Scaling Sustainable Aviation Fuel: Cost-Effective Pathways and Regional Economic Impacts

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Abstract

Scaling sustainable aviation fuel production is central to aviation decarbonization, yet policymakers and investors face uncertainty over which conversion pathways can deliver economically viable fuel while generating meaningful regional economic benefits. Holding total sustainable aviation fuel fixed at one hundred million gallons, we evaluate the technoeconomic feasibility and regional economic impacts three technology pathways, Hydro-processed Esters and Fatty Acids, Fischer Tropsch, and Alcohol to Jet, in the southern US under both single-technology and mixed-portfolio deployment scenarios. We show that technology pathway choice alone fundamentally reshapes cost structures, co-product revenues, employment intensity, and tax generation. AtJ achieves lowest minimum selling prices, FT generates larger co-product streams and stronger regional economic spillovers. HEFA's commercial maturity is constrained by high feedstock cost, low co-product production efficiency, and mediocre economic impact at the regional scale. Mixed-pathway portfolios mitigate trade-offs between cost competitiveness and regional economic impacts, providing an alternative solution to single-pathway deployment by building feedstock resiliency, diversifying economic impacts, and broadening employment opportunities. These findings demonstrate that SAF deployment strategy—not only production volume—plays a key role in determining economic outcomes, providing actionable guidance for regional planners and policymakers designing scalable, economically resilient SAF supply systems.

Keywords: Sustainable Aviation Fuel, Technoeconomic Analysis, Regional Economic Impact, Energy Transition Policy, Input-output Modeling.

Fifty Words Summary

Cost-competitiveness and economic benefits of SAF production technology pathways is less understood. Our paper fulfills this research gap using technoeconomic modeling and regional economic impacts of three SAF technologies in the US south.

1. Introduction

The carbon dioxide (CO_2) emission from the aviation sector remain as a major challenge in achieving net zero caron emission by 2050[1] (Lee et al., 2021). The aviation sector contributes 2.5% of global CO_2 emissions and 4% to the global warming impact (Bergero et al., 2023; Ritchie, 2024) exceeding one thousand million tons CO_2 emission per year in 2018. The emission from aviation sector grew 6.8 times in about 60 years (1960 to 2018) to 1034 teragram[2] of CO_2 per year ($TgCO_2yr^{-1}$) (Lee et al., 2021). The cumulative emissions from global aviation from 1940 to 2018 are 32.6 billion tons of CO_2, with approximately 50% of which is emission in the last 20 years (Lee et al., 2021). Bergero et al. (2023) projected that the demand for aviation will increase by 4% to 2.9 trillion trillion-kilometer equivalent (tkm$_e$ or 11.1 trillion passenger-kilometer equivalent pkm$_e$) and the carbon emission is projected to increase significantly as the business-as-usual scenario by 2050. As the demand for the air transportation is growing, decarbonization of aviation sector by using alternative fuel such as sustainable aviation fuel (SAF) is crucial to meet the global decarbonization goal by 2050[3] (Malina et al., 2022).

With the projected increase in aviation passenger traffic by 4.3% annually over the next two decades (ICAO, 2023), securing renewable, sustainable, domestically produced fuels represents a major challenge for the aviation industry (Bergero et al., 2023). To overcome this challenge, the United States (US) Department of Energy's (DoE) Grand SAF challenge lays out a target of domestic SAF production of three billion gallons by 2030 and thirty billion gallons by 2050. Further, the DoE's Bioenergy Technology's Office (BETO) Billion Ton Report has identified the need to grow domestic agriculture and forestry sector from 342 million to 1,750 million dry short tons to meet overall biofuel needs. Agricultural products such as corn, soybean, and sugarcane, herbaceous and woody biomass crops such as switchgrass, miscanthus, and hybrid popular as well as agricultural residuals and wood waste are near-term feedstocks for SAF. These feedstocks support starch, sugar, and biomass based SAF production pathways such as Alcohol to Jet (AtJ), Fischer Tropsch (FT), and hydro processed ester fatty acids (HEFA) (U.S. Department of Energy, 2024).

SAF represents a significant opportunity for the US agriculture and forestry production sector. The rapid adoption of electric vehicles (Forsythe et al., 2023) and a recent significant decline in the paper and pulp mill industries (Brandeis & Guo, 2016; Ebner & Cozort, 2023;

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[1] The CO_2 warming equivalent emissions estimate shows that the aviation sector's cumulative carbon and non-carbon emissions are currently causing the global climate warming about three times more than that of aviation CO_2 emission alone (Lee et al., 2021).

[2] One teragram is equal to 10^{12} grams, which is equal to one million metric tons. The United States Environmental Protection Agency develops this scale to enable consistency in calculations, assumptions, and reporting of global carbon emissions from transportation sector. This is a large-scale measurement of emission often used in national and global carbon reporting (US EPA, 2005).

[3] Sustainable aviation fuel is a set of low-carbon fuels that can be sustainably produced using bio-based renewable or waste products compared to existing conventional fossil-based fuels. Experiment have shown that SAF is capable of safely flying planes without mixing it with conventional fossil-based fuel making it an alternative to exiting conventional jet fuels (Malina et al., 2022).

Resource Wise, 2025) has left American farmers and foresters searching for markets for their agricultural feedstocks, forest products, and wood waste. SAF represents a transformative market opportunity to create a demand for feedstock, forest products, wood wastes, and ethanol thus, strengthen U.S. economy and ensure energy security (Craig et al., 2022; FAA, 2024; IEA, 2021; Langholtz et al., 2016; USDOE, 2024). Producing SAF from domestic crops such as corn, soybean, and dedicated energy crops, and wood waste from the forestry industry ensures energy security while providing income streams for US farmers and landowners.

Despite its promise, SAF adoption is hindered by high and uncertain costs. Current production costs are estimated to be two to five times greater than conventional jet fuel (EIA, 2025; Langholtz et al., 2016). These economics are closely tied to markets for agricultural feedstock inputs for SAF (Geleynse et al., 2018), which determine both the floor price of production and the volatility of long-term supply agreements (Dohlman et al., 2023). Feedstock price changes for corn, oilseeds, and forestry residues can alter SAF's economic feasibility, affecting the confidence of investors, airlines, and policymakers (Holladay et al., 2020). Improved clarity around SAF production cost and price trajectories are essential for effective policy design, private capital mobilization, and long-term commitment by SAF customers (Craig et al., 2022).

Collective action from policy makers, industry, and financiers is needed to overcome the economic and technological challenges to scale up SAF production and use (Malina et al., 2022). The large scale deployment of SAF to reach net-zero carbon emission requires a large scale investment to be combined with technological and operational improvements (Malina et al., 2022). Currently, the economic feasibility and regional economic impact of new investment in SAF production technology pathways such as FT, AtJ, and HEFA are less understood. Assessing the techno-economic efficiencies, price trajectories, and regional economic impacts of key SAF inputs and processes is critical to understand the impacts of these strategies and evaluate long-term economic feasibility and regional economic impacts enabling productivity gains, supply-chain optimization, and the application of financial instruments to hedge risk (Ferioli et al., 2009). Aviation decarbonization policies, including those aimed at promoting the SAF industry, should be integral to the US broader energy targets, actions on energy transition, and agricultural and environmental sustainability (Malina et al., 2022).

The purpose of this study is to evaluate the technoeconomic feasibility, production potential, and regional economic impacts of expanding SAF production in the southeastern US using HEFA, FT, and AtJ conversion technology pathways. We choose three technology pathways for three main reasons. First, all three pathways are approved under Advanced Standard Transforming Markets (ASTM) standards and represent the most technically feasible options for near- to medium-term SAF deployment (Calderon, Tao, Abdullah, Moriarty, et al., 2024). Second, deploying a single technology is insufficient to meet the region's projected SAF immediate and long-term demand, the analysis employs a structured scenario approach that considers three technology pathway combinations to meet SAF regional demand. Third, existing feedstock production and supply chain for biofuel energy markets are well established in the US which is easier in diverting them for SAF production. By integrating technoeconomic modeling with a regional input–output economic impact framework, the study examines how alternative SAF deployment strategies affect minimum selling prices, fuel and co-product yields, and the resulting changes in regional output, employment, labor income, and value added across interconnected sectors. Together, these insights provide a comprehensive understanding of the technical, economic, and regional development implications of SAF expansion and offer evidence-based guidance for policymakers, industry stakeholders, and planners seeking scalable and economically advantageous SAF supply strategies for the southeastern US.

This paper makes three contributions to the literature on sustainable aviation fuel deployment and energy transition policy. First, we demonstrate that SAF deployment strategy materially affects economic outcomes even when total fuel production is fixed. By holding SAF output constant at one hundred million gallons per year, we isolate how technology pathway choice—rather than scale alone—drives differences in minimum selling prices, co-product revenues, employment intensity, value added, and tax generation. This shifts the focus from production volume to production pathways, a distinction that is absent from existing SAF technoeconomic and economic impact studies. Second, we show that trade-offs between cost competitiveness and regional economic benefits differ sharply across SAF pathways. AtJ pathways offer lower minimum selling prices but generate fewer downstream spillovers, while FT pathways produce higher co-product revenues and stronger regional economic impacts despite higher estimated production costs. HEFA, although commercially mature, is constrained by feedstock availability rather than technoeconomic performance. These results challenge the implicit assumption that lower-cost pathways necessarily dominate from a regional development or policy perspective. Third, the paper provides evidence that diversified SAF technology portfolios can dominate single-pathway deployment. Mixed-pathway scenarios mitigate the economic risks associated with feedstock constraints, price volatility, and co-product dependence, while delivering more balanced outcomes across cost, employment, and tax revenue metrics. This portfolio-based insight is directly relevant for policymakers designing SAF incentives, infrastructure investments, and regional development strategies under deep aviation decarbonization targets. Together, these contributions advance understanding of SAF scale-up by linking pathway-level technoeconomic performance to economy-wide impacts, and by highlighting that optimal SAF strategies depend on managing trade-offs across cost, scalability, and regional economic objectives—not on fuel volume alone. This analysis does not estimate causal effects of SAF policy or investment decisions. Instead, it isolates accounting-based economic consequences associated with pathway-specific production structures under a fixed output assumption.

The rest of the paper presents the methods, results, discussion with policy implications, and a concluding summary. In the methods section, we define joint and individual technology pathway scenarios to achieve one hundred million gallons of SAF using three technology pathways and underlying assumptions. We then describe the techno-economic modeling of these scenarios using Aviation Sustainability Center (ASCENT) techno-economic assessment (TEA) models and TEA outputs mapping into Impact Analysis for Planning (IMPLAN) tool to assess economic impacts. The results section reports findings from the TEA, including SAF and co-product production, minimum selling prices, revenue at minimum selling prices, and projected revenue at fixed market prices, alongside total construction, feedstock, and operating costs, as well as other proprietor income/profit over a 20-year operating period. Economic impacts from IMPLAN are then presented by key indicators, including employment, labor income, value added, output, and tax revenues at the county, state, and federal levels. We also highlight major industries affected by SAF investments. The paper concludes with a discussion of these results, policy implications, and a conclusion briefly summarizing the study.

2. Methods

2.1. Scenario Assumptions for One Hundred Million Gallons of SAF Production Pathways

This section describes the technology pathway assumptions used to produce one hundred million gallons of SAF annually. Given uncertainty in technology development, feedstock availability, and policy support, the analysis adopts a scenario-based framework that considers both a joint technologies pathway scenario and individual technology pathway scenarios. The joint scenario assumes SAF production is met through a combination of AtJ, FT, and HEFA pathways, reflecting a transition-consistent mix of commercially available and emerging technologies. The individual pathway scenarios independently scale each technology to the same production level to isolate pathway-specific economic impacts under a standardized capacity assumption, rather than to represent expected market outcomes.

2.1.1. Joint Technologies Pathway Scenario

The joint technologies pathway scenario assumes a blended SAF production system in which AtJ, FT, and HEFA jointly supply a total of one hundred million gallons of SAF annually. These three pathways are ASTM approved standard SAF technology pathways which represent the most technically feasible options for near- to medium-term SAF deployment. While HEFA is currently the only pathway operating at commercial scale, one technology pathway is insufficient to meet SAF production goal (Calderon, Tao, Abdullah, Talmadge, et al., 2024). AtJ and FT are at advanced demonstration to early commercialization stages and are expected to play an increasing role as technologies mature and supporting policies expand (Mawhood et al., 2016). Relying on one technology pathway may be detrimental to the development of other technology pathways to reach the decarbonization goal (Calderon, Tao, Abdullah, Talmadge, et al., 2024).

We exogenously allocate production across AtJ (30%), FT (50%), and HEFA (20%) to reflect a transition-consistent balance among commercial readiness, scalability potential, and feedstock availability constraints. AtJ’s share reflects its ability to leverage existing ethanol production and distribution infrastructure, enabling incremental scale-up while remaining sensitive to alcohol feedstock prices and conversion efficiencies (Bianco et al., 2025). FT accounts for the largest share due to its superior long-run scalability and feedstock flexibility (Huang et al., 2018; Ismael et al., 2025). This is further supported by the use of agricultural and forestry residues and the feasibility of large, centralized facilities that achieve economies of scale (Akhtari et al., 2014; Hamelinck et al., 2004). HEFA is capped at 20% despite its commercial maturity because lipid-based feedstocks face binding supply constraints and competing demand from renewable diesel markets, limiting feasible expansion at high SAF volumes (Calderon, Tao, Abdullah, Talmadge, et al., 2024; Ismael et al., 2025).

This joint scenario represents a realistic transition pathway that combines near-term deploy ability with medium- and long-term scalability under optimistic but plausible assumptions about technology development and policy support. It serves as the primary scenario for evaluating the economic and regional impacts of a diversified SAF production portfolio.

2.1.2. Individual Technology Pathway Scenarios

In addition to the joint pathway scenario, the analysis evaluates individual SAF pathway scenarios in which either AtJ, FT, or HEFA is independently assumed to produce one hundred million gallons of SAF annually. These scenarios are constructed as analytical cases to isolate pathway-specific economic effects under a standardized production scale. Evaluating each pathway at an equivalent output level enables consistent comparison of investment requirements, supply-chain linkages, and regional economic impacts across technologies. These individual pathway scenarios are conceptually consistent with the joint pathway scenario because they reflect scale-up outcomes achievable under sustained policy support, targeted incentives, and public investment in infrastructure, feedstock supply, and technology deployment. Under such policy-enabled high-deployment conditions, multiple SAF pathways can expand concurrently and aggregate SAF production can exceed one hundred million gallons annually. Accordingly, the individual pathway scenarios are interpreted as policy-relevant upper-bound or marginal expansion cases that complement, rather than contradict, the transition-oriented joint scenario.

