COBEAL TECHNICAL INTELLIGENCE SYNTHESIS

Mexico's Circular Economy At A Glance: Why Mexico Is Ready to Move Up in Global SAF Production

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Feedstock Geography, Water Discipline, and Aviation Fuel Economics

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SCOPE LIMITATION

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Executive Summary

Mexico is positioned to move upward in global sustainable aviation fuel production because its circular-economy base combines material scale, urban density, industrial capacity, state-level policy activity, airport demand, and North American clean-fuel relevance. This document synthesizes four evidence streams — published circular-economy scholarship, the 2025 Netherlands Enterprise Agency market study, Cobeal's Mexico waste-to-value mapping, and Cobeal's SAF technical intelligence work — to present the case that Mexico's readiness is measurable, not aspirational.

The central finding is that Mexico's SAF opportunity is a circular-infrastructure opportunity. It is grounded in feedstock geography, process fit, logistics, water management, carbon accounting, and aviation fuel compatibility. Cobeal's Mexico Circular Economy Initiative identifies where national waste streams can be converted into deployable waste-to-value assets. Cobeal's SAF Technical Workstream defines how those assets can be screened for aviation fuel relevance. Cobeal's 2025 Fischer-Tropsch white paper defines the water and system-boundary discipline required for credible circularity claims.

Mexico's path is practical and sequential. The first phase prioritizes high-density organics platforms, metropolitan thermal hubs, specialized conversion assets, and supply and offtake validation. The second phase expands the viable site network and integrates product corridors. The third phase creates national integration and a model suited for broader Latin American replication.

KEY NUMBERS AT A GLANCE

720,606
Food distribution & retail centers mapped by Cobeal GIS

8.95 Mt/yr
Food loss & waste from distribution & retail centers

476
Priority WtE-AD plant sites with positive energy balance

0.8%
SAF's share of global aviation fuel in 2026 (IATA)

120,128
Tonnes of urban solid waste generated per day in Mexico (2020)

52%
Organic fraction of Mexico's urban solid waste

21 of 32
Mexican states with circular-economy legislation or programs

698
Viable WtE-AD sites under maximum methane-yield scenario

1. The Global SAF Opening

The scale of aviation's fuel requirement makes sustainable aviation fuel one of the most consequential industrial challenges of the decade. The global commercial jet fuel market stood at 106 billion gallons in 2019 and is projected to grow to more than 230 billion gallons by 2050. Fuel represents 20 to 30 percent of airline operating costs, and airlines have committed to carbon-neutral growth in international commercial aviation beginning in 2021, with a goal of reducing CO2 emissions by 50 percent by 2050 relative to 2005 levels.

Against that long-term demand, current SAF supply is marginal. IATA estimates global SAF production at approximately 2.4 million tonnes in 2026, representing around 0.8 percent of aviation fuel use and adding an estimated US$4.3 billion in additional fuel cost to airlines. A 2025 Nature Communications study found that only 24 percent of globally announced SAF production capacity for 2024 was realized on time. Fischer-Tropsch projects are specifically cited as impeded by technical and operational barriers, with over 40 percent of announced 2030 capacity still in early development or at risk.

The gap between ambition and supply is not primarily financial. It is technical. Projects that advance without resolved feedstock qualification, syngas cleaning specifications, water management design, material compatibility testing, and carbon intensity verification encounter those problems at the engineering and permitting stage, when correction is expensive and often fatal to project timelines. This is the structural problem that Cobeal's pre-engineering intelligence workstream is designed to solve.

The consistent message from TEA and LCA across the SAF industry is that the main cost drivers are feedstock costs, yields, and plant capital recovery. Mexico's circular-economy platform addresses all three upstream, before capital is committed.

REGULATORY FRAMEWORKS SHAPING SAF DEMAND

Framework	Jurisdiction	Key Requirement	Mexico Relevance
CORSIA	International (ICAO)	Carbon-neutral growth from 2021; 130 participating states in 2026; Phase 2 mandatory from 2027	Mexican feedstocks eligible under biogenic carbon pathway with lifecycle data
ReFuelEU Aviation	European Union	2% SAF at EU airports from 2025; 70% by 2050; synthetic SAF sub-mandate from 2030	Drives global offtake demand and supply-chain investment
RFS (D3/D7)	United States (EPA)	50% lifecycle GHG reduction threshold; MSW qualifies as cellulosic biomass under certain conditions	FT pathways require EPA pathway approval; D7 for cellulosic biojet
LCFS	California (USA)	CI score below 20 gCO2e/MJ for full credit; post-recycling MSW eligible with pathway registration	Strong incentive for Mexican MSW-derived fuels serving California-linked supply chains
45Z Clean Fuel Credit	United States (IRS)	Applies to SAF produced Jan 1 2025 through Dec 31 2029;	Mexican feedstocks sit inside North American clean-fuel credit geography

		post-2025 feedstocks must be from US, Mexico, or Canada	when project structure qualifies
ASTM D7566	Global aviation standard	FT-SPK approved under Annex A1 at up to 50%v blend; full ASTM D4054 approval 3-5 years	Sets the certification requirement that Cobeal's technical workstream prepares clients for

2. Mexico's Circular-Economy Base

Mexico's circular economy rests on three converging foundations: cultural practice, material scale, and policy momentum. Together they create conditions that Cobeal's platform can convert into project-development logic.

