Treatment of Co-Products in Fuel System LCAs

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Agenda

- Introduction
- ISO 14040
- Allocation Approaches
- Regulatory LCAs
- Some examples of allocation system impacts
- Conclusions

Introduction

- Almost all systems for manufacturing transportation fuels produce more than one product.
- The treatment of the system emissions that are allocated between the various products can have a major influence on the reported emissions for individual fuels.
- This is an issue for the reference fuels (gasoline and diesel) as well as the alternative fuels.

ISO 14040 Guidance

- The study shall identify the processes shared with other product systems and deal with them according to the stepwise procedure presented below.
  - Step 1: Wherever possible, allocation should be avoided by
    - 1) dividing the unit process to be allocated into two or more sub-processes and collecting the input and output data related to these sub-processes, or
    - 2) expanding the product system to include the additional functions related to the co-products, taking into account the requirements of the system boundary.

ISO 14040 Guidance

- Step 2: Where allocation cannot be avoided, the inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects the underlying physical relationship between them; i.e. they should reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system.
- Step 3: Where a physical relationship alone cannot be established or used as the basis for allocation, the inputs should be allocated between the products and functions in a way that reflects other relationship between them. For example, input and output data might be allocated between co-products in proportion to the economic value of the products.

- Allocation procedures shall be uniformly applied to similar inputs and outputs of the system under consideration.

ISO 14040 Guidance

- There is also not a universal agreement that the hierarchy outline in 14040 is appropriate. Wang et. al. (2010) argue that
  - *"the displacement method can generate distorted LCA results if the co- products are actually main products (for the cases of biodiesel and renewable diesel from soybeans). It is far from settled whether use of a given method should be uniformly and automatically recommended for LCA studies. We suggest that a generally agreed-upon method should be applied for a given fuel production pathway. Consistency in choice of co-product method may not serve the purpose of providing reliable LCA results. On this note, the transparency of LCA method(s) selected is important in given LCA studies and sensitive cases with multiple co-product methods may be warranted in LCA studies where co-products can significantly impact study outcomes."*

Avoiding Allocation

- Displacement/Substitution – In this method, co-products emissions are accounted for by estimating the emissions associated with a substitute product (e.g., excess electricity from sugarcane ethanol displaces electricity that would otherwise be generated for the grid). This results in a numerical credit that is subtracted from the total emissions of the pathway.
- Advantages
  - Preferred method.
- Disadvantages
  - Requires more information and work.

Allocation Approaches

- Allocation – In this method, emissions are allocated across all products of the process according to the mass, energy, or economic value of the products. This approach is often used when there is no clear product vs. co-product in a process (e.g., oil refining).
- Advantages
  - Simple.
- Disadvantages
  - There is a tendency to truncate the system boundaries. Ignoring the use of the co-product.

Process Energy Allocation

- The energy and emissions allocated to the products is based on estimates of how much energy is used to produce each product. This approach has often been used for allocating the oil refinery emissions.
- Advantages
  - Relatively simple.
- Disadvantages
  - While widely accepted for oil refining, acceptance for other systems is less universal.
  - Not always possible to determine energy use by product.

Process Energy Allocation

- Compared to the displacement approach, this approach reduces emissions allocated to gasoline and diesel fuels.
  - Residual oil and petroleum coke could be substituted by coal or natural gas. The emissions for mining coal are less than those for producing and refining oil. The impact is that gasoline and diesel emissions increase and residual and coke emissions decrease compared to process energy allocation.
    - Natural gas combustion emissions are lower than coke or residual oil emissions.
  - LPG from refineries has similar issues.

Energy Allocation

- The total emissions are allocated based on the relative energy contents of the product and the co-product.
- Advantages
  - Simple.
  - In some cases may avoid unintended consequences.
- Disadvantages
  - Can truncate system boundaries. Doesn't account for emission differences between a bio and a fossil co-product.
  - "Value" of co-products may be inconsistent between similar systems.
  - Some practitioners have mixed net and gross heating contents in their analysis.

Glycerine Values

	Displacement	Energy	Mass
Glycerine for Soy BD	16,509	3,334	7,009
Glycerine for Canola BD	16,509	1,535	3,227
Glycerine for Palm BD	16,509	2,215	4,656
Glycerine for Jatropha BD	16,509	2,254	4,738
Glycerine for Algae BD	16,509	2,612	5,489
Glycerine for Tallow BD	16,509	2,243	4,714
Glycerine for Yellow Grease BD	16,509	574	1,207
Glycerine for Fish BD	16,509	5,729	12,041

Mass Allocation

- Allocation emissions by mass is also a simple approach where the mass of the individual products compared to the total product mass determines the allocation.
- Advantages
  - Simple
- Disadvantages
  - Can truncate system boundaries.
  - "Value" of co-products may be inconsistent between similar systems.
  - Large allocation to low value products possible, e.g. CO_2 from fermentation

Economic Allocation

- In this approach the product selling prices are used to allocate the emissions amongst the products. Not widely used in Attributional LCAs.
- Advantages
  - Simple.
  - Similar products have similar emissions.
- Disadvantages
  - Prices can fluctuate rapidly.
  - In less than perfect markets, prices don’t equal value.
  - Can truncate system boundaries because markets place little of no value on GHG emissions.

Regulatory LCAs

- In some jurisdictions LCAs are being applied for regulatory purposes.
  - In most cases, allocation is being used rather than displacement for some systems.
  - What are the implications?
    - Inconsistencies can send unintended market signals.
    - One type of fuel is favoured over another purely as a result of the allocation approach.

Ethanol Systems

- Hierarchy of allocation systems.
- GHGenius v 4.0. Central US Corn Ethanol

Allocation	Upstream GHG Emissions g CO_2eq/GJ (HHV)
Displacement	58,296
Energy Allocation	47,269
Mass Allocation	38,181

Biodiesel Systems

- Hierarchy of allocation systems.
- GHGenius v 4.0. Central US Soybean Biodiesel

Allocation	Upstream GHG Emissions g CO_2eq/GJ (HHV)
Displacement	36,506
Energy Allocation	27,745
Mass Allocation	13,711

Biodiesel Systems

- Hierarchy of allocation systems.
- GHGenius v 4.0. W Canada Canola Biodiesel

Allocation	Upstream GHG Emissions g CO_2eq/GJ (HHV)
Displacement	8,801
Energy Allocation	21,927
Mass Allocation	15,064

Conclusions

- Allocation systems can have a very large impact on the LCA results of transportation fuel systems.
- There are challenges with all of the approaches but the displacement/system expansion approach has the fewest market distorting impacts.
- Other approaches need to ensure that the system boundaries are not truncated, that the use of the co-product is included in the calculations.
- Little scientific justification for schemes that mix allocation approaches.

Thank You