Together with the joint pathway scenario, the individual pathway scenarios establish near-term-feasibility-bound and upper-bound estimates of economic impacts across alternative SAF development pathways. This combined analytical framework supports a more comprehensive evaluation of regional and economy-wide effects associated with both near-term deployment and longer-term SAF scale-up under deep aviation decarbonization strategies.

2.2. Technoeconomic Analysis of SAF Production in ASCENT Models

In this section we describe technoeconomic modeling aspects of three individual production pathways. The approach followed for the joint and individual pathway scenarios is identical. We summarize the process without differentiating the joint and individual technological pathways, creating four total scenarios—one joint technologies pathway scenario and three individual technology pathway scenarios. The only difference in modeling individual and joint scenario is that joint pathway scenario considers all three technologies jointly produce one hundred million gallons of SAF. Whereas the individual pathway scenarios are optimistic scenario considering hypothetical competitive advantage of individual technology to meet the one hundred million gallons of SAF solely.

We modeled SAF production scenarios using three unique TEA models developed by ASCENT for three SAF technology pathways. Three SAF technologies differ from each other based on their feedstock inputs, system requirement, production mechanism, and chemical process (Table 4). These three technologies have unique physical and chemical pathways and different feedstock requirements to produce sustainable aviation fuel. Thus, we used three different technoeconomic models (V3.1) for AtJ, FT, and HEFA pathways to model SAF and co-products productions process using these technologies (Brandt et al., 2021).

We used ethanol as the feedstock for the AtJ technology pathways. Ethanol is a mature, widely produced, and well-integrated biofuel intermediate with an established supply chain in the US. Ethanol production benefits from decades of technological optimization, extensive infrastructure, and clear regulatory frameworks, making it a reliable and scalable input for AtJ conversion. In addition, ethanol can be derived from a range of biomass sources—including corn, cellulosic feedstocks, and agricultural residues—allowing flexibility in feedstock sourcing while supporting rural economies. From a techno-economic and lifecycle perspective, ethanol-based AtJ pathways are among the most studied, with well-characterized conversion efficiencies, costs, and emissions profiles, which strengthens the robustness and comparability of our analysis. Using ethanol as the AtJ feedstock therefore reflects both current industry practice and near-term commercialization potential, while aligning the analysis with realistic deployment scenarios.

For FT technology pathway, we used forest residuals as the feedstock. Forest residual is an abundant, underutilized, and regionally available biomass resource with strong sustainability advantages. Forest residuals—such as logging residues, thinning materials, and mill wastes—do not compete directly with food production and are often left unused or disposed of at low value, making them a cost-effective and low–opportunity-cost input for FT conversion. Their use can also support forest health by reducing wildfire risk and improving land management outcomes. From a systems perspective, forest-residue-based FT pathways are well aligned with large-scale, centralized thermochemical conversion processes and have been extensively evaluated in prior techno-economic and lifecycle studies, providing well-established performance and emissions benchmarks. Consequently, using forest residuals as the FT feedstock reflects realistic feedstock availability, environmental co-benefits, and the current direction of commercial and policy interest in advanced, non-food-based sustainable aviation fuel pathways.

Similarly, we adopted used vegetable cooking oil (UCO) as the feedstock for the HEFA technology pathways because it is a readily available, low-cost waste-derived resource with well-established commercial use in biofuel production. As a waste stream, UCO avoids direct competition with food crops and minimizes land-use change concerns, offering clear environmental advantages over virgin oil feedstocks. HEFA conversion of UCO is one of the most technologically mature and commercially deployed SAF pathways, with proven conversion efficiencies, existing refinery integration, and well-documented cost and lifecycle emissions profiles. In addition, utilizing UCO supports circular economy principles by valorizing waste materials that would otherwise require disposal. Using UCO as the HEFA feedstock therefore aligns the analysis with near-term deployment realities, sustainability goals, and current industry practice in advanced sustainable aviation fuel production.

2.3. Mapping ASCENT Technoeconomic Model with IMPLAN

ASCENT TEA model produces total volume of SAF and co-products (Table 1A), annualized capital investment costs (Table 5A) for the first three years of construction period, total employee for operating SAF plants and total compensation for these employee (Table 5B), annualized total operating costs (Table 5C), fixed and variable annual operating costs, and feedstock costs (Table 6) for twenty years of operating period. The TEA model further lists itemized breakdown non-feedstock inputs costs such as chemical catalysts, hydrogens, electricity consumptions, hydro-processing costs, water consumptions, natural gases, and waste disposal. These parameters itemized cost were mapped with spending pattern in IMPLAN (Table 12).

In IMPLAN, we modeled construction period, and operation periods separately (Figure 1). The construction of SAF plant was assumed to be initiated in 2025 and completed in 2028. The operation of SAF plant is assumed to be onset in 2028 and operates until 2047 (i.e., three years of construction and twenty years of operating period). For the construction period, the annual construction cost is available as a single value per year from the ASCENT model. We used “Industry Output” event with “46-Construction of new manufacturing structures” as the industry specification for the construction period. An industry output event is designed to generate direct, indirect, and induced effect rippled through the economy using single input monetary value. The ASCENT model provides more detailed breakdown of parameters for operating period. We used “Industry Impact Analysis (Detailed)” (IIAD) event with “155 - Other basic organic chemical manufacturing” as industry speciation for the operation period. For both construction and operation period, we used data year as 2024, which is the most recent data available in IMPLAN. The year of construction and operation was used as the dollar year in each IMPLAN groups to model economic impact of construction and operating periods. In total, we used three industry output events to model three construction years and twenty IIAD events to model twenty operation years throughout the lifecycle of a SAF plant.

We further modeled other proprietor income (OPI) for the operation period in IMPLAN. OPI for joint technologies pathway scenario and individual technology pathway scenarios are available in Table **10** and Table **11**, respectively. The OPI at market value was calculated exogenously by obtaining total production volume of SAF and co-products for each year from ASCENT TEA models. The annual production volume of SAF and co-products were multiplied with inflation adjusted market prices of the respective product for the given year to obtain total revenue from SAF and co-products for each year at the respective market price. The total annual production cost is obtained from the technoeconomic model, which was subtracted from total revenue to obtain total profit which was used as OPI in IMPLAN. This profit is total return to capital which is an estimation of total profit before taxes and interests. OPIs are not adjusted for total construction cost as construction cost was modeled separately in IMPLAN.

Finally, we mapped itemized cost breakdown of inputs used for SAF production obtained from TEAM models to spending pattern in IMPLAN (Table 12). ASCENT model provides a breakdown of annual operating cost into its components such as feedstock costs, hydrogen cost, electricity, natural gas, catalysts, water expenses, and waste disposals. In IMPLAN, the IIAD event provides flexibility to modify the default industry spending pattern. The total monetary value related to each component obtained from the ASCENT TEA model was converted into percentage value of the total operating cost. Then, the calculated percentage was mapped with the industry category inside the spending pattern in IMPLAN. The adjusted spending pattern represents itemized cost-share of each commodity purchased on the modeled period for each technology. This procedure forces the spending pattern to flow along the supply chain industry corresponding to three technology pathways. For IMPLAN spending pattern industry categories not explicitly captured by the TEA models, we applied the default spending patterns supplied the IMPLAN and normalized them so that total expenditures summed to 100%. This approach ensures that all sectors are consistently represented in the economic impact analysis. Spending pattern for irrelevant feedstock commodities for a given technology pathway were suppressed (0%) for each technology. For example, forest residuals are feedstock for FT but not for AtJ and HEFA. So, commodity code for forest residual was replaced by 0% for FT and HEFA. Similar approach was used other technology pathways.

2.4. Regional Impact Analysis Modeling in IMPLAN

IMPLAN is used in this study to estimate the regional economic impacts associated with SAF production by capturing how an initial change in economic activity propagates through the broader economy. IMPLAN was developed in the 1970s by the US Forest Service to meet the planning requirement for economic analysis following the National Forest Management Act and the National Environmental Policy Act (Siverts et al., 1983). IMPLAN utilizes an Input-Output model to estimate the direct and indirect effects in the economy at the local, regional, and national levels as a result of economic shocks such as new investment or policy changes. Since its development in 1970s, IMPLAN has been one of the most popular tools to model economic impact (Henderson et al., 2017; Joshi et al., 2017).

IMPLAN decomposes total impacts into direct, indirect, and induced effects. Direct impacts represent the immediate economic activity generated by the project, such as employment, labor income, and output associated with SAF facility construction and operation. Indirect impacts capture upstream supply-chain effects arising from purchases of intermediate inputs, including feedstocks, chemicals, utilities, transportation, and maintenance services. Induced impacts reflect additional economic activity generated when workers employed directly and indirectly spend their earnings on household goods and services such as housing, food, healthcare, and retail. The sum of these components represents the total economic impact of the activity within the region.

IMPLAN estimates employment impacts as job-years, which include full-time, part-time, and seasonal positions supported by the modeled activity over one year. Labor income reflects total worker compensation, including wages, salaries, and employer-paid benefits. Value added measures the net contribution to regional gross domestic product (GDP) and consists of labor income, proprietor income, other property income (such as profits, rents, and interest), and taxes on production and imports net of subsidies. Economic output represents the total value of goods and services produced in the economy and includes both intermediate input purchases and value added, making it a broader measure of economic scale than value added.

In addition to economic activity, IMPLAN estimates government revenue impacts generated by the modeled activity. These impacts include federal, state, and county-level tax revenues arising from business operations, employee earnings, and household spending. Federal revenues include income and payroll taxes, while state and county revenues include income, sales, property, and other local taxes and fees. Together, these metrics provide a comprehensive assessment of how SAF-related investments contribute to employment, income generation, economic growth, and public revenues at multiple levels of government within the region.

3. Results

3.1. Technoeconomic Analysis in ASCENT TEA Models

3.1.1. Annual Production Volume of SAF and Co-products

Table 1A presents annual production volumes of SAF and associated co-products across the AtJ, FT, and HEFA pathways. Total SAF output is fixed at one hundred million gallons per year (378 million liters) under each technology pathway scenario. Under joint technologies pathway scenario, the distribution across pathways reflects the assumed deployment mix rather than differences in plant scale or utilization. Under this allocation, FT accounts for the largest SAF share (189 million liters), followed by AtJ (114 million liters) and HEFA (76 million liters). Under the individual technology pathway scenario, each pathway is scaled independently to produce one hundred million gallons of SAF annually, highlighting the maximum production potential and co-product outputs of each technology.

Co-product generation differs sharply across pathways and scales with SAF output. FT produces the largest co-product slate, including diesel (160 to 320 million liters) and naphtha (94 to 188 million liters), enhancing potential revenue and regional economic impacts from co-products. AtJ primarily yields gasoline (49 to 161 million liters) and has no diesel or naphtha output, offering lower co-product revenue but potentially more cost-competitive SAF. HEFA produces the most diversified but moderate volumes of coproducts among three technology pathways—diesel (30 to 151 million liters), naphtha (11 to 55 million liters), and propane (22 to 112 million liters). HEFA technology pathway is limited both by its SAF share and narrower product slate compared to FT.

These results demonstrate that even with a fixed SAF target, pathway choice strongly influences SAF and co-product production outcomes. FT's extensive co-product generation can offset higher SAF production costs through higher fuel production, whereas AtJ and HEFA pathways rely more heavily on SAF prices or policy support. Scaling each pathway individually illustrates the potential upper bounds of SAF and co-product output, reinforcing that deployment strategy—not just total volume—drives SAF production.

3.1.2. Minimum Selling Prices

Table 1B and Figure 2 report the minimum selling prices (MSPs) of major fuel products across three SAF conversion technology pathways expressed under joint and individual technology pathway scenarios. MSP represents the break-even price required to recover production costs under the modeled assumptions. Among the three technologies, AtJ consistently delivers the lowest MSPs for SAF which are US$0.84/liter and US$0.81/liter in joint and individual technology pathway scenarios, respectively. FT consistently delivers the highest MSPs for SAF and the MSP of SAF from HEFA technology pathways falls in between AtJ and FT. The higher minimum selling prices of FT indicate greater cost-recovery requirements relative to HEFA and AtJ pathways. The higher production cost of SAF from FT might face a higher market competition compared to SAF produced from other technologies. FT needs stronger policy support such as either higher incentives/subsides or higher fuel premiums that SAF buyers are willing to pay or both. Based on joint production pathway scenario, FT needs USD$0.84/liter and HEFA needs US$0.49/liter subsides or price premium to be competitive with AtJ. The minimum selling prices for SAF produced through AtJ pathway decreased to US$0.81/liter. Similarly, the minimum selling prices for SAF through FT and HEFA pathways also decreased to US$1.61/liter and US$1.23/liter, respectively. The decline in MSP indicates in individual technology pathways that scaling up SAF production through all three technology pathways reduce minimum selling price because of economics of scale. However, the decrease in minimum selling price by $0.03/liter for AtJ, US$0.07/liter for FT, and US$0.10/liter for HEFA for the increase in production volume by more than three times for AtJ, double for FT, and five times for HEFA suggests that the SAF production must be increased significantly to realize significant reduction in MSP solely from the economics of scale.

The co-product MSPs indicate clear differences in cost structure across SAF pathways and between joint and individual production scenarios. For the AtJ pathway, diesel MSPs range from US$0.82/liter to US$0.85/liter and gasoline MSPs from US$0.76/liter to US$0.80/liter, closely tracking SAF prices and indicating balanced cost allocation across fuel outputs. FT co-products show the highest MSPs across all pathways, with diesel and naphtha priced at US$1.64/liter to US$1.71/liter and gasoline at US$1.49/liter to US$1.55/liter, consistent with higher lipid feedstock costs. In the HEFA pathway, diesel MSPs are higher, at US$1.25/liter to US$1.36/liter, while naphtha MSPs range from US$1.15/liter to US$1.24/liter. Propane exhibits lower MSPs at US$0.52/liter to US$0.56/liter, reflecting its lower market value relative to liquid fuels. Across all technologies, MSPs are modestly lower in the individual pathway scenarios than in the joint scenario, indicating slightly improved cost recovery when each pathway is scaled independently to the same production level.

The MSP results indicate that AtJ is the most cost-competitive SAF pathway, HEFA occupies an intermediate cost position, and FT is the most expensive, implying progressively stronger policy support or price premiums are required for HEFA and especially FT to compete with AtJ. While scaling up production reduces MSPs across all pathways, the modest declines indicate that economies of scale alone are insufficient to close cost gaps without sustained incentives or market support. Co-product MSP patterns reinforce these findings, with AtJ showing balanced cost allocation, HEFA exhibiting differentiated product values, and FT reflecting persistently higher costs driven by lipid feedstock constraints.

3.1.3. Revenue at Minimum Selling Prices

Table 1C reports annual revenues from SAF and co-products evaluated at pathway-specific minimum selling prices (MSPs), expressed in million US dollars, under both joint and individual technology pathway scenarios. Because MSPs represent break-even prices, the reported revenues reflect the minimum revenue required for cost recovery rather than realized profits, and differences across scenarios are driven by production scale, MSP levels, and pathway-specific co-product yields.