FOUNDATION 1: CULTURAL AND INFORMAL CIRCULARITY

Reuse, repair, resale, recycling, renovation, and object-life extension have long operated through tianguis, repair trades, secondhand markets, and informal material recovery systems. This informal circular economy functions as a daily infrastructure that prolongs the life of objects and keeps materials in productive use. Mexico therefore does not begin its circular-economy transition from zero. It begins from an embedded cultural foundation that formal engineering systems and investment platforms can build on.

FOUNDATION 2: MATERIAL SCALE

Mexico generated 120,128 tonnes per day of urban solid waste in 2020, equal to 0.944 kilograms per inhabitant per day. Organic waste accounts for 52 percent of that composition — a fraction that supports energy and nutrient recovery through biological conversion and related pathways. In the food system, Mexico produces approximately 20 million tonnes per year of food loss and waste from farm gate to retail, plus 11 million tonnes per year from households, with an estimated economic cost of US$25 billion — approximately 2.5 percent of GDP. Special handling waste subtype III reached approximately 87 million tonnes in 2012, including 52.1 million tonnes of agricultural biomass, 18.0 million tonnes of poultry waste, and 16.8 million tonnes of livestock waste. Airport waste was estimated at 212,041 tonnes in 2018, 71 percent higher than in 2012.

FOUNDATION 3: POLICY MOMENTUM

The 2025 Netherlands Enterprise Agency market study identifies 21 of 32 Mexican states with circular-economy legislation or programs, and highlights six leading territories: Mexico City, Chihuahua, Jalisco, Puebla, Queretaro, and Guanajuato. At the federal level, Mexico announced its first Circular Economy Industrial Park in Tula, Hidalgo, covering 700 hectares, with organic waste treatment plants using gasification and carbonization processes and a goal of converting organic waste into biochar for fertilizer and fuel. These are not policy documents. They are physical assets under development.

MEXICO'S WASTE AND BIOMASS RESOURCE PORTFOLIO

Waste / Biomass Stream	Scale	Primary Conversion Fit	SAF Relevance
Urban solid waste (post-recycling MSW)	120,128 t/day nationally	Thermal conversion; gasification	Syngas feedstock for FT-SPK; landfill diversion value
Food loss and waste (distribution & retail)	8.95 Mt/year (Cobeal GIS)	Anaerobic digestion with CHP	Biogas, electricity, biofertilizer, carbon intensity value
Food loss and waste (farm gate to retail)	~20 Mt/year nationally	Anaerobic digestion; composting	Upstream feedstock for energy-positive organics platforms
Household food waste	~11 Mt/year nationally	Anaerobic digestion	Carbon value; waste-hierarchy alignment
Agricultural biomass (special handling waste)	52.1 Mt in 2012	Gasification; co-digestion; biochar	Biogenic carbon feedstock; syngas pathway eligibility
Poultry and livestock waste	34.8 Mt combined in 2012	Anaerobic digestion; biogas	RNG support; carbon intensity credit potential
End-of-life tires	Homogeneous high-energy stream	Controlled pyrolysis	Tire pyrolysis oil; syngas; carbon black; recovered metals
Airport waste	212,041 t in 2018	Sorting; thermal conversion	Aviation-sector circularity origin point
Plastics and post-recycling residuals	Incorporated in MSW fraction	Thermal conversion; gasification	Carbon-dense syngas feedstock; landfill diversion
Wastewater sludge	Urban industrial co-product	Hydrothermal liquefaction; anaerobic digestion	Lipid fraction for fuel intermediates

3.

Cobeal's Mexico Waste-to-Value Platform

Cobeal's Mexico Circular Economy Initiative frames waste-to-value development as a systems problem defined by geography, composition, throughput, and process fit. Waste streams create value when they are aggregated at viable density, controlled within an acceptance envelope, and assigned to conversion pathways that match their physical and chemical properties. The platform separates Mexico's resource base into three primary conversion lanes and one logistics and preprocessing layer.

THE FOUR-LAYER NATIONAL PLATFORM ARCHITECTURE

Layer	Primary Feedstock	Conversion Process	Core Outputs & Economic Role
Metropolitan processing hubs	Post-recycling MSW; residual carbon streams	Thermal conversion; gasification or controlled high-temperature conversion	Electricity; heat; syngas potential; landfill diversion; regional infrastructure anchor
Regional organics platforms	Food loss and waste; wet organics; process residuals	Anaerobic digestion with CHP and nutrient recovery	Biogas; electricity; heat; biofertilizer; RNG or hydrogen support; carbon-intensity value
Specialized conversion assets	End-of-life tires; homogeneous high-energy streams	Controlled pyrolysis	Tire pyrolysis oil; syngas; carbon black; scrap steel; high energy self-sufficiency
Preprocessing and transfer nodes	Sub-threshold and mixed regional material streams	Collection; sorting; baling; short-haul aggregation; acceptance control	Feedstock standardization; logistics efficiency; scale aggregation; quality envelope management

THE ENERGY-BALANCE INVESTMENT SCREEN

The energy-balance simulation is the central project screen in Cobeal's organics platform design. A positive energy quotient is achieved at treatment capacity of at least 8 tonnes of food loss and waste per day. Cobeal identifies 476 plants meeting the viable threshold under average methane-yield assumptions. Under maximum methane-yield assumptions, 698 sites qualify — a 47 percent increase over the baseline. Under minimum methane-yield assumptions, viability concentrates in larger facilities.

