle greenhouse gas emissions be allocated to clean hydrogen that is a by-product of industrial processes, such as in chlor-alkali production or petrochemical cracking?
(ii) How is byproduct hydrogen from these processes typically handled (for example, venting, flaring, burning onsite for heat and power)?

Comments on Co-Products

Hydrogen with Co-Products

Allocation methods are a critical component of life cycle analysis as energy inputs and emissions are distributed towards other products and co-products thereby reducing the carbon intensity of hydrogen. The life cycle analysis method should reflect the environmental impact of the production process which is described in the ISO standards.

Many allocation methods are considered within LCA frameworks these include substitution or displacement as well as mass, energy, or economic allocation and even consequential LCA. Given the reference to GREET in the IRA the frameworks within GREET would be appropriate choices for allocation methods. This constraint eliminates consequential LCA approaches such as those used under the EPA RFS which are also controversial and complicated to evaluate. The ISO standards recommend avoiding partitioning/allocation of the system that produce multiple products by instead "expanding the product system to include the additional functions related to the co-products" (ISO 14044, sec. 4.3.4.2).

The system expansion or substitution approach is recommended under ISO 14044 because it represents most closely the environmental impact of the co-product. Challenged to the substitution method include situations where the life cycle of the co-product is unknown. The co-product must be sold or productively used in order for a substitution credit to be valid. The constraint regarding sales of co-products has been implemented under the California Low-Carbon Fuel standard (LCFS) where evidence of sales of electric power, corn distillers grains from ethanol, and glycerin from biodiesel are required. Note that factoring co-products into allocation methods also requires the productive use of the material. The substitution method is implemented in numerous pathways in GREET as well as regulatory frameworks. Most notably corn DGS as well as export electric power from sugarcane ethanol receive substitution credits under the LCFS and this approach is the primary method available in the GREET model.

In the case of hydrogen production, export steam, electric power, solid carbon, and high value hydrocarbons and other gases are potential co-products. If electric power were a co-product, the substitution credit is so similar with the credit deployed in cellulosic ethanol and sugarcane pathways, that this method would be used without question. The analysis effort should allow for co-products such as steam, electric power, high value hydrocarbons, elemental carbon, oxygen, and exotic materials such as helium. Upstream life cycle data for materials that are not in GREET are available from commercial life cycle databases.

Providing an energy allocation credit for export electric power under-values its contribution to reducing GHG emissions.   Export steam is functionally similar to export power and arguably results in an even more well-defined displacement of natural gas or refinery fuel gas. In the case of export power, the basis for the electricity credit is somewhat controversial as questions of whether to apply a marginal natural gas-based power credit or grid average credit must be resolved. In the case of export steam from hydrogen, the energy simply reduces process energy requirements from other sources of steam.

The choice of substitution credit for steam sent to oil refineries could include the emissions associated with steam generation from refinery fuel gas. These emissions are somewhat higher than those from natural gas-based steam but the energy flows within a refinery are more complicated to analyzed. Therefore, in situations when steam is exported from a hydrogen plant, the following approach is reasonable and consistent with the GREET methodology. GREET implements the substitution credit for steam export via and adjustment to the energy efficiency of hydrogen production shown in Table 1. In situations with not steam export, the default energy efficiency is 71.8% and 80% with steam export. These inputs translate to 1.393 Btu Feedstock/Btu Hydrogen and 1.25 Btu Feedstock/Btu hydrogen respectively. The steam export credit is effectively implemented by subtracting the energy associated with export steam from the required natural gas used for hydrogen production.

Table 1. Efficiency Inputs in GREET for Hydrogen Production

	G.H2 Production	Production of Displaced Steam
Energy efficiency	71.8%	80.0%

Note that allocating total natural gas use between steam and hydrogen production based on energy content would results in awkward distributions of combustion and reformer CO_2. Therefore, simply backing natural gas used for steam production out of the total inputs is an appropriate and straightforward approach that is readily verifiable.

Many of the oher co-products that would be produced from hydrogen are available in the GREET1 and GREET2 models. In order to implement a substitution credit, the product must be sold for productive use. In the case of oxygen from electrolysis, GREET provides upstream life cycle data for the substitute value of oxygen based on production in an Air Separation unit (See ASU Tab in GREET1_2022). Double counting issues should be avoided if the oxygen is used to produce another fuel subject to the CHPS. For example, if oxygen from an electrolyzer is sent to a biomass gasifier, which then produces a low carbon fuel, allocating emissions to hydrogen and oxygen based on economic value is the best approach. In this case the CI of hydrogen is reduced and the biomass gasification system receives a relatively low CI source of oxygen. The IRS should provide guidance that clarifies that entities which purchase hydrogen that is the beneficiary of 45V may also use the low GHG hydrogen to produce other products such as aviation fuel under 45Z.

The GREET2 model also provides the upstream life cycle GHG emissions for carbon used in vehicle manufacture. The cell Mat_Sum!BU47 provides the GHG intensity for graphite that is used in the production of battery anodes. In instances where carbon is used for this application, a displacement of substitution credit would reflect the environmental impact of carbon production.

Numerous other instances of high value chemical production are possible with hydrogen. We recommend the use of GREET data to reflect the life cycle value or that the IRS publish life cycle GHG factors for a range of materials.