Under the joint pathway scenario, total revenues vary across technologies, with AtJ generating US$134.57 million, FT generating US$168.04 million, and HEFA generating US$738.88 million annually. The high revenue associated with HEFA reflects elevated MSPs for SAF and co-products rather than greater cost efficiency. FT revenues are supported by a diversified co-product slate in which diesel and naphtha account for a large share of total revenue. AtJ generates the lowest total revenue in the joint scenario, consistent with its lower MSPs and more limited co-product portfolio, leaving SAF as the dominant revenue source.

In the individual technology pathway scenarios—where each technology independently produces one hundred million gallons of SAF—total revenues increased markedly across all pathways relative to the joint scenario. AtJ total revenue rises to US$428.16 million, driven primarily by higher SAF volumes and increased gasoline output. FT total revenue increases to US$627.51 million, with substantial contributions from diesel and naphtha, reflecting the strong scaling of co-product production at larger SAF volumes. HEFA exhibits the largest increase in total revenue, reaching US$1,161.80 million annually, reflecting both expanded production volumes and persistently high MSPs for SAF and co-products.

Comparing across all four scenarios, total revenues are consistently higher in the individual pathway scenarios than in the joint scenario for all three technologies, reflecting the direct effect of scaling each pathway independently to a fixed SAF production level. However, the sum of revenues from three technology pathways under the joint technologies pathway scenario to produce one hundred million gallons of SAF annually is US$1040.77 million, which is significantly greater than AtJ and FT but slightly less than HEFA under individual technology pathway scenarios. The higher revenues in the individual scenarios do not imply improved economic competitiveness. They, instead, indicate a greater cost recovery requirement associated with larger production scales and pathway-specific cost structures. These results highlight that differences in total revenue primarily capture variations in MSPs and co-product intensity, underscoring the importance of jointly evaluating production scale, cost structure, and revenue composition when assessing SAF deployment pathways.

3.1.4. Net Present Value and Profit at $6/Gallon SAF Market Price

Table 1D reports profits from SAF and co-products at market prices across the AtJ, FT, and HEFA pathways, including average annual profit (average OPI), net present value (NPV), and equivalent annual profit (EAP), under both joint and individual technology pathway scenarios. Profits are calculated at US$6/gallon market prices, reflecting the ability of each pathway to generate returns above production costs and capture co-product value, rather than merely achieving break-even revenue.

Under the joint pathway scenario, the AtJ pathway generates positive profits, with an average annual profit of US$96.2 million, NPV of US$1,387.5 million, and EAP of US$84.9 million, indicating that AtJ is currently the most economically viable SAF pathway at the market conditions. In contrast, FT and HEFA pathways show negative profits in the joint scenario (FT: average annual profit US$76.0 million; HEFA: US$6.4 million), reflecting higher production costs, capital intensity, and feedstock constraints that are not fully offset by market prices for SAF and co-products. FT, in particular, exhibits substantial negative NPV (US$3,195.5 million), suggesting that large-scale deployment under current market conditions would be economically challenging without policy support or favorable market signals.

In the individual technology pathway scenarios—where each technology independently produces approximately one hundred million gallons of SAF—profits diverge further. AtJ profits increase significantly (average annual profit US$332.5 million; NPV US$4,885.1 million; EAP US$298.8 million), benefiting from higher SAF volumes and gasoline co-product contributions. FT profits decline further into the negative (average annual profit -US$112.3 million; NPV -US$5,450.6 million; EAP -US$333.3 million), reflecting amplified capital and operating costs at full production scale without joint revenue support from other pathways. HEFA shows marginally positive average annual profit (US$10.0 million) but negative NPV and EAP, indicating that while break-even can be approached, significant capital recovery remains constrained under current market conditions.

These results highlight that economic viability varies sharply by technology and scale. AtJ is currently the most competitive pathway, whereas FT and HEFA require either significant policy support, favorable co-product markets, or reductions in feedstock and capital costs to achieve positive returns. Profit outcomes also demonstrate that co-product value alone is insufficient to offset higher production costs in capital- or feedstock-intensive pathways, emphasizing the need for targeted incentives, such as production subsidies, offtake guarantees, or feedstock price supports, to enable sustainable SAF deployment across diverse technologies.

3.2. IMPLAN: Regional Economic Indicators by Impact

3.2.1. Employment

The joint technologies pathway scenario, which reflects concurrent deployment of AtJ, FT, and HEFA to produce one hundred million gallons of SAF, generates a combined total of 65,577 jobs summed across three technology pathways (Table 13.A1, Figure 3A, and Figure 3B). Employment effects are broadly distributed across direct, indirect, and induced effects, with particularly strong spillover effects from FT due to its capital and supply chain intensive structure. In contrast, individual technology pathway scenarios, each scaled to produce the same one hundred million gallons of SAF independently, generate larger employment impacts on their own, reflecting the higher standalone investment and supply chain requirements of single pathway scale-up scenarios.

Under individual technology pathway scenario, FT produces the largest employment impact, supporting 112,172 jobs, which is about 1.71 times larger than total employment from three technology pathways combined under the joint technologies pathway scenario. This difference is driven primarily by very large indirect employment effects and high Type I and social accounting matrix (SAM) multipliers, underscoring FT’s deep upstream linkages. AtJ, under the individual technology pathway scenario, supports 7,912 jobs, which is far smaller than total employment under the joint scenario, indicating that AtJ’s employment contribution is comparatively modest when deployed alone. The employment potential of AtJ in the joint case comes from interaction with other pathways. Unlike FT, AtJ has smaller supply chain linkage in the local economy, resulting into small employment impact in the local economy. HEFA generates 15,895 jobs under individual technology pathway scenario, which is significantly below the total employment supported by the joint pathways scenario, reflecting HEFA’s lower labor intensity and weaker supply-chain spillovers compared with FT.

These results highlight a key tradeoff for SAF deployment strategy reflecting variation in feedstock intensity, capital requirement, and upstream-supply chain linkage in each production pathway. Joint deployment of multiple technologies delivers a moderate but diversified employment outcome, spreading economic activity across pathways and supply chains. In contrast, single technology scales up, especially FT, can generate much larger employment impacts but concentrates investment and economic activity in one pathway. From a policy perspective, technology-diversified SAF strategies may prioritize risk reduction and system resilience, while technology-specific incentives (particularly for FT) may maximize job creation. The choice between joint and individual deployment thus reflects broader policy objectives regarding employment intensity, diversification, and regional economic development.

3.2.2. Labor Income

The joint technologies pathway scenario generates a combined labor income of approximately US$4.41 billion from three technology pathways (Table 13.A2, Figure 3C, and Figure 3D). Labor income impacts in the joint scenario are driven primarily by FT, which accounts for the majority of direct, indirect, and induced earnings, while AtJ and HEFA contribute more modest but complementary income effects. When compared with the individual technology pathway scenarios, the difference in scale and structure of the labor income generation from three individual technology pathways are distinctly visible.

The FT produces the largest labor income impact generating US$7.09 billion, which is higher than the total labor income under joint pathways scenario. FT is consistently delivering higher economic impact because of its deeply rooted supply-chain linkage in the local economy, high wage payment, and the large Type I and SAM multipliers. HEFA pathway, under single technology pathway, generates US$1.34 billion in labor income which is significantly below the total labor income supported by joint pathways scenarios. This is consistent with HEFA's lower labor-intensive supply chain and weak linkage in the local economy. AtJ supports US$589 million in labor income, which is also significantly smaller than the joint scenario total. AtJ also indicates a comparatively weaker wage and spillover effects when AtJ technology pathway is scaled individually.

This result demonstrates the employment finding that joint deployment of multiple SAF technologies yields moderate but diversified labor income impacts. This income remains spread across the economy because of diversified economic impact across multiple value chains associated with three different technology pathways. The variation in labor income reflects difference in labor intensity and wage structure across the technology pathway supply chain. From policy standpoints, joint pathway may be better aligned with balanced regional income distribution and risk diversification. The maximum income might be generated by developing technology specific incentives to support FT pathway. Policymakers should therefore weight on total income regeneration, technology diversification, feedstock resilience, and workforce concentration when designing SAF support policy.

3.2.3. Value Added (Contribution to the GDP)

The joint technologies pathway scenario generates a combined value added of approximately $8.3 billion as a contribution to the regional gross domestic product (GDP). Within the joint scenario, FT accounts for the largest share of GDP contribution, driven primarily by strong indirect and induced effects, while AtJ contributes substantial direct value added and HEFA provides a smaller but complementary contribution (Table 13.A3, Figure 3E, and Figure

3F). Compared to HEFA, AtJ generates higher contribution to GDP despite HEFA exhibiting stronger performance in other economic impacts indicator such as employment, labor income, and total output. This underscore differences in capital intensity, labor productivity, and value-added structure across SAF pathways.

In contrast, the individual technology pathway scenario shows a markedly different GDP output. FT under individual scenario delivers largest GDP contribution, adding 11.6 billion to the regional economy and exceeding the GDP contribution observed under the joint technologies pathway scenario. AtJ and HEFA both contributes US$5.8 and US$3.0 billion to the regional GDP. Both of these contributions are significantly smaller than joint technologies pathway scenario. These variations in the GDP across pathways and scenario are the result of variation in industry composition and regional value chain interactions captured by the economic impact model. The results from joint and individual technology pathway scenario highlights important economic tradeoffs between technology pathways through GDP contributions, employment generation, labor income, and total output.

3.2.4. Total Output

The total output represents gross economic activity across the economy (Table 13.A4, Figure 3G, and Figure 3H). The joint technologies pathway scenario generates a combined total economic impact of US$26.2 billion from three technology pathways. When compared with individual technology pathways, the scale of economic impact is prominently noticeable. Under individual technology pathway, FT has the largest economic impact, producing US$37.1 billion in total economic output. HEFA, under individual pathway scenario, produces US$15.0 billion in output, which is smaller than the joint scenario total, indicating that HEFA alone generates less economy-wide production activity than a diversified deployment strategy. Similarly, AtJ supports US$8.4 billion in the output, which is significantly below the joint pathways total, reflecting AtJ's modest production scale and lower upstream purchasing intensity when deployed independently.

The total output shows an important distinction for policy makers whether to support output maximizing strategy or balanced activities strategies. FT technology pathway deployment maximizes total production activity and supply-chain but also reflects a more resource and input intensive pathway. Whereas joint deployment of three SAF technologies balances SAF production and distribution of economic activities across multiple value chain and spreading impacts across a wider range of industries, reducing reliance on any single supply chain. In joint technologies pathway scenario, AtJ and HEFA plays a complementary role expanding the breadth of economic activity and help distribute production and economic effects across sectors and regions.

3.3. IMPLAN: Regional Taxes and Government Revenue

3.3.1. County Tax

The county tax results represent local government revenue generated through economic activity associated with SAF deployment (Table 13.B1, Figure 4A, Figure 4B). Under the joint technologies pathway scenario, the combined county tax revenue from AtJ, FT, and HEFA amounts to approximately US$198.1 million, reflecting diversified fiscal gains across multiple technologies and supply chains. When compared with individual technology pathway scenarios, clear differences in the scale of local tax generation emerge. The FT individual pathway generates the largest county tax revenue at US$320.0 million, exceeding the joint scenario total, driven by strong indirect and induced effects and high fiscal multipliers. In contrast, HEFA under the individual pathway generates US$68.7 million in county tax revenue. The county tax impact is significantly below the joint scenario total, indicating more limited local fiscal spillovers when deployed alone. Similarly, the AtJ individual pathway supports only US$21.3 million in county tax revenue.

From a policy perspective, the county tax results highlight a familiar tradeoff between revenue maximization and fiscal diversification. A single-technology FT deployment strategy maximizes county-level tax revenues, offering substantial short-run gains for local governments but concentrating fiscal benefits within one pathway and associated supply chains. In contrast, joint deployment of multiple SAF technologies generates lower total county tax revenue than FT alone but spreads fiscal benefits more broadly across industries and regions, reducing reliance on a single technology or feedstock system. Within the joint technologies pathway scenario, AtJ and HEFA play complementary roles, expanding the local tax base and contributing to a more stable and diversified revenue structure. These findings suggest that policymakers must balance maximum local revenue generation against resilience, diversification, and long-term fiscal stability when designing SAF deployment and incentive strategies.

3.3.2. State Tax

The state tax results capture government revenue accruing at the state level the production of one hundred million gallons of SAF (Table 13.B2, Figure 4C, Figure 4D). Under the joint technologies pathway scenario, the combined state tax revenue generated by AtJ, FT, and HEFA is approximately US$385.3 million. In comparison, individual technology pathway scenarios exhibit markedly different revenue outcomes. The FT individual pathway generates the largest state tax revenue at US$606.2 million, exceeding the joint scenario total, driven by strong indirect and induced effects and high state-level fiscal multipliers. In contrast, HEFA under the individual pathway produces US$132.3 million in state tax revenue, which is significantly below the joint pathways. Similarly, the AtJ individual pathway supports US$92.5 million in state tax revenue.

The state tax results reinforce the tradeoff between revenue maximization and fiscal diversification. A single-technology FT deployment strategy maximizes state-level tax revenues, offering substantial gains for public budgets but concentrating fiscal benefits within one technology pathway and its associated supply chains. By contrast, joint deployment of multiple SAF technologies yields lower total state tax revenue than FT alone but distributes fiscal benefits more evenly across sectors and regions, reducing dependence on a single pathway. Within the joint technologies pathway scenario, AtJ and HEFA play complementary roles, expanding the state tax base and contributing to a more stable and diversified fiscal structure. These findings suggest that state policymakers must weigh short-term revenue maximization against long-term resilience and balanced economic development when designing SAF policy and incentive frameworks.

3.3.3. Federal Tax

The federal tax results capture government revenue accruing at the national level from SAF production (Table 13.B3, Figure 4E, Figure 4F). Under the joint technologies pathway scenario, the combined federal tax revenue generated by AtJ, FT, and HEFA amounts to approximately US$1.04 billion. However, the scale of revenue generation differs under individual technology pathway scenarios. The FT individual pathway generates the largest federal tax revenue at

US$1.60 billion, which significantly exceeds the joint scenario total, driven by strong indirect and induced effects and high federal tax multipliers. In contrast, HEFA under the individual pathway produces US$345.5 million in federal tax revenue, which is significantly below the joint pathways scenario. The AtJ individual pathway generates US$352.9 million in federal tax revenue, reflecting a smaller economic footprint and lower upstream linkages relative to FT.