The transport-distance analysis reinforces the scale rule. Larger facilities tolerate longer haul distances while smaller facilities require tighter aggregation. A facility treating 2,537 tonnes per day remains energy-positive at approximately 320 kilometers per trip, while a 537 tonne-per-day facility remains positive at approximately 150 kilometers per trip. The transport-energy target is less than 10 to 15 percent of gross output. Co-location at existing final disposal sites supports lower hauling costs and infrastructure reuse.

The South-Central region generates 66 percent of national food loss and waste, which supports phased regional deployment rather than scattered pilots. Cobeal's GIS work maps 720,606 food distribution and retail centers, identifies 89 major supply centers with physical and operational infrastructure, and produces a deployable national project inventory organized by energy-positive thresholds.

476

Baseline energy-positive WtE-AD sites (average methane yield)

8 t/day

Minimum FLW treatment capacity for positive energy balance

698

66%

Upside WtE-AD sites (maximum methane yield) — 47% increase	Share of national FLW generated in South-Central Mexico

BIOLOGICAL CONVERSION: FOUR-UNIT PROCESS BOUNDARY

1	2	3	4
Industrial Shredding Mechanical size reduction; scales efficiently	**Anaerobic Digestion** Dominant energy consumer; biomethane production	**CHP Cogeneration** Biomethane to electricity and process heat	**Rotary Drum Drying** Biofertilizer production; energy falls with scale

4. State Policy Corridors and Industrial Readiness

Mexico's six leading circular-economy territories form a national implementation map that matches Cobeal's platform needs. Each territory contributes distinct policy, industrial, and logistical capabilities that are complementary rather than redundant. SAF-adjacent circular economy requires organics, residual carbon, industrial symbiosis, water systems, logistics, energy, manufacturing, and state-level coordination. Mexico's leading territories provide these functions in different combinations.

Territory	Circular-Economy Position	SAF-Adjacent Relevance
Mexico City	Circular Economy Law; 2024-2030 Circular Economy Program with twelve pillars including zero waste, right to repair, efficient water use, and circularity evaluation	Large demand center; organics recovery platform; secondary raw-material exchange; water and energy efficiency; airport-adjacent circularity
Chihuahua	Chihuahua Green City pilot industrial-symbiosis project supported by EU, COPARMEX, and Barcelona technical expertise; Juarez Circular Hub targeting 48,000+ companies	Manufacturing corridors; border logistics; industrial byproduct exchange; energy and water optimization
Jalisco	Roadmap for agribusiness, bioeconomy, advanced manufacturing, sustainable construction, tourism, logistics, and transportation	Food systems; logistics; bioeconomy; transport decarbonization; route-corridor planning
Puebla	Circular and Social Bioeconomy Strategy: agri-food circularity, bioenergy chains, industrial symbiosis, water management, regenerative infrastructure	Bioenergy chains; agri-food residues; circular water infrastructure; social innovation model
Queretaro	Initiative involving 250+ companies, 40 institutions, 600+ trained professionals, 350+ projects, 775+ million pesos in savings, 300,000+ tonnes of materials diverted from waste	Strongest state-level proof of execution; public-private circular model; measurable company-level results

Guanajuato	Roadmap to 2050 aligning waste management, construction, manufacturing, automotive, metals, leather, footwear, and chemical industries	Industrial corridor; manufacturing base; materials recovery; water-sensitive sectors; logistics connection
Hidalgo (Tula)	Federal Circular Economy Industrial Park: 700 hectares, gasification and carbonization for organic waste, biochar/fuel production target	Physical federal circular asset under development; gasification infrastructure precedent

Queretaro is especially important as the clearest state-level evidence that circular economy in Mexico moves through companies, institutions, training, projects, savings, and material recovery — not only through legislation.

5. SAF Market Relevance and Airline Economics

SAF economics begin with the input system. The consistent finding from techno-economic analyses across SAF pathways is that feedstock cost, product yields, and plant capital recovery are the largest cost drivers. Cobeal's Mexico platform addresses these drivers upstream — before basic engineering, before capital commitment, and before ASTM pathway approval — by locating dense feedstock corridors, defining scale thresholds, identifying viable sites, separating waste streams by process fit, and establishing phased rollout logic.

For airlines, the economic goal is a lower-cost and more stable SAF supply base. Airline economics are protected when the fuel pathway controls feedstock cost, energy consumption, hydrogen sourcing, water treatment, residual management, carbon accounting, permitting risk, and certification requirements. Mexico's circular-economy base gives Cobeal a national system from which these variables can be measured and organized before investment is committed.

The current SAF supply gap creates commercial opportunity for new qualified production geographies. Mexico's waste-to-value platform can enter SAF supply through feedstock-controlled, energy-positive, water-disciplined, and carbon-accounted infrastructure. That is the only route that produces results that both regulators and investors can accept.

