



I·C·I·S

Independent Commodity
Intelligence Services



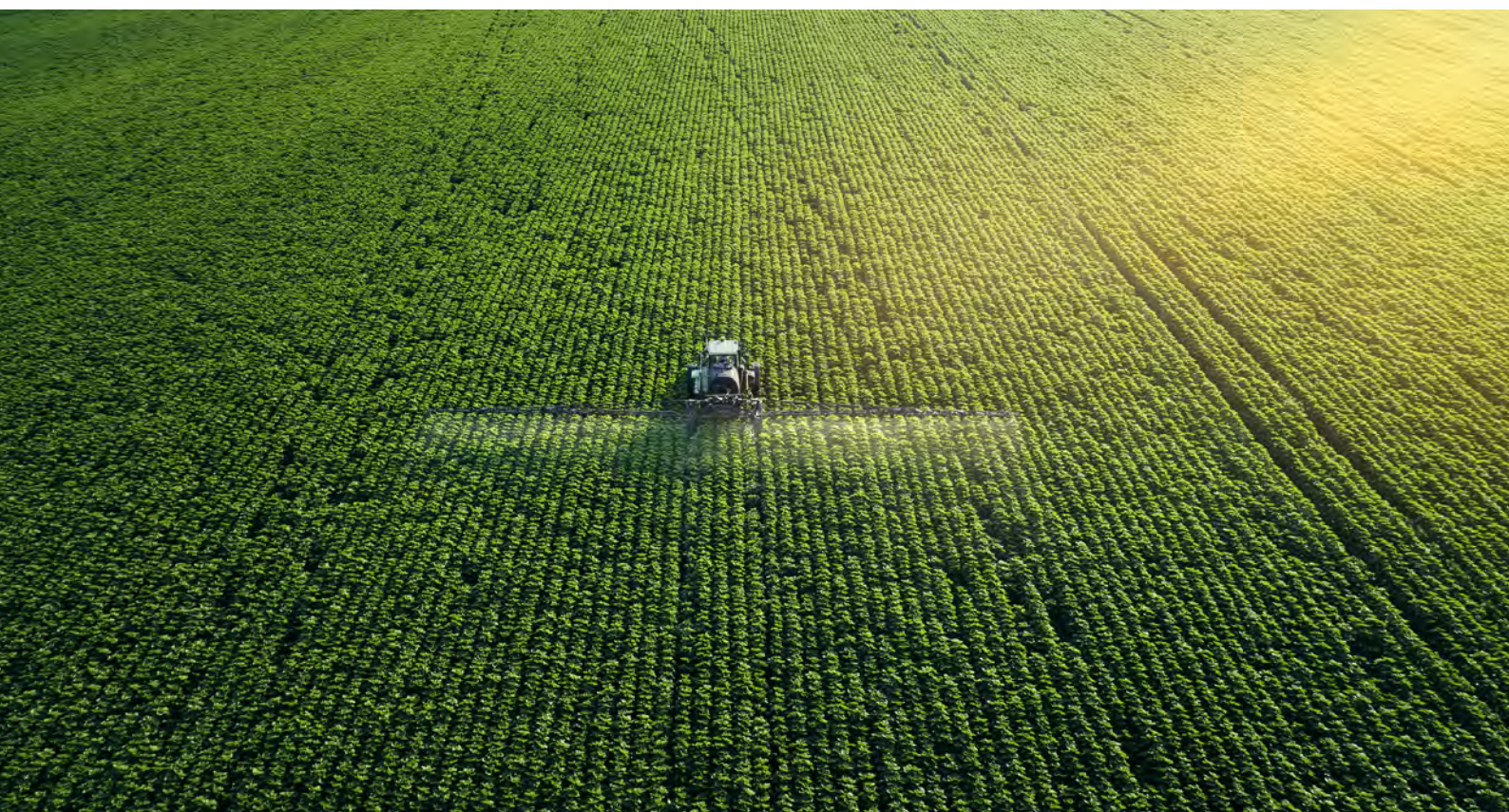
American[®]
Chemistry
Council

Expanding Agricultural Markets and Economic Impact with Mass Balance Accounting

Report for
American Chemistry Council (ACC)