<u>By-Product Hydrogen</u>

Hydrogen is also produced as a by product of processes such as chlorine via chlor alkali electrolysis or ethylene from naphtha steam cracking. In this case chlorine or olefins are the intended product and the hydrogen is either vented, flared, or used for process heat. The utilization of wastes is a common them in fuel LCA. Examples or waste that are converted to fuels include biodiesel from used cooking oil (UCO) and animal tallow as well as renewable natural gas (RNG) from landfill gas. In these situations, the waste feedstock is treated with zero upstream life cycle GHG emissions even though fats are used as feedstocks for oleo chemicals and landfill gas is a fuel for power generation. The EU RED deals with such waste products by assessing their economic value. If the revenue is less than 10% of total facility revenue, the materials can be treated as wastes. The EPA RFS and California LCFS both allow the treatment of UCO and tallow as well as landfill gas as wastes which is also the treatment in the GREET model.

The GREET model treats hydrogen from chlor alkali via mass allocation, which reflects the low value of waste hydrogen. Consistent with ISO 14040 as well as the treatment of UCO, tallow, and landfill gas in Federal and state low carbon fuel policies, this method is also suitable for the IRA Section 45V.

Use of GREET

While the GREET model is complex, it provides a recognized framework for life cycle analysis that is included in the Inflation Reduction Act (IRA) statute. The following considerations regarding the use of GREET are worthy of your consideration.

- The IRS could publish standard values for defined fuel pathways to make compliance with the IRA statue more straightforward. For example, water electrolysis with 100% renewable power or biomass gasification with a threshold for fossil energy inputs could receive a standard value for GHG intensity.
- GREET provides a recognized basis for the upstream life cycle factors of many fuels and energy carriers. The following are well understood and could be taken from GREET at face value:
    - Well to gate for natural gas and other process fuels. Improving up the CI for pipeline natural gas or diesel used in transport would be very challenging.
    - Statewide GHG intensity for electric power (notwithstanding the use of RECs). The values are available in GREET. LCA practitioners should avoid using eGRID power values that do not include upstream emissions.
    - Carbon intensity of corn ethanol used to produce hydrogen is readily adjusted to reflect process energy inputs, CO_2 capture, and other factors in the fuel cycle.
        - The indirect land use emissions from the CCLUB model are in GREET by reference.
        - Regenerative agriculture practices in the Feedstock CI Calculator (FD-CIC) are in GREET by reference.
        - The balance of nitrogen fertilizer shares and fertilizer shares requires further evaluation to assure that nitrogen and phosphate represented as the corn farming input aligns with the fertilizer shares
        - Fugitive emissions from ethanol T&D should be treated on a carbon neutral basis.
    - The GREET carbon balance for organic waste to RNG requires further evaluation. A totality of emissions approach would account for CO_2 emissions from landfills as well as biofuel production.
    - Fugitive emissions from vegetable oils and ethanol should result in zero non-biogenic CO_2 emissions.

ISO Standards

The use of ISO standards is appealing due to the extensive stakeholder input on these standards. However, the value of the standards should be identified. Several key elements are of interest:

- Explanation of terms such as co-products, displacement (substitution) method, and preference for avoiding allocation
- Requirements for stakeholder input in ISO 14040 seem out of place for individual hydrogen producers. The request for public input on the CHPS is consistent with the requirement to solicit stakeholder input.
- Requirements for third-party verification in ISO 14067 provides a framework for reviewing the GHG intensity of hydrogen. The ISO requirements include documentation

of uncertainty and data quality, which appear reasonable. IRS could provide further guidance for third party reviews.

- The documentation of biogenic carbon in ISO 14067 is helpful. IRS could provide further guidance.

Verification

(5) Unrelated Parties.
(a) What certifications, professional licenses, or other qualifications, if any, should be required for an unrelated party to verify the production and sale or use of clean hydrogen for the § 45V credit, § 45 credit, and § 48 credit?
(b) What criteria or procedures, if any, should the Treasury Department and the IRS establish to avoid conflicts of interest and ensure the independence and rigor of verification by unrelated parties?
(c) What existing industry standards, if any, should the Treasury Department and the IRS consider for the verification of production and sale or use of clean hydrogen for the § 45V credit, § 45 credit, and § 48 credit?

Many verification bodies are capable of assessing GHG emissions under § 45V based on experience with existing fuel programs including the California and Oregon LCFS and the EU Renewable Energy Directive. Verifiers who are accredited under the LCFS, ISCC, or RSB verification systems would have the capability of reviewing IRA GHG analyses. Verification bodies currently employ conflict of interest avoidance. Guidance from the California LCFS is suitable. Similar standards of data quality are employed for fuel verifications including requirements for record keeping, chain of custody for feedstock transfers, and data quality assurance.

Life Cycle Associates Qualifications

Life Cycle Associates Life Cycle Associates, LLC, is a California-based limited liability company formed in 2007 that analyzes the energy and environmental impacts of fuels and energy systems. Our work furthers the reduction of harmful emissions and negative impacts on the environment and climate. Life Cycle Associates provides services to a diverse client base, including fuel providers, technology developers, government agencies, investors, and environmental groups. The Company’s primary place of business is Portola Valley, California, 94028.

Our qualifications are based on over 60 years cumulative experience in alternative fuels, fuel production processes, delivery logistics, and environmental impacts. A significant portion of our work in alternative fuels concerns the evaluation of new fuel production technologies, their energy balance, and economics. LCA has expertise in sustainability issues and metrics and we have developed modeling tools to calculate sustainability results for a wide array of fuel pathways and sustainability criteria, including water use and discharge, biodiversity, land use change, criteria pollutants, and air toxics.

If you have any questions or comments, please let me know.

Best Regards,

Stefan Unnasch

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