THE COST STACK: WHERE MEXICO'S PLATFORM INTERVENES

SAF Cost Driver	Standard Challenge	Mexico Platform Advantage
Feedstock cost	Lipid-route feedstocks (fats, oils, greases) are insufficient in volume and compete with diesel markets	Mexico's MSW, FLW, agricultural residues, and livestock waste create a large, geographically mapped, low-cost residual carbon base
Feedstock quality control	Variable waste composition creates syngas quality uncertainty and catalyst risk	Cobeal's GIS mapping, acceptance specifications, and energy-balance screens identify viable sites before engineering

Plant capital recovery	Large capital-intensive plants require stable, long-term feedstock supply agreements	Cobeal's 476-site baseline creates a phased, density-ranked deployment schedule that matches capital commitment to feedstock confidence
Hydrogen sourcing	Hydrogen demand is high across all SAF pathways; steam methane reforming adds carbon intensity	Mexico's wet organics and biogas infrastructure support recovered-water electrolysis and waste-derived hydrogen as cost-reduction levers
Carbon-intensity scoring	Fossil carbon fractions reduce credit value; lifecycle data must be primary, not estimated	Cobeal's feedstock characterization suite (ASTM D6866 biogenic fraction, proximate analysis, seasonal variability) produces the primary data required for CORSIA, LCFS, and 45Z carbon models
Water treatment obligation	FT-produced water carries oxygenates, alkylamines, and BTEX traces; circular claims require documented treatment	Cobeal's FT system-boundary framework defines the water mass balance, treatment train, and contaminant fate documentation required before any circular claim is defensible
Permitting and certification risk	Projects that advance without regulatory pre-screening encounter delays at the engineering and permitting stage	Cobeal's pre-engineering workstream includes regulatory pathway memos, air and water issue registers, and LCFS/RFS/45Z data needs before basic engineering begins
Fuel compatibility	FT-SPK contains less than 1% aromatics; NBR O-ring swelling falls below the conventional range at blends above 50%v	Project design must specify blend composition, aromatic or cycloalkane dopant strategy, and ASTM D4054 tier testing pathway before offtake commitments are signed

Global SAF production in 2026 is approximately 2.4 million tonnes — 0.8 percent of aviation fuel use. Mexico does not need to displace existing SAF leaders to move upward. It needs qualified projects, feedstock control, carbon accounting, and aviation-grade execution.

6. Water Discipline and Circularity Criteria

Cobeal's 2025 Fischer-Tropsch white paper establishes a controlling argument for the entire field: Fischer-Tropsch synthesis is not circular by itself. It is the hydrocarbon conversion engine at the center of a system that must be designed, validated, and operated as a circular economy platform. The claim that an MSW-derived or biomass-derived SAF project is circular is only defensible when the engineered system boundary around FT has been explicitly constructed.

The FT reaction stoichiometrically produces water as a co-product — one mole of water per mole of carbon incorporated into hydrocarbon product. That water is not potable, not clean, and not a neutral byproduct. It is a contaminated effluent stream containing dissolved oxygenates, short-chain alcohols, carboxylic acids, ketones, aldehydes, BTEX traces, and — when the upstream syngas contains nitrogen impurities from biomass or MSW gasification — a full homologous series of tertiary alkylamines up to carbon chain length C19 in the water phase.

Voeten et al. (2024) confirmed through three independent analytical techniques that 89 percent of nitrogen from a 2.6 ppmV ammonia co-feed partitions into the FT water phase during cobalt-catalyzed synthesis. The dominant amine class detected was tertiary N,N-dimethylalkylamines, not the primary alkylamines that might be expected from simple ammonia addition. This finding has direct implications for water treatment design: the alkylamine load in FT-produced water must be validated and sized for before a water circularity claim can be made.

For Mexico, this matters because water is independently a circular-economy priority. State programs in Mexico City, Puebla, and Chihuahua all include water use efficiency, rainwater harvesting, and water-capture targets as explicit pillars. A SAF platform that proves the water loop — facility water balance, FT-water treatment to COD below 50 mg/L, nitrogen speciation analysis, and reuse or discharge pathway documentation — connects fuel production with water treatment, recovered water, industrial reuse, and environmental compliance in a single integrated design.

FT-PRODUCED WATER: CONTAMINANT PROFILE AND TREATMENT OBLIGATION

Component Class	Normal Load (mg/L)	Treatment Significance
Methanol	~4,038	Primary stripping target; high volatility; removed in stripper column
Ethanol	~1,935	Primary stripping target
C3-C6 Alcohols (total)	~1,700	Stripping plus membrane bioreactor (MBR)
Acetic Acid	~478	MBR biodegradation
C3-C6 Carboxylic Acids	~285	MBR biodegradation; drives COD load
Ketones (acetone, MEK)	~33	MBR treatment; monitoring required
BTEX traces	<15 µg/L	Regulatory monitoring required even at trace concentrations
Alkylamines (N,N-dimethyl series, C3-C19)	Up to 44 ppmw nitrogen*	MBR degradation; full-scale validation required; 89% of syngas nitrogen partitions here

*Data from Voeten et al. (2024) at 2.6 ppmV NH3 co-feed. Normal load data from Velocys Technologies (WO 2016/044348 A1). A Velocys-documented MBR process achieves greater than 99% COD removal from stripped FT water at steady state, producing treated effluent with COD below 5 mg/L suitable for cooling tower make-up or process reuse.