Index

03	Overview
04	U.S. Renewable Feedstock Overview
05	Opportunities for U.S. Agriculture
06	What is Mass Balance?
07	Industry Use of Mass Balance
08	Mass Balance Enables Diverse Chemical Value Chains
09	Current Limitations
10	Mass Balance Advantages for the U.S. Economy
10	Comparison of Benefits from Mass Balance vs. Segregated
12	U.S. Economy: Direct and Indirect Economic Impacts
13	Conclusion



Overview

The integration of renewable feedstocks into the U.S. chemical industry presents a transformative economic opportunity for American agriculture. As profit margins tighten and global competition increases, U.S. farmers face growing pressure to diversify their revenue streams. An emerging demand for renewable chemical inputs – enabled by mass balance accounting – offers a high-value outlet for existing crops and animal fats, with minimal infrastructure changes in the chemical industry and broad economic benefits.

Mass balance accounting allows renewable chemical feedstocks produced from oil grains and fats to be mixed and co-processed with fossil-based ones, while maintaining traceability of these feedstocks in products produced in the chemical value chain. Utilizing mass balance accounting reduces market entry barriers and accelerates time to market for biogenic materials in products like plastics and foams, and gives potential value for sustainably sourced feedstock.

As an illustration, ICIS modeling found that a 10 percent non-fossil content target for U.S. ethylene by 2030 stimulates new demand that could create an estimated **\$6.7 billion in new market opportunity for U.S. farmers**, and **over 34,000 permanent jobs**, exceeding the gains possible via segregated supply chains.

The mass balance approach is essential to unlocking this opportunity. Without mass balance accounting, chemical manufacturers would be required to develop new infrastructure and supply chains to produce renewable chemicals via segregated routes, thus increasing the time for market adoption.

Economic impacts extend well beyond the farm gate. ICIS modeling shows that achieving a 10 percent non-fossil content target for U.S. ethylene would require approximately **\$3.2 billion in new capital investment** in bio-naphtha and ethanol dehydration facilities. These facilities are projected to **generate \$1.7 billion in annual renewable material output** and support the creation of over 5,000 permanent jobs in the U.S. economy.

This policy window offers an unprecedented chance to strengthen the rural economy, advance domestic manufacturing, and support corporate sustainability goals. With proper policy support, including federal recognition of mass balance accounting for renewable feedstocks, USDA and Farm Bill programs can play a pivotal role in catalyzing this transition.



U.S. Renewable Feedstock Overview

The U.S. is a large producer of corn, soybean and tallow. Soybean and corn are two of the country's largest agricultural outputs. In the case of soybean, approximately 30 percent of the total soybean oil output is used for biofuels production¹. While agricultural commodities are already used in fuel production, penetration into the chemicals market has been limited so far, representing a huge untapped opportunity for U.S. farmers.

Vegetable oils such as corn and soybean oil can also be processed to produce bio-naphtha, which can be used as feedstock in chemical processes. Tallow, used cooking oils, and other vegetable oils can be hydrotreated to produce bio-naphtha. Record harvests and high inventories in the U.S., and strong competition with other large agricultural commodities exporting countries have recently weakened profit margins for U.S. farmers².

The electrification of road transport³ is expected to contribute to a gradual reduction in the demand for bioethanol as a gasoline blend stock for light vehicles due to the penetration of electric vehicles (EVs), based on ICIS estimates. Bioethanol, mainly used to meet Renewable Fuel Standard (RFS) requirements, will need new markets as the market share of EVs expands. Bioethanol can be converted to ethylene, and bio-naphtha can be produced through the hydrotreated vegetable oil (HVO) process from vegetable oils, cooking oils, or animal fats. In addition, the implementation of decarbonization targets in the aviation sector will increase demand for sustainable aviation fuel (SAF), boosting bio-naphtha production as a by-product and expanding production of renewable raw materials for the chemical industry. However, the HVO process can switch configurations and maximize bio-naphtha yield.

¹ICIS calculations based on USDA data

²ICIS analysis based on USDA Crop Production data

³International Energy Agency (IEA)



Opportunities for U.S. Agriculture

The potential expansion of renewable chemical production offers new opportunities for U.S. farmers, but several challenges could hinder adoption. In the near term, farmers face uncertainty around future demand, the potential for developing long-term commercial agreements with chemical companies, and the evolving policy landscape, all of which make it challenging to commit their crops to renewable chemical production.