From a policy perspective, the federal tax results highlight a familiar tradeoff between revenue maximization and fiscal diversification at the national level. A single-technology FT deployment strategy maximizes federal tax receipts, offering substantial short-run gains to the federal budget but concentrating economic activity and fiscal benefits within one SAF pathway. In contrast, joint deployment of multiple SAF technologies yields lower total federal tax revenue than FT alone but spreads fiscal benefits across a broader set of industries and value chains, reducing reliance on a single technology or feedstock system. Within the joint technologies pathway scenario, AtJ and HEFA play complementary roles, expanding the federal tax base and contributing to a more stable and diversified revenue structure. These findings suggest that federal policymakers must balance revenue maximization with economic diversification, risk mitigation, and long-term fiscal sustainability when designing SAF deployment and incentive policies.

3.3.4. Total Tax

The total tax results capture overall government revenue generated from SAF-related economic activity across all levels of government, including federal, state, county, and additional sub-county general, and special districts. The sub-county and special districts taxes are not reflected in the federal, state, or county tax categories (Table 13.B4, Figure 4G, Figure 4H). Under the joint technologies pathway scenario, the combined total tax revenue generated by AtJ, FT, and HEFA amounts to approximately US$1.94 billion. In comparison, individual technology pathway scenarios show pronounced differences in revenue generation. The FT individual pathway generates the largest total tax revenue at US$3.05 billion. In contrast, HEFA under the individual pathway generates US$658.1 million in total tax revenue. Similarly, the AtJ individual pathway supports US$501.3 million in total tax revenue.

From a policy perspective, the total tax results reinforce the tradeoff between revenue maximization and fiscal diversification across all levels of government. A single-technology FT deployment strategy maximizes aggregate tax receipts, offering substantial gains across federal, state, and local budgets but concentrating fiscal benefits within one SAF pathway and its associated supply chains. By contrast, joint deployment of multiple SAF technologies yields lower total tax revenue than FT alone but distributes fiscal benefits more broadly across districts and tax bases, reducing reliance on a single technology or feedstock system. Within the joint technologies pathway scenario, AtJ and HEFA play complementary roles, expanding the overall tax base and contributing to a more stable and diversified revenue structure. These findings suggest that policymakers must balance short-term tax revenue maximization against long-term fiscal resilience, diversification, and equitable distribution of public revenues when designing SAF deployment and incentive strategies.

3.4. IMPLAN: Economic Impact Across the Industry

The economic impact of additional investment in the sustainable aviation fuel (SAF) industry varies markedly across the region, reflecting the distinct input requirements and linkages associated with each SAF production pathway. Across the AtJ, FT, and HEFA pathways, certain industries consistently exhibit high sensitivity to investment, while others register comparatively modest gains, highlighting potential leverage points for regional policy and economic development. Under the joint technologies pathway scenario (Table 2 and Figure 5), sectoral impacts are moderate in scale but broadly distributed across upstream production, energy, construction, and service industries. Core sectors such as basic organic chemical manufacturing, construction of manufacturing structures, electric power transmission, and natural gas distribution emerge as common beneficiaries across pathways, while housing, healthcare, real estate, finance, and transportation reflect induced household-spending effects. This pattern indicates that joint deployment spreads economic activity across multiple value chains, reducing reliance on any single industry or feedstock system and supporting a more balanced regional economic footprint.

In contrast, the individual technology pathway scenario (Table 3 and Figure 6) generates larger and more concentrated sectoral impacts, particularly for the FT pathway, which dominates upstream chemical manufacturing, energy supply, construction sectors. Standalone deployment intensifies feedstock-specific linkages: AtJ strongly engages grain and crop farming, FT drives forestry, industrial gas manufacturing, and energy-related industries, and HEFA concentrates impacts in fats, oils, and oilseed processing sectors. While individual pathway investments, especially FT, maximize output gains in key industries. FT also concentrate economic activity within narrower segments of the supply chain, increasing exposure to feedstock availability, infrastructure constraints, and market volatility. Relative to this concentration, the joint pathway scenario trades some scale for diversification and resilience, suggesting that technology-mixed SAF deployment strategies may better support stable, broad-based regional development alongside long-term decarbonization goals.

4. Discussions and Policy Implications

This study evaluates the regional economic implications of scaling SAF production to one hundred million gallons annually in Georgia as a representative case of a feedstock-diverse southern economy using three ASTM-approved pathways: AtJ, FT, and HEFA, under both joint and individual technology pathway deployment scenarios. While impact magnitudes are region-specific, the relative ranking and trade-offs across SAF pathways are expected to generalize to regions with similar feedstock availability and industrial structures. By integrating techno-economic modeling with IMPLAN economic impact analysis, the results provide a comprehensive assessment of how alternative SAF investment strategies shape employment, income, gross economic activity, GDP contributions, fiscal revenues, and sectoral spillovers.

Across all indicators, individual technology pathway scenarios, particularly FT, generate larger absolute economic impacts than the joint deployment scenario. Standalone FT deployment consistently maximizes employment, labor income, output, value added/GDP, and tax revenues across federal, state, county, and sub-county districts. These results reflect FT's capital intensity, extensive upstream supply-chain requirements, and strong indirect and induced effects, as evidenced by high Type I and SAM multipliers. From a narrow economic-scale perspective, FT-focused investment strategies therefore offer the largest immediate gains in production activity, GDP contribution, and public revenues. In contrast, AtJ and HEFA generate more modest standalone impacts, reflecting smaller production footprints and more limited upstream linkages, though each pathway activates distinct agricultural, energy, and processing sectors.

However, the joint technologies pathway scenario presents a qualitatively different economic profile. While total impacts are smaller than those achieved by standalone FT deployment, joint deployment produces substantial and diversified economic gains, including reasonable contributions to employment, labor income, GDP, and tax revenues. Importantly, joint deployment distributes economic activity across multiple supply chains and industries—spanning agriculture, forestry, energy, construction, manufacturing, transportation, finance, and household-serving sectors—thereby reducing dependence on any single technology, feedstock, or industrial cluster. Sectoral results reinforce this distinction: individual deployment intensifies feedstock-specific linkages (e.g., grains for AtJ, forestry for FT, fats, and oils for HEFA), whereas joint deployment broadens the economic footprint and moderates concentration risks.

The distinction between output and value added or GDP further sharpens the policy relevance of these findings. While FT maximizes gross output and supply-chain throughput, joint deployment generates a large and more evenly distributed contribution to regional GDP, supporting stable economic growth rather than purely input-intensive activity. Similarly, tax results show that although FT-only deployment maximizes total government revenues, joint deployment spreads revenues more evenly across federal, state, county, and sub-county districts, enhancing fiscal resilience and reducing vulnerability to technology-specific shocks. These tradeoffs are particularly salient for state and local governments, where stable revenue streams and diversified tax bases are often prioritized alongside growth.

The results highlight a central policy tradeoff in SAF deployment strategy. Technology-specific incentives are well suited to output, GDP, and revenue maximizing objectives, particularly in the near term. In contrast, technology-diversified strategies emphasize balanced growth, risk mitigation, and regional resilience, aligning more closely with long-term energy transition goals and equitable economic development. From a policy perspective, these findings suggest that SAF support mechanisms should not be evaluated solely on the basis of aggregate economic magnitude. Instead, policymakers should consider how economic benefits are distributed across industries, regions, and levels of government, and how deployment strategies interact with supply-chain constraints, workforce capacity, and feedstock availability.

The economic impacts reported in this study should be interpreted as accounting-based estimates derived from a fixed-coefficient input–output framework, rather than as causal or equilibrium effects of SAF policy or investment decisions. IMPLAN traces how pathway-specific production cost structures propagate through existing regional supply chains under the assumption of constant production technologies, fixed prices, and unconstrained factor availability. As such, the results do not capture price or wage adjustments, substitution across inputs, crowding-out of other economic activity, or displacement effects that may arise under large-scale or long-run deployment. Reported impacts therefore represent gross economic activity supported by SAF production, not net changes relative to an alternative baseline. In addition, employment effects are expressed in job-years, reflecting labor demand over the construction and operational phases, rather than permanent job creation. Within these bounds, the input-output framework provides a transparent and policy-relevant accounting of how differences in SAF pathway input structures and feedstock requirements translate into distinct regional economic patterns, enabling consistent comparison across technologies while holding output constant.

Summarizing, this analysis indicates that joint SAF deployment pathways can complement, rather than substitute for, technology-specific scale-up strategies. A phased or hybrid policy approach—combining near-term support for high-impact pathways such as FT with longer-term incentives for diversified deployment—may offer the most effective balance between economic scale, resilience, and sustainability. By explicitly linking techno-economic feasibility with regional economic outcomes, this study provides a policy-relevant framework for designing SAF strategies that advance decarbonization while supporting durable and inclusive economic growth.

5. Conclusions

This paper integrates the ASCENT techno-economic model with IMPLAN's total economic impact framework to evaluate the economic implications of producing a fixed volume of one hundred million gallons of sustainable aviation fuel using alternative technology pathways. By holding SAF output constant, the analysis isolates how differences in capital requirements, operating structures, and supply chain linkages translate into varying employment, labor income, and value-added impacts from equivalent production targets. The results show that achieving the same SAF volume can generate markedly different regional economic outcomes depending on the underlying technology and investment profile, highlighting that SAF policies should account not only for emissions reductions and fuel volumes but also for how investment dollars circulate through local and regional economies. Designing technology-aware and regionally targeted incentives can therefore enhance the economic returns of SAF deployment while advancing decarbonization objectives.

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Tables

Table 1: Annual production, prices, revenue, and profit from SAF technologies and their co-products to produce one hundred million gallons of SAF.

SAF and Co-products Production, Revenue, and Profits	Joint Technologies Pathway Scenario			Three Individual Technology Pathway Scenarios		
	AtJ	FT	HEFA	AtJ	FT	HEFA
A: Annual Production Quantity (Million Liters):						
SAF [4]	114	189	76	378	378	378
Diesel	-	160	30	-	320	151
Gasoline	49	-	-	161	-	-
Naphtha	-	94	11	-	188	55
Propane	-	-	22	-	-	112
B: Minimum Selling Prices (US$/Liter):						
SAF	0.84	1.68	1.33	0.81	1.61	1.23
Diesel	-	1.71	1.36	-	1.64	1.25
Gasoline	0.80	-	-	0.76	-	-
Naphtha	-	1.55	1.24	-	1.49	1.15
Propane	-	-	0.56	-	-	0.52
C: Annual Revenue at Minimum Selling Price (Million US$):						
SAF	95.85	318.16	100.86	304.79	607.72	465.57
Diesel	-	274.54	41.11	-	274.54	41.11
Gasoline	38.72	-	-	123.37	-	-
Naphtha	-	146.17	13.57	-	279.54	62.81

[4] We standardized analysis based on total volume of SAF produced at one hundred million gallons (378 Million Liters) and allow co-product to freely adjust to SAF production volume. 378 million liters of SAF is about one hundred million gallons of SAF.

Propane	-	-	12.50	-	-	58.02
Total Revenue at MSP	134.57	168.04	738.88	428.16	627.51	1161.80
D: Profits from SAF and Co-product at Market Prices (Million US$):						
Average Annual Profit (Average OPI)	96.18	-76.03	-6.38	332.5	-112.3	10.0
Net Present Value (NPV)	1,387.54	-3,195.45	-221.14	4,885.1	-5,450.6	-154.3
Equivalent Annual Profit (EAP)	84.86	-195.42	-13.52	298.8	-333.3	-9.4

Notes: The annual revenue at minimum selling price for SAF and co-products is calculated assuming minimum selling price and annual production remain constant throughout the operation period. The market prices for sustainable aviation fuel = $6/gallon ($1.59/liter), diesel = $2.35/gallon ($0.62/liter), naphtha = $525/Metric ton ($0.65/liter), and gasoline = $1.77/gallon ($0.47/liter) and propane = $0.82/gallon ($0.22/liter). Market Prices were used in the calculation of annual revenue and profit. Average annual profit (AAP) is the average of OPI in

Table **10**. Loan repayment for the entire project was included in the Net Present Value (NPV) and Equivalent Annual Profit (EAP) calculations, but loan repayment is not adjusted in Average OPI Profit calculation. Annual profits at MSP, net present value, and OPI at market prices are adjusted for inflation. Equivalent annual profit (EAP) is defined as the constant real annual profit that yields the same net present value as the project's stream of annual profit over its operating life. NPV = $\sum_{t=1}^{T=20} \frac{\pi_t}{(1+r)^t}, and$ EAP = $NPV * \frac{r(1+r)^T}{-1+(1+r)^T}$, where discount rate (r) = 0.02, final year (T) = 20, operating year (t) = 1 to 20, and π is nominal annual profit.

Table 2: Top fifteen Industry sectors impacted by the new investment in three SAF production pathway technologies (Joint technologies pathway scenario).

IMPLAN Industry Code	IMPLAN Industry Description	Industry Total Output	Impact Output		
			AtJ	FT	HEFA
155	Other basic organic chemical manufacturing	1,496.63	2,070.52	8,388.61	2,510.39
2	Grain farming	286.36	75.11	-	-
46	Construction of new manufacturing structures	7,208.89	69.34	2,147.99	127.28
42	Electric power transmission and distribution	22,042.71	31.94	2,157.62	14.96
431	Owner-occupied housing	67,700.74	11.83	314.85	28.84
43	Natural gas distribution	2,012.79	10.29	211.18	NA
383	Wholesale - Other nondurable goods merchant wholesalers	16,732.16	8.63	224.67	36.34
429	Other real estate	61,171.07	6.47	194.23	16.19
472	Hospitals	37,002.41	6.22	165.32	15.19
399	Truck transportation	19,695.89	5.48	147.43	20.65
423	Monetary authorities and depository credit intermediation	41,067.07	5.36	151.79	12.55
451	Management of companies and enterprises	27,280.78	4.85	132.24	14.92
36	Electric power generation - Nuclear	3,080.74	4.4	297.06	NA
152	Industrial gas manufacturing	250.28	4.23	166.28	34.36
465	Offices of physicians	27,345.27	4.15	-	-
10	All other crop farming	1,465.85	-	1,117.73	-
15	Forestry, forest products, and timber tract production	75.88	-	597.56	-
65	Fats and oils refining and blending	1,175.12	-	-	188.79
64	Soybean and other oilseed processing	4,356.41	-	-	76.52
381	Wholesale - Grocery and related product wholesalers	8,149.26	-	-	20.06

Notes: Industries ranked beyond top fifteen for the given technology pathway are not reported. Units are Million US$. IMPLAN Industry code is the nominal value given by IMPLAN for each industry listed under the INPLAN industry description column. Industry total output is the total current production capacity of the industry in the state of GA, USA. Impact output for each technology is the total impact made by additional investment in the SAF industry following three feedstock pathways at the proportion of 30% from AtJ, 50% from FT, and 20% from AtJ technology pathways to produce one hundred million gallons of SAF. The industry

Table 3: Top fifteen Industry sectors impacted by the new investment in three SAF production pathway technologies (Three individual technology pathway scenarios)