ELEVEN-DIMENSION CIRCULARITY EVIDENCE MATRIX

System Dimension	What Must Be Demonstrated	Evidence Required	Risk if Not Resolved

Carbon provenance	Feedstock is predominantly biogenic; fossil fraction quantified	^{14}C analysis per ASTM D6866 on actual feedstock samples	CORSIA/LCFS ineligibility; carbon credit value collapse
Hydrogen source	H_2 is derived from renewable electricity, waste-derived biogas, or recovered process streams	Energy and mass balance with H_2 source verified; CI contribution quantified	Carbon intensity too high for SAF certification credit
Energy basis	Facility energy is self-generated from waste-to-energy recovery or renewable supply	Mass and energy balance with grid dependency explicitly bounded	CI score elevated; renewable claim unsupported
FT water treatment	FT-produced water is treated to meet reuse specification; alkylamine fate demonstrated	Water balance; COD removal to <50 mg/L; nitrogen speciation analysis	Water discharge violation; circular water claim unsupported
Syngas nitrogen management	NH_3/HCN at FT inlet verified to meet catalyst tolerance; water treatment sized for alkylamine load	Syngas composition analysis; FT water characterization per Voeten et al. (2024)	FT catalyst deactivation; SAF nitrogen specification breach (2 ppmw per ASTM D7566)
Residual management	Ash, char, and slag are classified, disposed of, or reused within regulatory framework	Residual characterization; heavy metals/PFAS/leachate testing	Disposal cost overrun; environmental liability
Aircraft material compatibility	Fuel composition meets NBR O-ring swell range at intended blend fraction	Swell testing per Faulhaber et al. (2023) methodology; blend composition verified	Blend limit constraint below 50%v; retrofit cost for legacy fleets
SAF fuel specification	Fuel meets ASTM D7566 and applicable OEM fuel-approval specifications	ASTM D4054 tier testing programme initiated; laboratory analysis complete	Fuel is not certifiable as SAF regardless of production route
Carbon intensity verification	CI score verified against CORSIA, LCFS, RFS, or 45Z as applicable	Lifecycle model with primary feedstock data; third-party CI verification pathway	Incentive payment disqualification; project IRR collapse
Chain of custody	Feedstock provenance traceable from waste origin to fuel product	Mass balance system; transaction certification; traceability protocol	Carbon credit invalidation; LCFS audit failure
Waste hierarchy alignment	Feedstock is post-recycling residual; recycling-first hierarchy respected	Waste classification documentation; diversion records; RDF specification	Regulatory challenge in jurisdictions with strict waste hierarchy requirements

7. The Cobeal SAF Technical Workstream

Cobeal occupies the technical intelligence layer between feedstock opportunity and engineering-ready project basis. This layer — which encompasses feedstock discovery, characterization, conversion pathway selection, pilot testing, carbon intensity modeling, regulatory pre-consultation, and engineering data package preparation — determines whether a regional waste or biomass resource can credibly support SAF production and what the technical design basis for that production system should be.

Cobeal does not position itself as a SAF plant builder at the pre-engineering phase. The positioning is more precise and more valuable: Cobeal constructs and delivers the technical system boundary that transforms a waste characterization data set into a qualifiable, bankable engineering basis. That basis is what basic engineering firms, technology licensors, project finance institutions, and offtake counterparties require before they can make commitments.

THE COBEAL TECHNICAL WORKSTREAM: SIX WORK PACKAGES

1	2	3	4	5	6
Feedstock Intelligence	**Sampling & Testing**	**Pathway Screening**	**Pilot Test Basis**	**Engineering Package**	**Investment Readiness**
MSW, RDF, biomass, organics, ag residues	Moisture, ash, HHV, chlorine, metals, variability	Gasification, FT, ATJ, RNG, hydrogen support	Preprocessing, syngas, cleanup, residues	Design basis for basic and detailed engineering	Risk register, carbon data, permitting, go/no-go

Work Package	Scope	Primary Deliverables
WP1: Feedstock Intelligence	County, city, hauler, facility, and contract mapping. MSW, RDF/CSR, woody biomass, organics, agricultural residues, and manure screening. Current destination, logistics, control points, and opportunity timing.	Feedstock atlas; control-point map; opportunity score; first-pass pathway screen
WP2: Sampling and Testing	Moisture, ash, HHV/LHV, chlorine, sulfur, metals, and variability. Biogenic/fossil carbon fraction per ASTM D6866. PFAS screening. Seasonal variability profile. RDF or biomass acceptance specification.	Characterization report; acceptance criteria; preprocessing requirements; contamination profile
WP3: Pathway Screening	Gasification plus FT, methanol, ATJ, RNG support, and hydrogen support options. Technology-fit matrix by feedstock type and quality envelope. Route selection based on syngas quality, hydrogen balance, carbon efficiency, and commercial risk.	Pathway screening matrix; technology-fit table; selected and rejected routes with rationale
WP4: Pilot Test Basis	Preprocessing trials, gasification trials, syngas analysis, tar and contaminant measurement. Mass and energy balance assumptions for engineering. Go/no-go recommendation for basic engineering.	Pilot test plan; syngas quality targets; engineering data package; mass and energy balance

WP5: Regulatory and Carbon Readiness	Solid waste and biomass classification. Air, water, residue, and permitting issue register. LCFS, RFS, 45Z, and CORSIA data needs. Carbon intensity model framework.	Regulatory pathway memo; carbon intensity data framework; permitting issue register
WP6: Engineering Design-Basis Package	Feedstock and preprocessing specifications. Syngas quality targets and contaminant limits. Interface assumptions for vendors and engineering teams. Risk register with owners and mitigation path.	Design basis memorandum; risk register; go/no-go gates for FEED authorization