Despite these uncertainties, **expanding into the chemical industry market could offer U.S. farmers valuable opportunities to diversify their revenue.** Allocating part of their production capacity to biomass for chemical raw materials would allow farmers to build relationships with chemical companies seeking reliable, sustainable raw materials sources. Drawing from their experience with biofuel supply chains, farmers could enter these new markets, using existing grain storage, logistics infrastructure, and established traceability systems. This lower barrier to entry could simplify operations and reduce the complexity of transitioning into new markets, compared to establishing entirely new supply chains.

Chain of custody models, particularly mass balance, are enablers for the lower cost and scalable use of renewable feedstocks in the chemical industry. For farmers, mass balance provides a practical entry point into the chemical value chain by allowing them to begin with small volumes and expand participation as demand grows and the value chain matures.

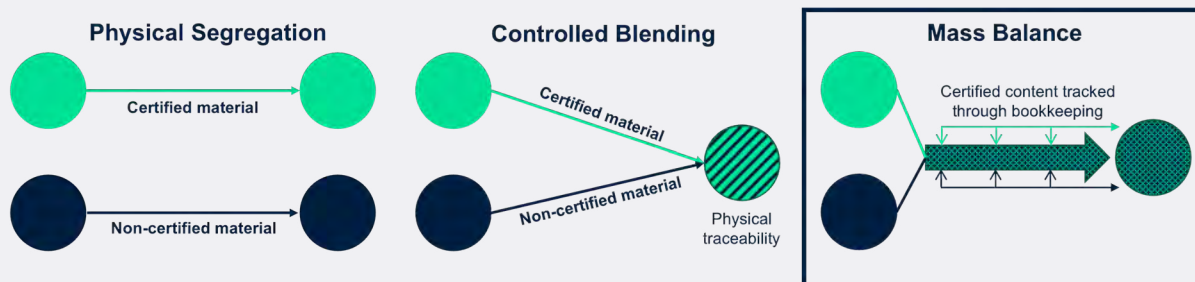


Chain of custody models,
particularly mass balance,
are enablers for the lower cost
and scalable use of renewable
feedstocks in the chemical industry

What is Mass Balance?

Mass balance is a chain of custody accounting method used to track the quantity of a specific input, such as a certified raw material, renewable or recycled feedstock, as it moves through production processes into final products. The method allows certified and non-certified materials to be physically mixed or co-processed, provided that the volume of certified output does not exceed the volume of certified input entering the system. It differs from the segregated model, which requires the physical separation of materials or feedstocks throughout the entire supply chain. Compared to the other chain of custody models, mass balance helps to reduce costs and allows the use of existing logistic routes and production assets. The strict physical separation required by other chain of custody models (controlled blending and physical segregation) limits their scalability and can be more capital intensive, particularly in complex chemical manufacturing. Figure 1 depicts a comparison of these chain of custody models, highlighting the key distinctions in material handling and traceability.

Figure 1: Overview of chain of custody models



Certification plays a critical role in mass balance systems by verifying that sustainability or other claims linked to the input are credible and independently assured. This oversight provides stakeholders across the supply chain and consumers with confidence in the claims being made.



Industry Use of Mass Balance

Mass balance is already used for agricultural commodities such as cocoa, coffee, and cotton, offering cost-efficiency, scalable growth, simplified logistics, and greater participation than complete segregation. Voluntary certification schemes, including Fairtrade, Rainforest Alliance and the Better Cotton Initiative, set the standards, accredit auditors and issue certifications to ensure compliance. In the energy sector, mass balance applies in specific contexts such as biogas injected into natural gas grids for use in road transportation. In these systems, renewable and fossil-based inputs are physically mixed, and certification schemes ensure that the renewable content is tracked and accounted for through mass balance. For biofuels, such as bioethanol and biodiesel, compliance systems often require controlled blending with fossil fuels at distribution terminals to meet blend requirements, such as E10 or B20. Unlike agricultural commodities, where certification schemes may guarantee minimum prices or premiums, the main economic driver for the use of renewable feedstocks in the energy sector is the stable demand created by regulatory mandates. These mandates encourage companies to purchase certified renewable feedstocks to meet regulatory compliance requirements, thereby increasing demand for biofuel crops.