IMPLAN Industry Code	**IMPLAN Industry Description**	**Industry Total Output**	**Impact Output**		
			AtJ	**FT**	**HEFA**
155	Other basic organic chemical manufacturing	1,496.63	6,382.32	15,508.35	11,455.08
2	Grain farming	286.36	1,117.41	-	-
46	Construction of new manufacturing structures	7,208.89	142.03	3,789.72	292.35
42	Electric power transmission and distribution	22,042.71	92.52	3,975.23	60.98
431	Owner-occupied housing	67,700.74	48.2	570.65	113.3
43	Natural gas distribution	2,012.79	29.63	406.62	-
383	Wholesale - Other nondurable goods merchant wholesalers	16,732.16	28.7	394.97	151.56
472	Hospitals	37,002.41	25.24	299.57	59.68
429	Other real estate	61,171.07	23.92	351.99	62.06
423	Monetary authorities and depository credit intermediation	41,067.07	18.54	271.69	48.63
465	Offices of physicians	27,345.27	17.13	-	40.54
399	Truck transportation	19,695.89	16.35	263.13	81.93
451	Management of companies and enterprises	27,280.78	15.88	241.26	60.91
492	Limited-service restaurants	23,252.42	13.86	-	-
36	Electric power generation - Nuclear	3,080.74	12.74	547.31	-
10	All other crop farming	1,465.85	-	2,015.68	-
15	Forestry, forest products, and timber tract production	75.88	-	1,104.37	-
152	Industrial gas manufacturing	250.28	-	292.31	143.02
65	Fats and oils refining and blending	1,175.12	-	-	786.72
64	Soybean and other oilseed processing	4,356.41	-	-	318.86

Notes: Industries ranked beyond top fifteen for the given technology pathway are not reported. Units are Million US$. IMPLAN Industry code is the nominal value given by IMPLAN for each industry listed under the INPLAN industry description column. Industry total output is the total current production capacity of the industry in the state of GA, USA. Impact output for each technology is the total impact made by additional investment in the SAF industry following three feedstock pathways at the proportion of 30% from AtJ, 50% from FT, and 20% from AtJ technology pathways to produce one hundred million gallons of SAF. The industry

Figures

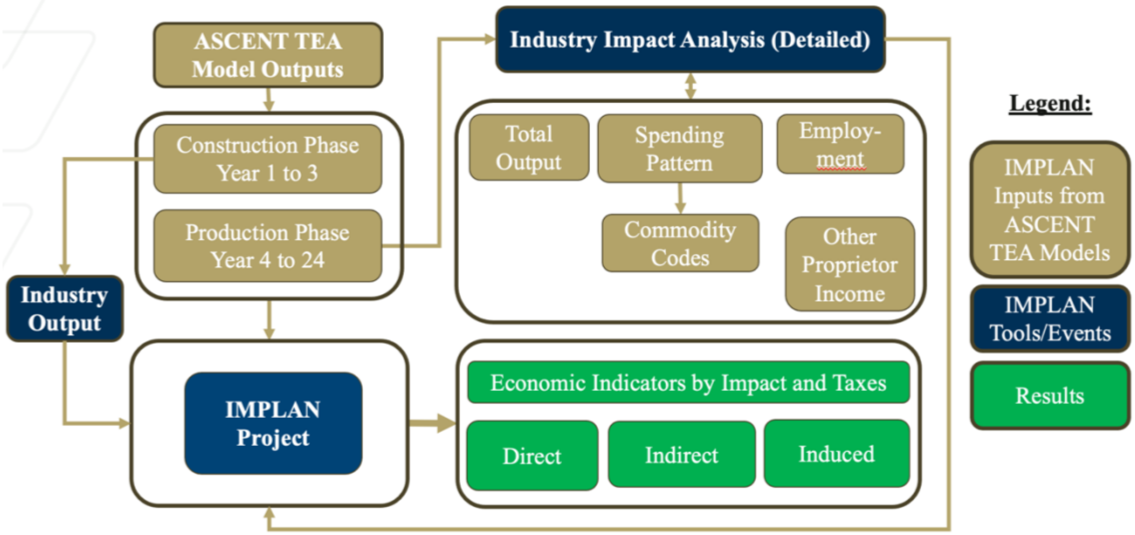
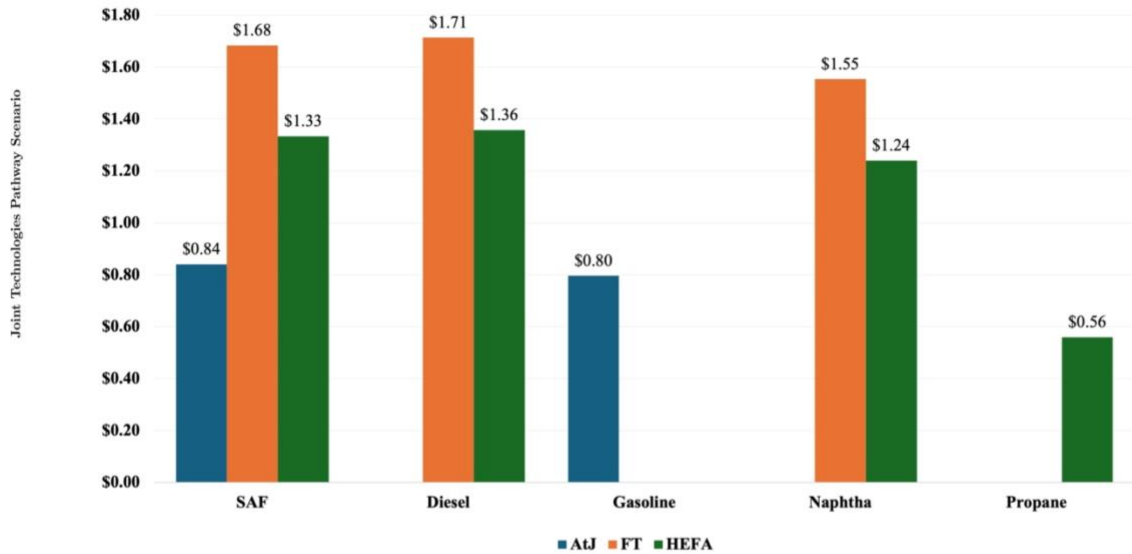
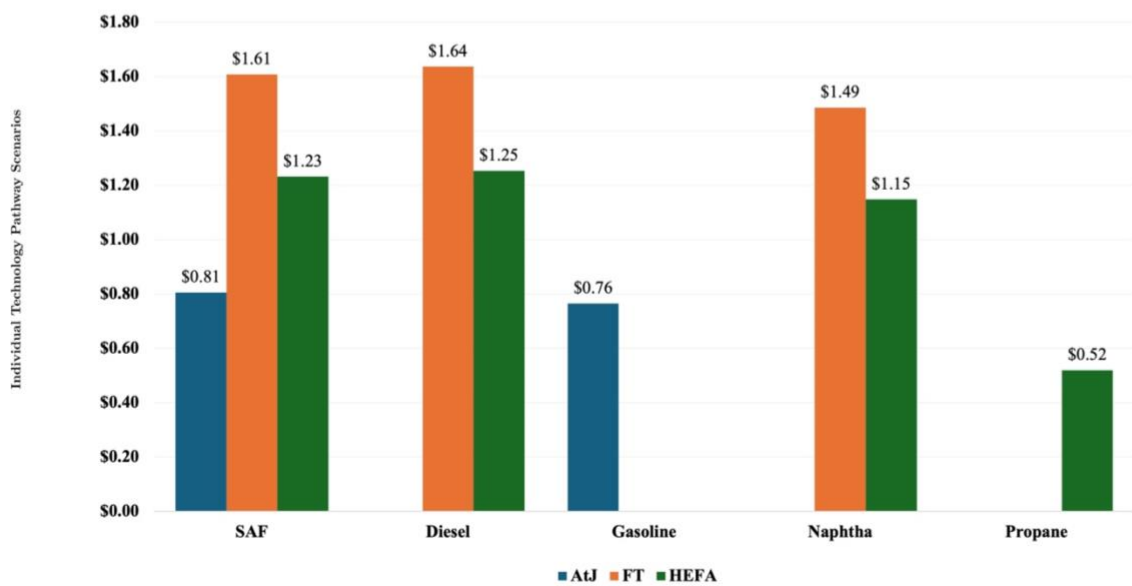


Figure 1: IMPLAN Modeling Approach

Notes: This figure demonstrates flow-chart of parameters modeled in IMPLAN. The same approach was followed for individual and joint case scenario for all three technology pathways.



(A)



(B)

Figure 2: Minimum selling prices of SAF and Co-products from AtJ, FT, and HEFA Pathways A: Joint technologies pathway scenario and B: Three individual technology pathway scenarios.

Notes: Minimum selling prices are based on annual production of one hundred million gallons of SAF at the proportion of 30:20:50 from AtJ, HEFA, and FT pathways, respectively. Co-products of AtJ pathways are diesel and gasoline. Co-products of FT pathway are diesel, naphtha, and gasoline. Co-product of HEFA pathway are diesel, naphtha, and propane. Units are US$/Liter.

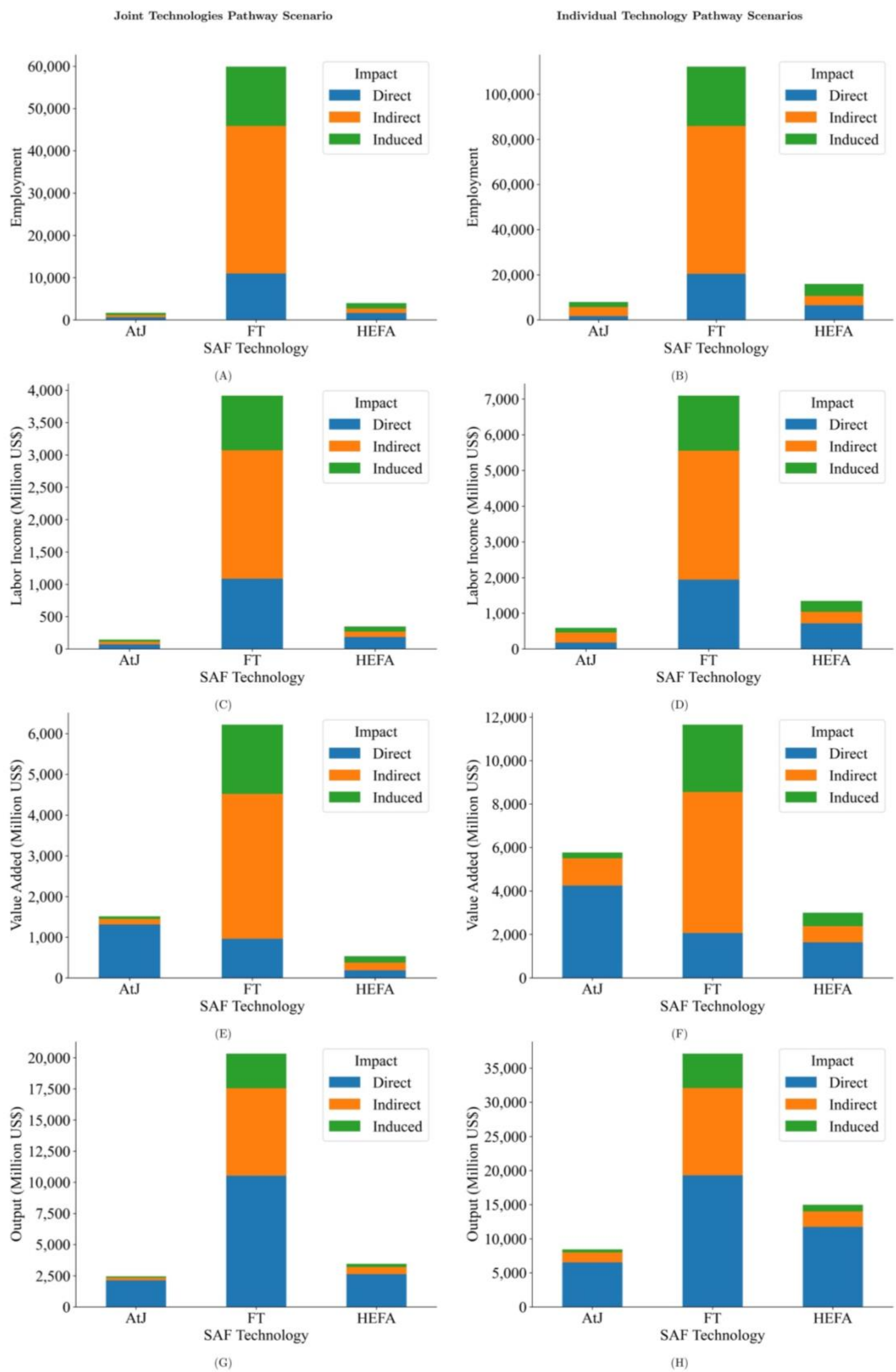

Joint Technologies Pathway Scenario
Individual Technology Pathway Scenarios
Impact
Direct
Indirect
Induced
Employment
Labor Income (Million US$)
Value Added (Million US$)
Output (Million US$)
AtJ
FT
HEFA
SAF Technology
(A)
(B)
(C)
(D)
(E)
(F)
(G)
(H)

Figure 3: Economic impact of one hundred million gallons plant in Southeast USA.

Notes: The first column represent results from joint technologies pathway scenario where three technologies are jointly producing one hundred million gallons of SAF annually. The second column represents result from three individual technology pathway scenario where three technologies are assumed to produce one hundred million gallons of SAF per year. In both cases, total economic impacts are grouped by technology pathways. The first row is the total employment generated because of new investment in the region. The second row represents total labor income generated by the new investment in the region. The third row represent total value added by the new investment which is equivalent to total contribution to the GDP in the local economy. The total output in the fourth row is the total economic output generated by the new investment in the economy by the new investment. These economic impacts are divided into direct, indirect, and induced effects.