SIX-GATE PROJECT DECISION MODEL

Gate	Evidence Required to Open	Cobeal Work Package
G1: Feedstock Qualification	WP1-WP2 characterization complete; biogenic fraction confirmed; seasonal variability bounded; acceptance specification drafted	WP1 + WP2
G2: Pathway Selection	Gasification pathway screened against feedstock profile; syngas cleaning specification drafted; FT inlet constraints confirmed; technology-fit rationale documented	WP3
G3: Pilot Testing Completion	Bench/pilot syngas composition data; tar and nitrogen measurement; FT water sample characterized; mass and energy balance drafted; go/no-go recommendation issued	WP4
G4: Regulatory and Carbon Readiness	Carbon intensity model complete; CORSIA/LCFS/45Z pathway identified; permitting pre-consultation complete; chain-of-custody framework drafted	WP5
G5: Basic Engineering Authorization	Design basis memorandum issued; eleven-dimension circularity evidence matrix complete; technical risk register at acceptable residual level	WP6
FID: Final Investment Decision	All G1-G5 evidence packages delivered; EPC procurement initiated; financing committed; offtake and carbon credit agreements in place	Beyond Cobeal pre-engineering SOW; Cobeal EPCIC role begins

8. Cobeal's Aviation-Sector Partner Matrix

Cobeal's pre-engineering intelligence services are structured to match the specific decision needs of each aviation-sector stakeholder category. The deliverables are produced from primary feedstock and process data, not from generic literature estimates. Each client category receives the technical record it needs to make a defensible next decision.

Client Category	Primary Need	Cobeal Deliverable
Airlines	SAF supply-chain validation; carbon intensity verification; long-term offtake basis	Feedstock atlas; carbon intensity model; pathway feasibility summary; risk register
Airports	Local waste-to-fuel feasibility; airport waste and biomass resource mapping; regional SAF hub planning	Feedstock opportunity ledger; control-point map; preliminary volume estimates; siting and logistics constraints
SAF Developers	Feedstock testing; preprocessing design basis; pathway selection; engineering data package preparation	Full WP1-WP6 deliverable set; go/no-go recommendation; design basis memorandum
Fuel Distributors	Regional feedstock and fuel offtake analysis; blend compliance verification	Feedstock volume estimates; carbon intensity data framework; blend specification review
Infrastructure Investors	Technical diligence; risk register; milestone gate verification; project readiness scoring	Technical due diligence report; eleven-dimension circularity evidence matrix audit; risk-adjusted readiness estimate
EPC/Engineering Firms	Feedstock data package; design basis; process assumptions; syngas quality targets	Engineering data package; design basis memorandum; mass and energy balance; technical specification set
Municipal Agencies/Waste Authorities	Waste-to-value feasibility; diversion strategy; facility siting; regulatory alignment	Feedstock opportunity ledger; technology screening; permitting memorandum; carbon intensity screen

THREE ENGAGEMENT TIERS

Tier 1: SAF Feedstock Intelligence Study

Best for airlines, airports, and investors evaluating regional SAF supply-chain opportunities before committing to a developer or technology. Deliverables: desktop feedstock atlas, opportunity screen, preliminary volume estimates, carbon intensity screen, go/investigate recommendation.

Tier 2: Feedstock Qualification and Pathway Study

Best for SAF developers, airport authorities, and waste-management partners with identified feedstock streams seeking a qualified technical basis. Deliverables: full characterization suite, conversion pathway ranking, preliminary engineering basis, pilot test protocol, carbon intensity model.

Tier 3: Engineering Support Package

Best for developers advancing toward basic engineering (FEED), financing, or FID who require a complete, independently defensible technical package. Deliverables: full WP1-WP6 set, design basis memorandum, mass and energy balance, eleven-dimension circularity evidence matrix, risk register, go/no-go for FEED authorization.

9. MSW Feedstock Characterization Requirements

Regardless of which conversion scenario is adopted, MSW feedstock for SAF production pathways requires systematic characterization before any engineering basis can be established. A comparative lifecycle assessment by Raj et al. (2026) evaluated seven MSW-to-biofuel pathways and found that integrated two-stage gasification with upstream recycling and material flow optimization achieves an avoided global warming potential of negative 1,095 kg CO2 equivalent per tonne of MSW — the strongest environmental performance among all modeled routes. This result is pathway-specific and feedstock-dependent. It requires primary feedstock characterization for each regional application and cannot be transferred from Indian or European MSW datasets to a Mexican waste stream without field verification.

The biogenic carbon fraction of the target waste stream must be determined by radiocarbon analysis per ASTM D6866 on actual feedstock samples from the specific supply corridor. A Mexico City municipal solid waste stream may have a biogenic fraction substantially different from the Indian or European streams used in published lifecycle studies. That difference directly affects the carbon intensity score and therefore the economic value of carbon credits and incentive payments that anchor the project financial model.