Mass balance is already used for agricultural commodities such as cocoa, coffee, and cotton, offering cost-efficiency, scalable growth, simplified logistics, and greater participation than complete segregation

Mass Balance Enables Diverse Chemical Value Chains

The overall incorporation of renewable feedstock in the chemical industry has been limited. Mass balance enables the use of renewable feedstocks in various chemical value chains where segregated routes are more challenging or impractical, such as aromatic derivatives.

Ethylene is one of the most important and widely produced chemical feedstocks globally, serving as a building block for a vast range of essential products across industries. Its largest use is in polyethylene production, the most common plastic used in packaging, consumer goods, agriculture, automotive, construction, medical, aerospace and industrial applications.

Most ethylene is derived from fossil-based feedstock using steam crackers. Several refiners and chemical producers have started to introduce bio-naphtha, sourced from conventional refiners that co-process with renewable inputs or as a by-product from HVO processes, into existing steam crackers. These processes typically convert feedstocks such as soybean oil, used cooking oils, and animal fats into renewable diesel and/or SAF, with bio-naphtha recovered as a secondary output. Although bio-naphtha production usually occurs as a by-product, producers could intentionally swing the production technology toward bio-naphtha if market demand for renewable chemicals and plastics grows.

The mass balance approach offers a practical pathway to introduce renewable feedstock into the ethylene value chain, primarily by integrating bio-naphtha into the feedstock mix of large steam crackers traditionally relying on fossil naphtha. In this case, it is impractical to fully segregate renewable and fossil inputs at a large scale, making mass balance accounting essential to track and attribute the renewable share across the resulting products, including ethylene-derived plastics. Additionally, it gives flexibility to the producer to attribute content to better balance demand.



Current Limitations

Steam crackers are pivotal manufacturing assets in producing base chemicals like ethylene and rely on fossil inputs like naphtha. However, accounting for the integration of renewable raw materials, such as bio-naphtha, into the mix of fossil-based raw materials utilized in most existing assets faces significant hurdles without mass balance accounting. Without mass balance accounting, operators must rely on physical traceability, which is impractical in integrated systems like steam crackers. Some of the challenges identified include:



Steam crackers are continuous, interconnected systems with extensive piping, multiple towers and reactors, and intermediary holdup drums. Fully segregating renewable and fossil raw materials is technically unfeasible due to material “hold-up” in equipment. Operators would have to resort to campaigns, processing renewable raw materials in batches, preceded by costly flushing to remove fossil residues. This would impact the competitiveness of manufacturers in the United States.



Physical traceability requires flushing renewable raw materials through hot and cold sections of the steam cracker until contamination is deemed eliminated – i.e., it would be challenging to achieve a 100 percent biogenic material. Even minimal fossil contamination during campaigns would invalidate “green” claims, deterring investment in renewable feedstocks.



Supply logistics would need to be segregated (e.g., storage tanks, pipeline networks, railway cars, trucks), which adds additional costs and complexity to the logistic challenge of bridging petrochemical hubs on the Gulf Coast with traditional agricultural hubs in the Midwest. Mass balance can help address these logistics challenges, depending on the balance boundaries chosen.

Integrating bio-naphtha as a supplemental raw material can help avoid major overhauls in operations. Additions can be mixed or co-processed with fossil feedstocks, reducing the need for segregation. Mass balance is crucial for effectively integrating renewable sources in the steam crackers’ feedstock mix.



Mass Balance Advantages for the U.S. Economy

With growing consumer awareness, pressure to increase sustainability across chemical value chains is increasing. Over the last few years, this has contributed to announcements of voluntary targets from chemical companies to leverage renewable raw materials such as bio-naphtha. Despite potential advantages, the use of renewable raw materials in the chemical industry has been limited so far. This is particularly the case with building blocks such as ethylene due to several factors, including high capital investment costs associated with the segregated production route, as with, for example, bioethanol-to-ethylene (BTE). Unlike the segregated model, mass balance allows for existing assets to be leveraged, significantly reducing direct capital investments, while utilizing existing logistics and allowing for flexible attribution of renewable content across derivatives.