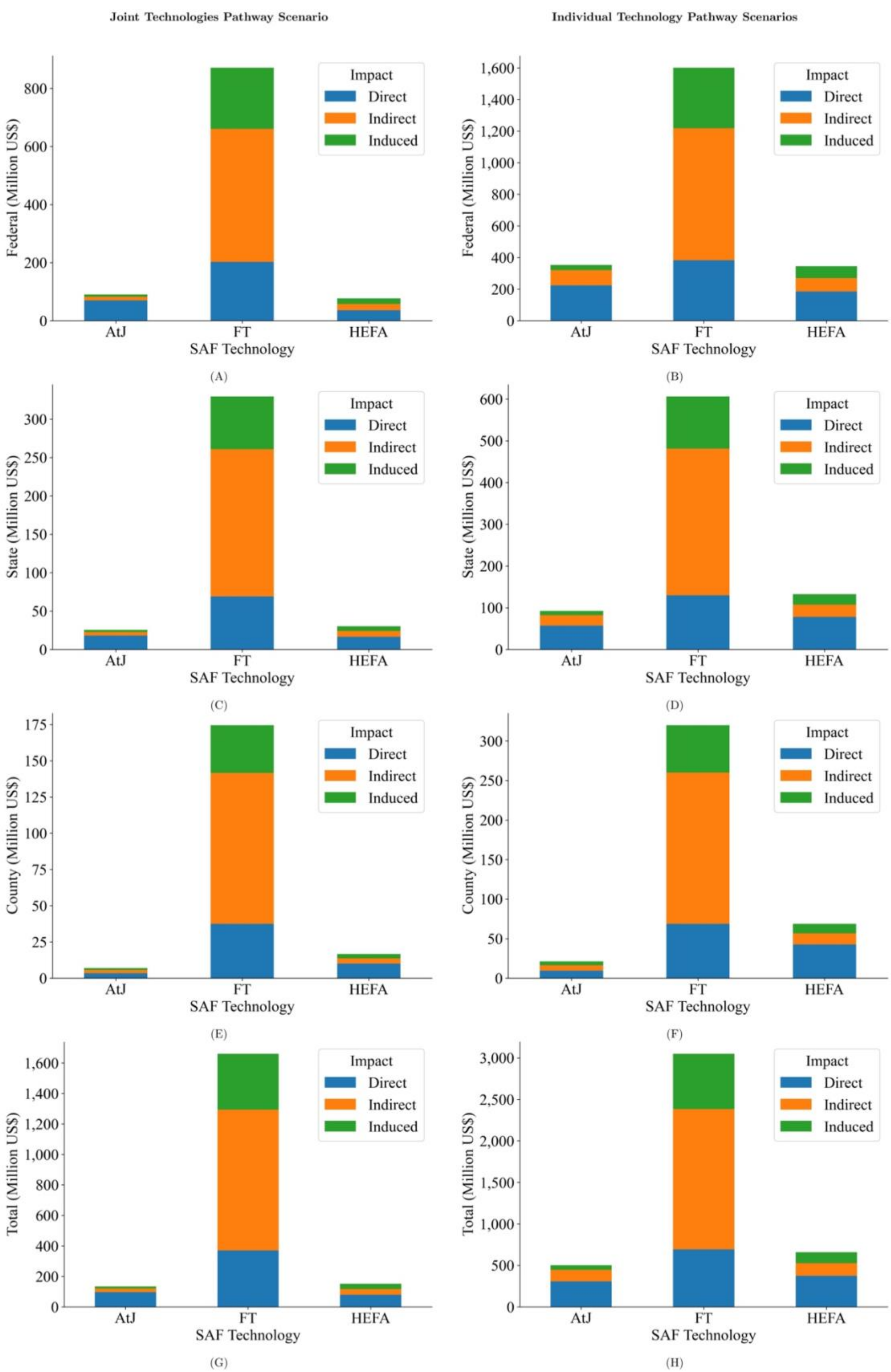

Joint Technologies Pathway Scenario
Individual Technology Pathway Scenarios
Impact
Direct
Indirect
Induced
Federal (Million US$)
State (Million US$)
County (Million US$)
Total (Million US$)
AtJ
FT
HEFA
SAF Technology
(A)
(B)
(C)
(D)
(E)
(F)
(G)
(H)

Figure 4: Tax/Government revenue impact of one hundred million gallons plant in Southeast USA.

Notes: The first column represent results from joint technologies pathway scenario where three technologies are jointly producing one hundred million gallons of SAF annually. The second column represents result from three individual technology pathway scenarios where three technologies are assumed to produce one hundred million gallons of SAF per year. In both cases, tax impacts are grouped by technology pathways. The first row is the total federal tax generated because of new investment in the region. The second row represents total state tax generated by the new investment in the region. The third row represent county tax generated by the new investment which is equivalent to total contribution to the GDP in the local economy. The total tax in the fourth row represents the sum of total tax generated at the federal, state, county, sub-county districts, and sub-county special districts levels by the new investment in the economy by the new investment. These economic impacts are divided into direct, indirect, and induced effects.

Appendix

Table 4: ASCENT Technoeconomic Model parameters and input values to produce one hundred million gallons of SAF per year using AtJ, FT, and HEFA technology pathways (Joint technologies pathway scenario).

Description	**AtJ**	**FT**	**HEFA**
Financial parameters:			
Plant Maturity	n^{th}	n^{th}	n^{th}
Incentives	No	No	No
Analysis Perspective	Weighted average cost of capital (WACC)	Weighted average cost of capital (WACC)	Weighted average cost of capital (WACC)
Depreciation Schedule	Double declining balance to straight line	Double declining balance to straight line	Double declining balance to straight line
DDB to SL Duration (Years)	7	7	7
SL duration (Years)	7	20	20
Real cost of equity	10%	10%	10%
Corporate tax rate	17.3%	17.3%	17.3%
Inflation	2%	2%	2%
Equity Share	30%	30%	30%
Loan interest rate (no incentives)	8%	8%	8%
Loan Terms (years)	10	10	10
Property Insurance (% of FCI)	1%	1%	1%
Local Tax (% FCI)	1.5%	1.5%	1.5%
Location specific parameters:			
Feedstock type	Ethanol	Forest residuals	Vegetable Oil
Feedstock price ($/ton)	$485	$110	1005
Feedstock transportation cost ($/ton)	$0	$0	$0
Labor factor (location wages: US price)	1.0	1.0	1.0
Labor Burden	60%	60%	60%
Consumables factor (location price: US price)	1.0	1.0	1.0
Electricity ($/kWh)	0.072	0.072	0.072
Natural gas ($/MMBtu)	5.09	5.09	-
Hydrogen ($/kg)	1.75	-	1.75
Capital cost factor (location price: US price)	1.0	1.0	1.0
Process specific parameters:			

Facility scale (t/yr feedstock)	680,000 [5]	3,937,934 [6]	621,000 [7]
Cleaning loss for FOGs (wt%)	-	-	2%
Distillate breakdown (wt %) (SAF: diesel: gasoline)	70:0:30	-	-
Distillate breakdown (wt %) (jet:diesel:naphtha)	-	40:40:20	-
Distillate breakdown (wt %) (jet:diesel:gasoline)	-	20:9:71	-
Distillate breakdown (wt %) (jet:diesel:others)	-	-	55:26:19

Other constants:

Cost year	2021	2021	2021
Operating hours (hrs/yr)	7,884	7,884	7,884
Hours per day	24	24	24
Alcohol flow (kg/hr)	86,251	-	-
Refined oil/hours after loss (kg/hr)	-	-	78,767
Feedstock scale (t/day)	2,070	11,988	1,890
Feedstock price ($/kg)	0.485	0.11	1.01
Maintenance and repair (% of FCI)	6%	6%	6%
Working capital (Annual OPEX)	20%	20%	20%
Incentive adjusted loan interest rate	8%	8%	8%
Cost growth factor	1	1	1.0
Effective corporate tax rate	17.3%	17.3%	17.2%
Weighted average Rate	7.6%	7.6%	7.6%
Nominal discount rate	12.2%	12.2%	12.2%
Total distillate yield (wt/wt)	0.60	0.18	0.83
SAF fuel yield (wt/wt)	0.42	0.07	-
Jet fuel yield (wt/wt)	-	-	0.46
Diesel yield (wt/wt)	0	0.07	0.22
Naphtha yield (wt/wt)	-	0.75	0.07
Gasoline yield (wt/wt)	0.18	0	-
Propane yield (wt/wt)	-	-	0.51

Distillate breakdown:

SAF Fuel (%)	70%	40%	-

[5] The feedstock quantity for 100 Million gallons SAF for individual technology pathway scenario through AtJ technology pathway is 680,000. Other ASCENT TEA model parameters remain the same.

[6] The feedstock quantity for 100 Million gallons SAF for individual technology pathway scenario through FT technology pathway is 3,937,934. Other ASCENT TEA model parameters remain the same.

[7] The feedstock quantity for 100 Million gallons SAF for individual technology pathway scenario through HEFA technology pathway is 621,000. Other ACENT TEA model parameters remain the same.

Jet fuel (%)	-	-	55%
Diesel (%)	0%	40%	26%
Naphtha (%)	30%	20%	8%
Propane (%)	-	-	11%
Process conversion:			
Boiler feedwater (for process steam) (kg/kg oil)	-	-	0.25
Cooling water (kg/kg Oil)	-	-	5.33
Electricity (kW/kg oil)	-	-	0.02
Hydrogen (kg/kg oil)	-	-	0.04
Catalyst lifetime (years)	-	-	0.5
Wet hourly space velocity:			
Hydrogenation (1/hr)	-	-	2
Isomerization/cracking (1/hr)	-	-	5
Product densities:			
SAF density (kg/l)	0.75	-	-
Gasoline density (kg/l)	0.75	-	-
Diesel density (kg/l)	0.89	0.89	0.89
Jet density (kg/l)	-	0.75	0.75
Propane density (kg/l)	-	-	0.51
Naphtha density (kg/l)	-	0.75	0.75
Raw materials:			
Cooling tower water ($/kg)	0.00002	0.00002	0.00002
Steam cost ($/kg)	-	0.011	-
Green hydrogen ($/kg)	-	6	-
Catalysts: Hydrogenation & Hydrocracking ($/kg)	-	-	146
Boiler Feedwater ($/kg)	-	-	0.00002
Refrigeration cost at -50^{o}C ($/MMBtu)	$15.9	-	-

Table 5: Cost of construction (3 years) and operation SAF plant (20 years) to produce one hundred million gallons of SAF per year using AtJ, FT, and HEFA technology pathways.

Description	Joint Technologies Pathways Scenario			Three Individual Technology Pathway Scenarios		
	AtJ	**FT**	**HEFA**	**AtJ**	**FT**	**HEFA**
A: Construction Period Investment (Million US$):						
Year 1 Construction Cost	5.46	169.24	10.03	11.63	310.45	23.95
Year 2 Construction Cost	41.79	1294.66	76.72	89.01	2,374.97	183.21
Year 3 Construction Cost	22.73	704.30	41.73	48.42	1,291.99	99.67
B: Employment, Employee, Wages, and Salary:						
Employee receiving Wages and Salaries	42	157	35	114	307	144
Annual Employee Compensation	2.52	10.30	2.41	6.47	19.97	9.21
C: Annual Operating Costs (Million US$):						
Year 1 Operating Cost	112.45	495.38	127.22	87.26	-346.55	-101.15
Year 2 Operating Cost	138.30	486.49	167.76	285.66	58.38	13.16
Year 3 Operating Cost	140.53	543.11	171.11	293.14	-34.23	13.43
Year 4 Operating Cost	143.34	612.72	174.54	299.00	-152.40	13.70
Year 5 Operating Cost	146.21	580.87	178.03	304.98	-67.25	13.97
Year 6 Operating Cost	149.13	592.48	181.59	311.08	-68.59	14.25
Year 7 Operating Cost	152.12	650.22	185.22	317.30	-161.73	14.53
Year 8 Operating Cost	155.16	616.42	188.92	323.65	-71.36	14.83
Year 9 Operating Cost	158.26	628.75	192.70	330.12	-72.79	15.12
Year 10 Operating Cost	161.43	690.02	196.55	336.72	-171.63	15.42
Year 11 Operating Cost	164.65	654.15	200.49	343.46	-75.73	15.73
Year 12 Operating Cost	167.95	667.23	204.50	350.33	-77.25	16.05
Year 13 Operating Cost	171.31	732.25	208.59	357.33	-182.14	16.37
Year 14 Operating Cost	174.73	694.19	212.76	364.48	-80.37	16.70
Year 15 Operating Cost	178.23	708.07	217.01	371.77	-81.97	17.03
Year 16 Operating Cost	181.79	777.07	221.35	379.20	-193.29	17.37
Year 17 Operating Cost	185.43	736.68	225.78	386.79	-85.28	17.72
Year 18 Operating Cost	189.14	751.41	230.30	394.52	-86.99	18.07
Year 19 Operating Cost	192.92	824.64	234.90	402.41	-205.12	18.43
Year 20 Operating Cost	196.78	781.77	239.60	410.46	-90.50	18.80

Table 6: Cost breakdown to produce one hundred Million gallons SAF per year (Joint technologies pathway scenario).

Operating Years	AtJ			FT			HEFA		
	Feedstock Costs	Fixed Operating Costs	Variable Operating Costs	Feedstock Costs	Fixed Operating Costs	Variable Operating Costs	Feedstock Costs	Fixed Operating Costs	Variable Operating Costs
1	89.09	11.16	12.21	175.83	208.67	110.89	101.33	15.49	10.40
2	111.97	11.38	14.95	178.26	212.84	95.40	137.81	15.80	14.15
3	111.98	11.61	16.94	228.71	217.10	97.30	140.57	16.11	14.43
4	114.22	11.84	17.28	248.79	221.44	142.49	143.38	16.43	14.72
5	116.51	12.07	17.63	253.77	225.87	101.23	146.25	16.76	15.01
6	118.84	12.32	17.98	258.84	230.38	103.26	149.17	17.10	15.32
7	121.22	12.56	18.34	264.02	234.99	151.21	152.16	17.44	15.62
8	123.64	12.81	18.70	269.30	239.69	107.43	155.20	17.79	15.93
9	126.11	13.07	19.08	274.68	244.49	109.58	158.30	18.14	16.25
10	128.63	13.33	19.46	280.18	249.38	160.46	161.47	18.51	16.58
11	131.21	13.60	19.85	285.78	254.36	114.01	164.70	18.88	16.91
12	133.83	13.87	20.25	291.50	259.45	116.29	167.99	19.26	17.25
13	136.51	14.15	20.65	297.33	264.64	170.29	171.35	19.64	17.59
14	139.24	14.43	21.06	303.27	269.93	120.98	174.78	20.03	17.94
15	142.02	14.72	21.49	309.34	275.33	123.40	178.28	20.43	18.30
16	144.86	15.01	21.92	315.53	280.84	180.71	181.84	20.84	18.67
17	147.76	15.31	22.35	321.84	286.45	128.39	185.48	21.26	19.04
18	150.72	15.62	22.80	328.27	292.18	130.96	189.19	21.68	19.42
19	153.73	15.93	23.26	334.84	298.03	191.77	192.97	22.12	19.81
20	156.80	16.25	23.72	341.53	303.99	136.25	196.83	22.56	20.21

Table 7: Cost breakdown to produce one hundred Million gallons SAF per year (Individual technology pathway scenarios).