MINIMUM FEEDSTOCK CHARACTERIZATION PARAMETERS

Parameter	Method/Standard	Engineering Significance
Moisture content	ASTM D3173 / oven drying	Determines drying energy burden; affects autothermal check for gasification
Proximate analysis (VM, ash, FC)	ASTM D3172	Predicts gasification behavior; ash determines slag and fouling risk
Higher and lower heating value	ASTM D5865 / IS 1350	Determines energy yield; autothermal threshold check
Chlorine content	ASTM D4208 / XRF	HCl formation in syngas; damages catalysts and heat exchangers; PVC indicator
Sulfur content	ASTM D4239	H2S in syngas; poisons FT cobalt catalysts; sets desulfurization specification
Nitrogen content	ASTM D5373 / elemental analysis	NH3/HCN in syngas; drives alkylamine formation in FT water (Voeten et al., 2024)
Alkali metals (Na, K)	ICP-OES / XRF	Catalyst poisoning; slagging risk in gasifier
Heavy metals (Pb, Cd, Hg, Zn, Cr)	ICP-MS / EPA 3050B	Regulatory classification of ash residuals; catalyst protection
PFAS screening	EPA 533 / 537.1	Increasingly required for waste-derived feedstocks; affects ash disposal pathway
Biogenic vs. fossil carbon fraction	ASTM D6866 / 14C analysis	Determines CORSIA and LCFS eligibility; affects carbon credit value
Particle size distribution	ASTM D5233 / laser diffraction	Preprocessing design; gasifier feeding system specification
Seasonal variability profile	Multi-season sampling programme	Sets operating envelope; required for bankable yield guarantee

10. Mexico's Route Upward in Global SAF Production

Mexico's route upward in global SAF production follows from six aligned conditions: a large and diverse feedstock base, urban and industrial density that supports aggregation, active circular-economy policy across leading states, manufacturing and logistics corridors that support industrial deployment, North American relevance under the U.S. 45Z clean-fuel geography when projects qualify, and a Cobeal platform architecture that converts these conditions into project screens and deployment stages.

THE FIFTEEN-POINT READINESS ARGUMENT

Readiness Dimension	Evidence	SAF Implication
Material scale	120,128 t/day urban solid waste; 52% organic; 20 Mt/year FLW farm-to-retail; 11 Mt/year household FLW	Feedstock availability is not the constraint. Feedstock qualification and density are.
Aggregation geography	South-Central Mexico generates 66% of national FLW; 720,606 centers mapped; 89 major supply centers identified	Geographic concentration enables phased corridor deployment rather than scattered pilots.
Energy-positive site inventory	476 WtE-AD sites at positive energy balance; ≥8 t/day threshold; 698-site upside case	Mexico has a deployable, energy-ranked project inventory. This is an implementation map, not a resource narrative.
Process diversity	Wet organics to AD; post-recycling MSW to thermal conversion; ELT to pyrolysis; preprocessing nodes	Feedstock-matched conversion improves technical reliability and supports co-product diversification.
Circular-economy policy	21 of 32 states with CE legislation; six territories with advanced programs; Tula federal park	State programs create corridor-scale implementation channels; federal park demonstrates physical commitment.
State proof of execution	Queretaro: 250+ companies; 600+ professionals trained; 350+ projects; 775M+ pesos in savings; 300,000+ t diverted	Circular economy in Mexico moves through companies and institutions, not only through policy documents.
Federal industrial signal	Tula, Hidalgo: 700-hectare CE industrial park; gasification and carbonization for organic waste	Federal investment is reaching physical assets. The policy transition to infrastructure deployment is underway.
Manufacturing and logistics	Mexico's vehicle, electronics, and industrial export capacity; cross-border corridor infrastructure	SAF scale-up needs fabrication, industrial operations, logistics, and workforce capacity. Mexico has that base.
Cultural circularity	Tianguis, repair trades, informal material recovery embedded in daily urban practice	Circular economy does not start from zero in Mexico. Formal

		engineering builds on embedded cultural practice.
Aviation demand anchor	Fuel is 20-30% of airline operating cost; airlines need qualified, lower-carbon supply at scale	Mexico's waste-to-value platform protects airline economics by controlling the feedstock and system variables that drive SAF cost.
North American feedstock value	IRS 45Z: post-2025 qualifying feedstocks must be produced or grown in the US, Mexico, or Canada	Mexican feedstocks sit inside the North American clean-fuel credit geography when project ownership, production, and compliance are structured correctly.
Global supply gap	IATA: 2.4 Mt SAF in 2026, 0.8% of aviation fuel use; 65% of 2050 emissions reduction needed from SAF	The global market has room for new production geographies. Mexico does not need to displace existing SAF leaders.
Beyond HEFA bottleneck	Fats, oils, and greases alone cannot meet aviation demand; MSW, biomass, and residuals routes required	Mexico's advantage is not used cooking oil. It is MSW, FLW, organics, agricultural residues, livestock waste, and tires.
Water-loop integration	FT process water carries 89% of syngas nitrogen as alkylamines; Mexico's state programs include water-efficiency pillars	A SAF platform that proves the water loop connects fuel production with water treatment, recovered water, and environmental compliance.
Phased rollout logic	Phase 1: top 50 organics platforms >100 t/day, 2 metro thermal hubs, 2 ELT pyrolysis plants; Phase 2: ~426 platforms; Phase 3: national integration	The first phase focuses on highest-density, highest-confidence sites. Mexico's readiness is grounded in a deployment sequence, not a vision statement.