It is important to note that this is a developing industry at a much smaller scale today than that of conventional feedstocks. Therefore, market volatility poses challenges and hinders investments due to perceived higher business risk. Regulatory mechanisms have driven the incorporation of renewable feedstock into alternative markets. In the absence of a clear mechanism to support demand for renewable feedstock incorporation into the chemical industry, volumes are expected to be driven by case-by-case opportunities linked to decarbonization efforts in the fuels market, voluntary corporate sustainability efforts and consumer demand for renewable alternatives.



Comparison of Benefits from Mass Balance vs. Segregated Route

ICIS analysis highlights a substantial economic opportunity for U.S. farmers by supplying renewable feedstocks to the growing renewable chemicals industry. The study examined the potential gains from an illustrative 10 percent minimum non-fossil content target for U.S. ethylene production by 2030. ICIS conducted this analysis to assess potential opportunities for U.S. farmers arising from the chemical industry's adoption of a mass balance framework to incorporate renewable feedstocks. The analysis was based on the hypothetical implementation of a non-fossil content target for ethylene production. It did not assess potential technical barriers to processing renewable feedstocks in U.S. steam crackers/chemical facilities or economic costs thereof to U.S. chemical producers and consumers.

ICIS examined two cases – one using the segregated route and another using a mass balance approach, both based on 10 percent of ethylene production derived from non-fossil feedstocks.

Table 1: Summary of 10 percent non-fossil content scenarios and results⁴

Case	Renewable ethylene demand	Route	Oil grains demand	Fats demand	Capital Expenditure	Potential Revenue
Mass balance	4.2 mmt	On-purpose bio-naphtha	25.7 mmt	1.2 mmt	US\$3.2 billion	US\$6.7 billion
Segregated	4.2 mmt	Bioethanol-to-ethylene	20.8 mmt	n/a	US\$9.0 billion	US\$3.6 billion

According to the [ICIS Supply and Demand Database](#), the U.S. is forecast to produce 42.4 million tonnes of ethylene in 2030. The results presented highlight the vast untapped opportunity that the incorporation of renewable feedstock could bring to farmers in the U.S.

Meeting a 10 percent non-fossil ethylene target would necessitate about 4.2 million tonnes of non-fossil ethylene in 2030. To estimate the potential demand for farmers, it is necessary to assume how renewable inputs can be attributed to products. There are different possible mechanisms for mass-balance attribution, and the corresponding conversion factor directly impacts the amount of renewable feedstock needed to meet the target and, consequently, the volume of biomass feedstock required.

For U.S. farmers, the additional demand could range from 26.9⁵ to 76.7⁶ million tonnes of grains (corn, soybean, and canola) and fats (including tallow, grease, and other fats), based on ICIS assumptions of yield and oil grains profile distribution. The results underlying these assumptions are presented in Table 1. Considering recent average prices of grains (published by USDA) and fats, and ICIS ethylene demand projections, this increased demand represents an estimated \$6.7 to \$18.6 billion in potential new economic opportunity for U.S. farmers. This demonstrates the economic benefits that integrating renewable feedstocks into U.S. chemical production can deliver directly to the agricultural sector⁷, if mass balance is in place. This potential contrasts with \$3.6 billion for corn farmers when only the segregated BTE route is considered.

⁴ICIS modeled the supply of non-fossil ethylene first from existing sources such as bio-naphtha and bio-LPG as a byproduct from SAF, ethanol dehydration and other renewable feedstock. The remaining ethylene required to meet the established target will likely be produced from technologies maximizing bio-naphtha output instead of SAF (i.e., on-purpose bio-naphtha HVO). For comparison purposes, ICIS also modeled a case where mass balance cannot be used to support achieving the hypothetical targets. In this case, the non-fossil ethylene demand was met exclusively through the BTE route since this is the most advanced route today. The mass balance case considers a mix of corn, soybeans, and canola, which have different production yields of oil. In contrast, the segregated case focuses solely on corn, which generally offers a higher yield of ethanol due to the sugar content. As a result, the volume of grains required differs between the cases.