Operating Years	AtJ			FT			HEFA		
	Feedstock Costs	Fixed Operating Costs	Variable Operating Costs	Feedstock Costs	Fixed Operating Costs	Variable Operating Costs	Feedstock Costs	Fixed Operating Costs	Variable Operating Costs
1	295.5	25.9	40.5	351.7	384.6	221.8	506.7	43.0	52.0
2	371.4	26.4	49.6	356.5	392.3	190.8	689.1	43.8	70.7
3	371.5	27.0	56.2	457.4	400.2	194.6	702.8	44.7	72.2
4	378.9	27.5	57.3	497.6	408.2	285.0	716.9	45.6	73.6
5	386.5	28.1	58.5	507.5	416.3	202.5	731.2	46.5	75.1
6	394.2	28.6	59.6	517.7	424.7	206.5	745.9	47.4	76.6
7	402.1	29.2	60.8	528.0	433.2	302.4	760.8	48.4	78.1
8	410.1	29.8	62.0	538.6	441.8	214.9	776.0	49.3	79.7
9	418.3	30.4	63.3	549.4	450.7	219.2	791.5	50.3	81.3
10	426.7	31.0	64.6	560.4	459.7	320.9	807.3	51.3	82.9
11	435.2	31.6	65.8	571.6	468.9	228.0	823.5	52.4	84.5
12	443.9	32.2	67.2	583.0	478.3	232.6	840.0	53.4	86.2
13	452.8	32.9	68.5	594.7	487.8	340.6	856.8	54.5	88.0
14	461.9	33.5	69.9	606.5	497.6	242.0	873.9	55.6	89.7
15	471.1	34.2	71.3	618.7	507.5	246.8	891.4	56.7	91.5
16	480.5	34.9	72.7	631.1	517.7	361.4	909.2	57.8	93.3
17	490.1	35.6	74.1	643.7	528.0	256.8	927.4	59.0	95.2
18	499.9	36.3	75.6	656.5	538.6	261.9	945.9	60.1	97.1
19	509.9	37.0	77.1	669.7	549.4	383.5	964.9	61.3	99.1
20	520.1	37.8	78.7	683.1	560.3	272.5	984.2	62.6	101.0

Notes: Units are in Million US$.

Table 8: SAF and Co-product revenue from one hundred Million gallons SAF per year (Joint technologies pathway scenario).

Operating Years	AtJ		FT		HEFA	
	SAF Revenue	Co-product Revenue	SAF Revenue	Co-product Revenue	SAF Revenue	Co-product Revenue
1	120.26	15.16	199.34	106.43	79.72	20.37
2	196.26	24.75	325.32	173.69	130.11	33.25
3	200.19	25.24	331.82	177.16	132.71	33.92
4	204.19	25.75	338.46	180.71	135.36	34.59
5	208.27	26.26	345.23	184.32	138.07	35.29
6	212.44	26.79	352.13	188.01	140.83	35.99
7	216.69	27.32	359.18	191.77	143.65	36.71
8	221.02	27.87	366.36	195.60	146.52	37.45
9	225.44	28.43	373.69	199.51	149.45	38.19
10	229.95	29.00	381.16	203.51	152.44	38.96
11	234.55	29.58	388.78	207.58	155.49	39.74
12	239.24	30.17	396.56	211.73	158.60	40.53
13	244.03	30.77	404.49	215.96	161.77	41.34
14	248.91	31.39	412.58	220.28	165.01	42.17
15	253.88	32.01	420.83	224.69	168.31	43.01
16	258.96	32.65	429.25	229.18	171.67	43.87
17	264.14	33.31	437.83	233.76	175.11	44.75
18	269.42	33.97	446.59	238.44	178.61	45.65
19	274.81	34.65	455.52	243.21	182.18	46.56
20	280.31	35.35	464.63	248.07	185.82	47.49

Notes: Revenue is sum of total revenue from SAF and co-products such as Diesel, Naphtha, Gasoline, and Propane for each Technology pathway. SAF Price = $6/Gal, Diesel Price = $2.35/Gal, Naphtha Price = $525/Metric Ton, Gasoline Price = $1.77/Gal, and Propane Price = $0.22/Gal. All prices were converted to $/liter assuming 1 gallon = 3.78541 liter. Prices are assumed to be wholesale price and were adjusted for inflation. Unit of revenues: Million US$.

Table 9: SAF and Co-product revenue from one hundred million gallons SAF per year. (Individual technology pathway scenarios).

Operating Years	AtJ		FT		HEFA	
	SAF Revenue	Co-product Revenue	SAF Revenue	Co-product Revenue	SAF Revenue	Co-product Revenue
1	398.9	50.3	398.7	212.9	398.6	101.9
2	651.0	82.1	650.6	347.4	650.5	166.3
3	664.0	83.7	663.6	354.3	663.5	169.6
4	677.3	85.4	676.9	361.4	676.8	173.0
5	690.9	87.1	690.5	368.6	690.4	176.4
6	704.7	88.9	704.3	376.0	704.2	180.0
7	718.8	90.6	718.4	383.5	718.2	183.6
8	733.1	92.4	732.7	391.2	732.6	187.2
9	747.8	94.3	747.4	399.0	747.3	191.0
10	762.8	96.2	762.3	407.0	762.2	194.8
11	778.0	98.1	777.6	415.2	777.4	198.7
12	793.6	100.1	793.1	423.5	793.0	202.7
13	809.5	102.1	809.0	431.9	808.9	206.7
14	825.6	104.1	825.2	440.6	825.0	210.8
15	842.2	106.2	841.7	449.4	841.5	215.1
16	859.0	108.3	858.5	458.4	858.4	219.4
17	876.2	110.5	875.7	467.5	875.5	223.8
18	893.7	112.7	893.2	476.9	893.0	228.2
19	911.6	114.9	911.0	486.4	910.9	232.8
20	929.8	117.2	929.3	496.1	929.1	237.4

Notes: Revenue is sum of total revenue from SAF and co-products such as Diesel, Naphtha, Gasoline, and Propane for each Technology pathway. SAF Price = \$6/Gal, Diesel Price = \$2.35/Gal, Naphtha Price = \$525/Metric Ton, Gasoline Price = \$1.77/Gal, and Propane Price = \$0.22/Gal. All prices were converted to \$/liter assuming 1 gallon = 3.78541 liter. Prices are assumed to be wholesale price and were adjusted for inflation. Unit of revenues: Million US\$.

Table 10: OPI Calculation for one hundred Million gallons SAF annual production (Joint technologies pathway scenario).

Operating Years	AtJ			FT			HEFA		
	Annual Revenue	**Annual Cost**	**OPI Profit**	**Annual Revenue**	**Annual Cost**	**OPI Profit**	**Annual Revenue**	**Annual Cost**	**OPI Profit**
1	135.42	112.45	22.97	305.76	495.38	-189.62	100.10	127.22	-27.13
2	221.01	138.30	82.71	499.01	486.49	12.51	163.36	167.76	-4.40
3	225.43	140.53	84.90	508.99	543.11	-34.12	166.62	171.11	-4.49
4	229.94	143.34	86.60	519.17	612.72	-93.55	169.96	174.54	-4.58
5	234.54	146.21	88.33	529.55	580.87	-51.32	173.36	178.03	-4.67
6	239.23	149.13	90.09	540.14	592.48	-52.34	176.82	181.59	-4.76
7	244.01	152.12	91.90	550.94	650.22	-99.28	180.36	185.22	-4.86
8	248.89	155.16	93.73	561.96	616.42	-54.46	183.97	188.92	-4.96
9	253.87	158.26	95.61	573.20	628.75	-55.55	187.65	192.70	-5.06
10	258.95	161.43	97.52	584.67	690.02	-105.35	191.40	196.55	-5.16
11	264.13	164.65	99.47	596.36	654.15	-57.79	195.23	200.49	-5.26
12	269.41	167.95	101.46	608.29	667.23	-58.95	199.13	204.50	-5.36
13	274.80	171.31	103.49	620.45	732.25	-111.80	203.11	208.59	-5.47
14	280.29	174.73	105.56	632.86	694.19	-61.33	207.18	212.76	-5.58
15	285.90	178.23	107.67	645.52	708.07	-62.56	211.32	217.01	-5.69
16	291.62	181.79	109.82	658.43	777.07	-118.64	215.55	221.35	-5.81
17	297.45	185.43	112.02	671.60	736.68	-65.08	219.86	225.78	-5.92
18	303.40	189.14	114.26	685.03	751.41	-66.38	224.25	230.30	-6.04
19	309.47	192.92	116.55	698.73	824.64	-125.90	228.74	234.90	-6.16
20	315.66	196.78	118.88	712.71	781.77	-69.07	233.31	239.60	-6.29

Notes: Revenue is sum of total revenue from SAF and co-products such as Diesel, Naphtha, Gasoline, and Propane for each Technology pathway. SAF Price = \$6/Gal, Diesel Price = \$2.35/Gal, Naphtha Price = \$525/Metric Ton, Gasoline Price = \$1.77/Gal, and Propane Price = \$0.22/Gal. All prices were converted to \$/liter assuming 1 gallon = 3.78541 liter. Prices are assumed to be wholesale price and were adjusted for inflation. Other Proprietor Income (OIP) is the difference of operating cost and revenue for the given year. OPI does not corresponds with the total profit because the fixed construction cost for the first three years was ignored in the calculation. Revenue, cost, and OPI are measured in Million US\$.

Table 11: OPI Calculation for one hundred Million gallons SAF annual production (Individual technology pathway scenarios).

Operating Years	AtJ			FT			HEFA		
	Annual Revenue	Annual Cost	OPI Profit	Annual Revenue	Annual Cost	OPI Profit	Annual Revenue	Annual Cost	OPI Profit
1	449.2	361.9	87.3	611.5	958.1	-346.5	500.5	601.6	-101.2
2	733.1	447.4	285.7	998.0	939.6	58.4	816.8	803.6	13.2
3	747.8	454.6	293.1	1,018.0	1,052.2	-34.2	833.1	819.7	13.4
4	762.7	463.7	299.0	1,038.3	1,190.7	-152.4	849.8	836.1	13.7
5	778.0	473.0	305.0	1,059.1	1,126.3	-67.2	866.8	852.8	14.0
6	793.5	482.5	311.1	1,080.3	1,148.9	-68.6	884.1	869.9	14.2
7	809.4	492.1	317.3	1,101.9	1,263.6	-161.7	901.8	887.3	14.5
8	825.6	501.9	323.6	1,123.9	1,195.3	-71.4	919.8	905.0	14.8
9	842.1	512.0	330.1	1,146.4	1,219.2	-72.8	938.2	923.1	15.1
10	858.9	522.2	336.7	1,169.3	1,341.0	-171.6	957.0	941.6	15.4
11	876.1	532.7	343.5	1,192.7	1,268.5	-75.7	976.1	960.4	15.7
12	893.6	543.3	350.3	1,216.6	1,293.8	-77.2	995.7	979.6	16.0
13	911.5	554.2	357.3	1,240.9	1,423.0	-182.1	1,015.6	999.2	16.4
14	929.8	565.3	364.5	1,265.7	1,346.1	-80.4	1,035.9	1,019.2	16.7
15	948.3	576.6	371.8	1,291.0	1,373.0	-82.0	1,056.6	1,039.6	17.0
16	967.3	588.1	379.2	1,316.9	1,510.1	-193.3	1,077.7	1,060.4	17.4
17	986.7	599.9	386.8	1,343.2	1,428.5	-85.3	1,099.3	1,081.6	17.7
18	1,006.4	611.9	394.5	1,370.1	1,457.1	-87.0	1,121.3	1,103.2	18.1
19	1,026.5	624.1	402.4	1,397.5	1,602.6	-205.1	1,143.7	1,125.3	18.4
20	1,047.1	636.6	410.5	1,425.4	1,515.9	-90.5	1,166.6	1,147.8	18.8

Notes: Revenue is sum of total revenue from SAF and co-products such as Diesel, Naphtha, Gasoline, and Propane for each Technology pathway. SAF Price = $6/Gal, Diesel Price = $2.35/Gal, Naphtha Price = $525/Metric Ton, Gasoline Price = $1.77/Gal, and Propane Price = $0.22/Gal. All prices were converted to $/liter assuming 1 gallon = 3.78541 liter. Prices are assumed to be wholesale price and were adjusted for inflation. Other Proprietor Income (OIP) is the difference of operating cost and revenue for the given year. OPI does not corresponds with the total profit because the fixed construction cost for the first three years was ignored in the calculation. Revenue, cost, and OPI are measured in Million US$.

Table 12: Mapping ASCENT techno-economic model output with IMPLAN spending pattern commodity codes for three major SAF technology pathways.

ASCENT TEA Model Parameters and IMPLAN Spending Pattern Commodity Codes	Default (%)	AtJ (%)	FT (%)	HEFA (%)
Feedstock Commodities:				
Corn (3002, Grains)	7.07	52	0	0
Non-corn ethanol (3152, Other basic organic chemicals)	9.47	31	0	0
Forest residuals (3015, Forest, timber, and forest nursery products)	0.22	0	45	0
Used Cooking Oil (3065, Fat and oil refining and blending)	0.50	0	0	85.74
Non-feedstock Commodities:				
Hydrogen (3125, Industrial gas)	0.92%	2.21	8	5.99
Electricity (3042, Electricity transmission and distribution)	1.69%	2.76	16	0.12
Natural Gas (3043, Natural gas distribution)	0.69%	2.21	4	-
Catalyst (3155, Other basic organic chemicals)	9.47%	2.21	6	-
Water/steam (3042, Electricity transmission and distribution)	4.3%	-	4	0.01
Isomerization catalyst (3155, Other basic organic chemical)	9.47%	-	-	0.77
Hydrogenation Catalyst (3155, Other basic organic chemical)	9.47%	-	-	1.92
Ash (3461, Waste management and remediation services	1.44%	-	0.9	-
Hydro-processing (3155, other basic organic chemicals)	9.47%	-	2.7	-

Notes: The column default represents the default spending pattern given by IMPLAN for commodities for "155 - Other basic organic chemical manufacturing" industry specification used in Industry Impact Analysis (Detailed) IMPLAN event. The default spending pattern event was adjusted proportionally to represent itemized cost-share of each commodity purchased on the modeled period for each technology. We kept default values of unadjusted commodities and normalized spending pattern to 100%. Item "Corn (3002, Grains)" represents "corn" as input for ethanol and AtJ pathway which corresponds with 3002 spending pattern commodity code assigned to Grains. Spending pattern for irrelevant feedstock commodities were suppressed (0%) for each technology. For example, forest residuals are feedstock for FT but not for AtJ and HEFA. So, commodity code for forest residual was replaced by 0% for FT and HEFA. Similar approach was used other technology pathways. If more than one items from TEA models falls in the same spending pattern commodity category, they are summed together. For example, In AtJ, ethanol non-corn and catalyst both were coded as "other basic organic chemicals". So, their cost-share percentage allocations were added as a single spending pattern commodity. Similarly, for FT, electricity and water expenses were added as a single spending pattern commodity. The default values were not divided proportionally between commodities sharing common commodity code. For example, the default value for “other basic organic chemical” is 9.47% which are listed in default column in three different rows. Dashes (-) means commodities are irrelevant to the give technology pathway. The percentage allocation of the spending pattern of the components is same for joint and three individual technology pathway scenarios.