PHASED DEPLOYMENT ROADMAP

Phase	Timeline	Priority Deployments	Milestone Outputs
Phase 1: Foundation	Years 1-3	Top 50 organics platforms above 100 t/day; 2 metropolitan thermal hubs; 2 ELT pyrolysis plants; feedstock sampling and characterization for priority corridors	Feedstock atlases for 3 leading corridors; energy-balance validation for 50 sites; design basis memos for metropolitan hubs; WP1-WP4 packages for anchor sites; carbon intensity models for LCFS/45Z pathways
Phase 2: Expansion	Years 3-6	~426 additional organics platforms; additional thermal and pyrolysis assets; product corridor integration; supply and offtake validation	Full 476-site baseline operational or in engineering; national biofertilizer and biogas supply integration; RNG and hydrogen support infrastructure in South-Central corridor

Phase 3: National Integration	Years 6+	National network integration; Latin America replication model; aviation fuel qualification and ASTM D4054 pathway completion	Qualified SAF blendstock supply from at least one integrated FT or ATJ pathway; CORSIA or LCFS-registered carbon intensity; Latin American waste-to-value platform export

11. National Platform Economics

The economics of a national waste-to-value platform come from systems coordination. Waste materials acquire higher value when collection, classification, conversion, energy recovery, water treatment, residual management, and carbon accounting are planned together. Cobeal's model applies this principle through feedstock-matched conversion, density-driven siting, scale-enforced energy positivity, and phased rollout.

Mexico's circular economy creates co-product and co-benefit options that improve project economics beyond the primary fuel stream. Anaerobic digestion produces biogas, power, heat, biofertilizer, and carbon value. Thermal conversion produces electricity, heat, syngas, and residual mineral streams. Controlled pyrolysis produces tire pyrolysis oil, syngas, carbon black, and recovered metals. Water treatment creates reclaimed water value. Carbon accounting creates incentive value where eligibility criteria are satisfied. These outputs diversify revenue and support platform resilience across market conditions.

This platform approach addresses airline economics because it controls SAF cost at the beginning of the value chain. SAF cost is influenced by feedstock quality and price, supply stability, preprocessing energy, hydrogen and water architecture, conversion yield, plant capital intensity, and the risk premium attached to permitting, certification, and carbon accounting. A waste-to-value platform that measures these variables before engineering provides a stronger basis for investment review than a platform that encounters them for the first time at FEED.

CO-PRODUCT VALUE MAP ACROSS PLATFORM LAYERS

Platform Layer	Primary Outputs	Co-Product Outputs	Carbon / Incentive Value
Regional organics platforms (AD)	Biogas; biomethane; electricity	Heat; biofertilizer; reclaimed water	Carbon intensity credit under LCFS/RFS where feedstock and pathway qualify; RNG pathway eligibility
Metropolitan thermal hubs	Electricity; heat; syngas	Residual mineral streams; recovered metals	Landfill diversion credit; avoided methane value; LCFS low-CI electricity credit potential
Specialized ELT pyrolysis	Tire pyrolysis oil; syngas	Carbon black; scrap steel; recovered materials	Circular economy material recovery value; fossil-carbon diversion from landfill
FT synthesis (SAF pathway)	Paraffinic hydrocarbons (FT-SPK); naphtha	FT-produced water (engineered treatment); light ends	CORSIA; LCFS; RFS D7; 45Z where structure and CI score qualify
ATJ synthesis (SAF pathway)	Iso-alkane SAF blendstock	Light ends; wastewater streams	CORSIA; LCFS; RFS D3/D7; 45Z where

			structure and CI score qualify
Water treatment system	Treated effluent for cooling tower or reuse	Recovered water credit; wastewater load reduction	Water circularity claim support; environmental compliance value

12. Conclusion

Mexico is ready to move upward in global sustainable aviation fuel production because its circular-economy base can be organized into feedstock-controlled, energy-positive, aviation-relevant waste-to-value infrastructure. The country has material scale, urban density, industrial corridors, circular-economy policy momentum, cultural reuse practices, and North American clean-fuel relevance. Cobeal's work supplies the project-development architecture that converts these conditions into siting, testing, route selection, design-basis, water-loop, carbon-readiness, and investment-review decisions.

The word ready is used here as a technical-economic category: Mexico has measurable feedstock streams, usable industrial corridors, policy activity, circular-economy practices, aviation relevance, and a Cobeal systems architecture that can translate resource geography into project decisions. Readiness begins with feedstock mapping and moves through testing, pathway screening, pilot basis, design basis, risk allocation, and financeable decision gates. Mexico has the conditions for all of these steps.

The strongest feedstock argument comes from the combination of national data and Cobeal's mapping. The strongest economic argument is scale discipline. The strongest policy argument is state complementarity. The strongest aviation argument is supply scarcity. The strongest circularity argument is the eleven-dimension evidence matrix that Cobeal's technical workstream delivers before capital is committed. These arguments do not require optimism. They require engineering discipline applied at the right point in the project sequence.

Mexico's path is therefore practical and sequential. The first phase prioritizes high-density organics platforms, metropolitan thermal hubs, specialized conversion assets, and supply and offtake validation. The second phase expands the viable site network and integrates product corridors. The third phase creates national integration and a model suitable for broader Latin American replication. This is how circular-economy planning becomes industrial development, and how waste geography becomes aviation fuel economics.

Mexico's circular economy is ready for a national waste-to-value platform because the country has the feedstock, the policy map, the industrial base, the logistics corridors, the airport demand, and the North American credit relevance. Cobeal's contribution is the systems architecture: feedstock-matched conversion, density-driven siting, energy-positive thresholds, water-loop discipline, carbon-intensity readiness, and phased deployment.

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