⁵Considering that all bio-naphtha input can be attributed to ethylene (highest conversion factor).

⁶Considering that bio-naphtha's yield to ethylene is similar to conventional naphtha. The bio-naphtha input in this model would be attributed across all cracker products, meaning the total demand figure includes attribution to ethylene, co- and by-products.

⁷ICIS estimates based on published average prices.

U.S. Economy: Direct and Indirect Economic Impacts

Under the scenario of a 10 percent content target, the economic impact analysis on the renewable chemical industry assumes that by 2030, up to 15 new manufacturing assets would be constructed (and put into service) of HVO and ethanol dehydration plants. Development of these plants would likely require \$3.2 to \$6.8 billion in capital investment. If these new investments were to become operational, the U.S. could see significant new output of renewable raw materials, potentially generating more than \$1.7 to \$3.6 billion of output.

Meeting the 10 percent content target through the alternative segregated route is estimated to require 30 BTE plants, representing an approximate \$9 billion investment. Excluding additional segregation logistics, this is higher than the scenario that leverages mass-balance bio-naphtha.

A significant economic footprint can result from the renewable chemical industry, extending far beyond direct employment and renewable raw materials output. The industry's impact cascades through the economy, generating employment and output not only directly but also indirectly via its demand for goods and services from suppliers. These supplying businesses, fueled by the feedstock industry's needs, further contribute by making their purchases and compensating their workforce. This interconnectedness means a mature renewable chemical industry can stimulate multiple cycles of economic activity and reinvestment. Beyond the direct economic contributions, a sector's broader influence can be measured by examining its indirect and induced impact on the economy. Table 2 presents a summary of the total economic impact of new renewable raw materials manufacturing on both the renewable chemical industry and the U.S. agricultural sector.

Table 2: Economic impact of new renewable raw materials manufacturing (\$2024)^a

Sector	Employment	Output (\$bn)
Renewable Chemicals	5,000 - 12,000	\$3 - 6
Agriculture	34,000 - 95,000	\$24 - 65

Table values are a sum of the modelled direct, indirect, and induced economic impact for the mass balance case.

^aThe ranges presented result from the assumptions on how biogenic inputs can be attributed to ethylene. Lower bound is the result of the case when all bio-naphtha input can be attributed to ethylene (highest conversion factor), resulting in lower demand for grains. Upper bound is the result of assuming that bio-naphtha yield to ethylene is similar to the one obtained when processing conventional naphtha (lower conversion factor), and bio-naphtha is attributed across all cracker products, including ethylene as well as co- and by-products.

Conclusion

The recognition of mass balance accounting for renewable feedstocks in the U.S. chemical industry represents a pivotal opportunity to unlock significant economic and environmental benefits. By enabling the scalable, lower-cost incorporation of renewable feedstocks into existing chemical infrastructure, mass balance offers a practical and credible pathway to use renewable feedstocks without requiring complete segregation or infrastructure overhauls.

ICIS modeling underscores the transformative potential of this approach: under an illustrative 10 percent non-fossil ethylene content scenario by 2030, U.S. farmers could see over **\$6.7 billion in new market opportunities** and support the creation of **over 34,000 permanent agricultural jobs**. Compared to the segregated route, the mass balance approach requires significantly less capital investment, reduces market barriers, and accelerates time to market to use biogenic materials in products.

This chain of custody model is familiar to the agriculture sector, with commodities like cocoa, coffee, and cotton already reaping the benefits of cost-efficiency, scalable growth, simplified logistics, and greater value offered by mass balance accounting. With the proper policy support, including federal recognition of mass balance accounting for renewable feedstocks, the United States can strengthen the rural economy, advance domestic manufacturing, and help corporations meet voluntary commitments.



Authors



Prashanth Sabbineni

Strategy & Transactions - Americas, ICIS Consulting
prashanth.sabbineni@icis.com



Cassia Oliveira de Lima

Sustainability & Circular Economy, ICIS Consulting
cassia.lima@icis.com

Expanding Agricultural Markets and Economic Impact with Mass Balance Accounting

Report for
American Chemistry Council (ACC)

Try ICIS

www.icis.com