Table 13: Life cycle economic impact of a new SAF plant to produce one hundred million gallons of SAF per year using AtJ, FT, and HEFA technology pathways.

	Joint Technologies Pathway Scenario			Three Individual Technology Pathway Scenarios		
Impact Indicators	**AtJ**	**FT**	**HEFA**	**AtJ**	**FT**	**HEFA**
A: Economic Indicators by Impact:						
A1: Employment						
Direct	627.21	10,950.88	1,650.16	1,668.80	20,353.10	6,460.87
Indirect	545.05	34,904.40	1,040.32	4,027.90	65,534.84	4,201.99
Induced	528.25	14,041.46	1,289.18	2,215.46	26,283.74	5,232.54
Total	1,700.52	59,896.74	3,979.66	7,912.16	112,171.68	15,895.39
Type I Multiplier [8]	1.87	4.19	1.63	3.41	4.22	1.65
SAM Multiplier [9]	2.71	5.47	2.41	4.74	5.51	2.46

[8] Type I Multiplier = (Direct + Indirect)/Direct. Type I Multiplier (industry linkage only) measures the direct and indirect effects of an economic change, but not household or institutional feedback. Type I includes direct effects (immediate change in the target industry such as new SAF plant output and ethanol production) and indirect effects (supplier and inter-industry effects such as ethanol and corn purchases, trucking, and utilities). It does not include household spending and labor-income induced effects. **Interpretation:** Type I multiplier 1.87 for employment from the AtJ pathway means under joint technologies pathway scenario means for every 100 direct jobs, there are additional 87 (indirect) jobs created in the supplier and supporting industry. In the same scenario for AtJ pathway, Type I multiplier value of 1.64 means for every $1 of direct labor income generated by SAF industry though AtJ technology pathway, an additional of $0.64 of labor income is generated in supplier industry through inter-industry purchases.

[9] SAM Multiplier = (Direct + Indirect + Induced)/Direct = Total/Direct. Type SAM Multiplier measures direct, indirect, and induced effects. It adds household spending and institutional feedback loop to the type I method. This includes direct (target sector), indirect (supply-chain linkage), induced effects (local household spending such as retail, housing, services etc.), and transfer among institutions (household, government, and capital accounts). Type SAM Multiplier = (Direct + Indirect + Induced)/Direct = Total/Direct. **Interpretation:** For AtJ under joint technologies pathway scenario, Type SAM multiplier value of 2.71 for employment means for every 100 direct jobs, there are additional 171 additional jobs (indirect and induced) supported throughout the economy. Each direct job supports 2.71 total jobs in the economy. In the same scenario for AtJ pathway, Type SAM multiplier value of 2.10 means for every $1 of direct labor income generated by SAF industry though AtJ technology pathway, an additional of $1.10 of labor income is generated throughout the economy.

A2: Labor Income (Million US$)						
Direct	68.27	1,085.94	185.86	177.42	1,937.70	715.22
Indirect	43.69	1,986.05	82.74	282.23	3,617.40	322.17
Induced	31.75	843.90	77.48	129.79	1,539.80	306.55
Total	143.71	3,915.89	346.08	589.44	7,094.89	1,343.94
Type I Multiplier	1.64	2.83	1.45	2.59	2.87	1.45
SAM Multiplier	2.10	3.61	1.86	3.32	3.66	1.88

A3: Value Added[10] (Million US$)						
Direct	1,313.46	960.66	183.18	4,246.88	2,065.11	1,631.83
Indirect	136.61	3,559.80	190.42	1,257.27	6,486.22	751.24
Induced	63.92	1,698.85	156.04	260.75	3,094.40	616.29
Total	1,513.99	6,219.31	529.63	5,764.90	11,645.73	2,999.37
Type I Multiplier	1.10	4.71	2.04	1.30	4.14	1.46
SAM Multiplier	1.15	6.47	2.89	1.36	5.64	1.84

A4: Output (Million US$)						
Direct	2,138.13	10,529.83	2,636.91	6,519.53	19,285.98	11,744.26
Indirect	203.33	7,017.16	556.11	1,482.74	12,784.29	2,239.52
Induced	104.25	2,770.80	254.47	425.45	5,048.62	1,005.40
Total	2,445.72	20,317.79	3,447.48	8,427.72	37,118.89	14,989.19
Type I Multiplier	1.10	1.67	1.21	1.23	1.66	1.19
SAM Multiplier	1.14	1.93	1.31	1.29	1.92	1.28

B: Tax Results (Government Revenue (US$):

B1: County (Million US$)						
Direct	3.35	37.41	10.06	9.48	68.73	42.55
Indirect	2.30	104.16	3.59	6.77	191.26	14.17
Induced	1.24	32.98	3.03	5.06	60.01	11.96
Total	6.90	174.54	16.69	21.31	320.00	68.68

[10] Value added in IMPLAN is equivalent to “Contribution in GDP” in the economic term.

Type I Multiplier	1.69	3.78	1.36	1.71	3.78	1.33
SAM Multiplier	2.06	4.67	0.60	2.25	4.66	0.62
B2: States (Million US$):						
Direct	18.06	69.01	16.56	57.07	129.67	78.20
Indirect	4.82	191.83	7.41	24.89	351.53	29.23
Induced	2.59	68.70	6.31	10.53	125.03	24.90
Total	25.47	329.54	30.28	92.50	606.23	132.33
Type I Multiplier	1.27	3.78	1.45	1.44	3.71	1.37
SAM Multiplier	1.41	4.78	0.55	1.62	4.68	0.59
B3: Federal (Million US$):						
Direct	69.98	202.10	35.99	224.27	382.14	184.64
Indirect	12.64	458.60	21.53	96.30	836.18	84.57
Induced	7.92	210.45	19.33	32.28	382.98	76.26
Total	90.54	871.15	76.84	352.85	1,601.30	345.47
Type I Multiplier	1.18	3.27	1.60	1.43	3.19	1.46
SAM Multiplier	1.29	4.31	0.47	1.57	4.19	0.53
B4: Total Million (US$):						
Direct	96.85	369.37	78.96	306.23	692.34	374.57
Indirect	23.51	923.96	38.38	138.99	1,689.97	151.01
Induced	13.76	365.77	33.59	56.09	665.63	132.56
Total	134.12	1,659.09	150.94	501.31	3,047.95	658.14
Type I Multiplier	1.24	3.50	1.49	1.45	3.44	1.40
SAM Multiplier	1.38	4.49	0.52	1.64	4.40	0.57

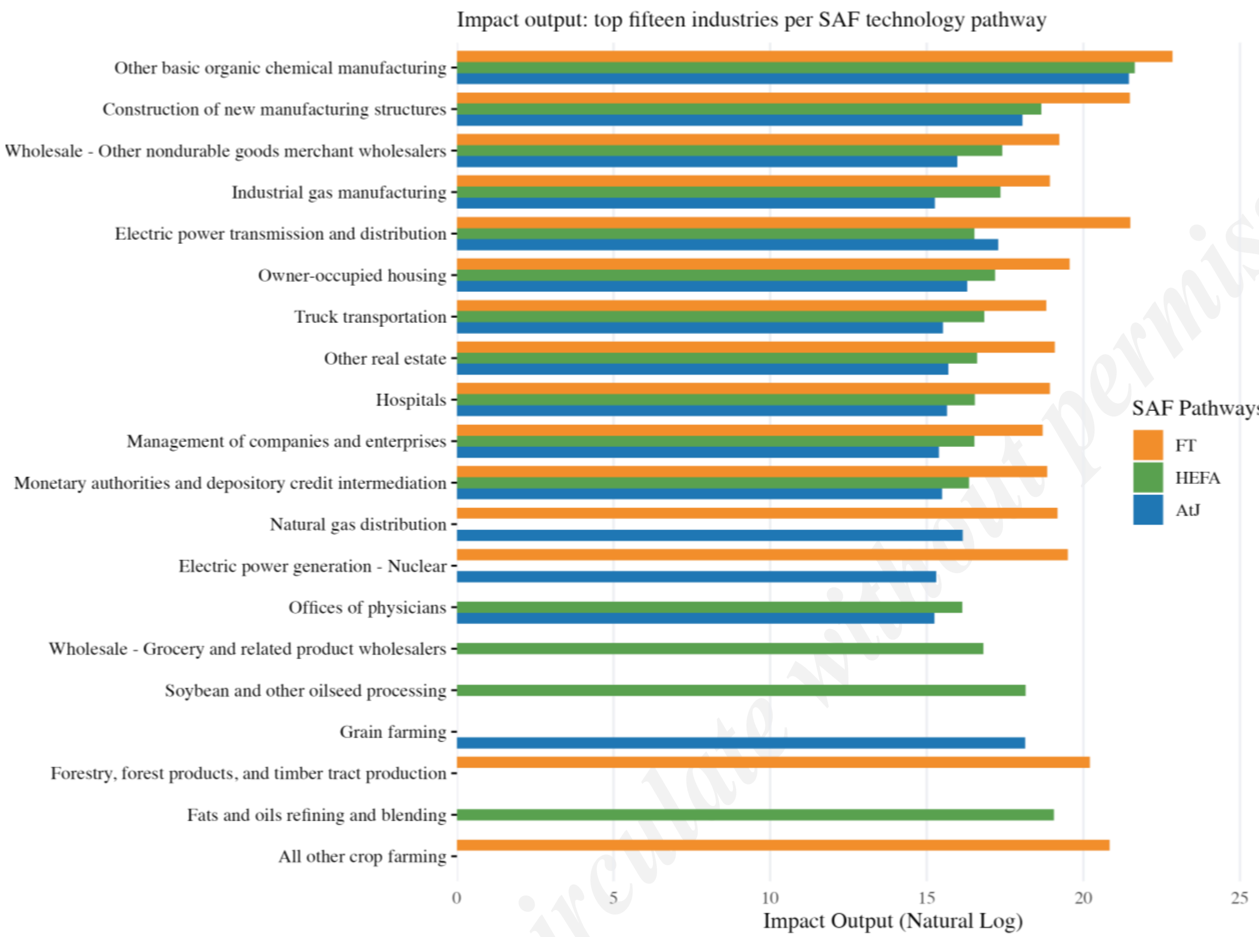


Figure 5: Industries impacted by new investment in three SAF technologies (Joint technologies pathway scenario)

Notes: Top fifteen impacted industries by the new investment in three SAF Technologies to produce one hundred million gallons of SAF annually. There are twenty industries listed in the chart because the industry impacted by three technologies varies. For example, AtJ and FT impacted "Electric power generation – Nuclear" and "Natural gas distribution" but HEFA did not.

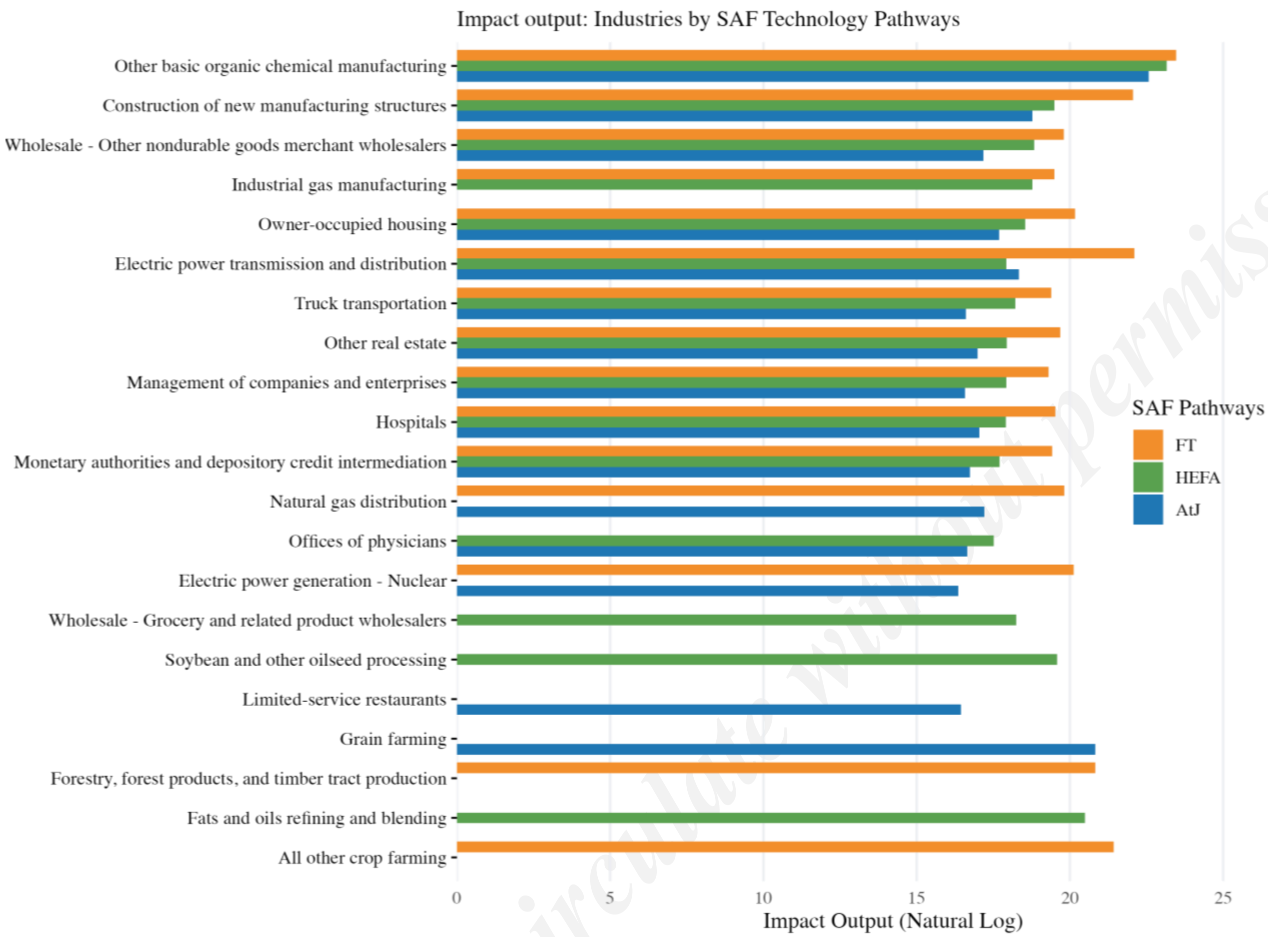


Figure 6: Industries impacted by new investment in three SAF technologies (Three individual technology pathway scenarios)

Notes: Top fifteen impacted industries by the new investment in three SAF Technologies to produce one hundred million gallons of SAF annually. There are twenty industries listed in the chart because the industry impacted by three technologies varies. For example, AtJ and FT impacted "Electric power generation – Nuclear" and "Natural gas distribution" but HEFA did not.