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X-150 SAF

Sustainable Aviation Fuel from Waste

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Executive Summary

The X-150 SAF configuration produces sustainable aviation fuel (SAF) from organic waste through gasification, Fischer-Tropsch synthesis, and hydroprocessing. This system addresses aviation’s decarbonization challenge by converting waste into drop-in jet fuel compatible with existing aircraft and infrastructure.

Key Benefits:

- **25-35 liters SAF production** per 150 kg/h unit per day
- **€0.80-1.20/liter production cost**
- **9,000 liters annual SAF** (8,000 operating hours)
- **80-90% CO_2 reduction** vs. conventional jet fuel
- **ASTM D7566 certified** drop-in fuel

Technology Overview

Process Flow

The X-150 SAF system produces renewable jet fuel through five integrated stages:

Stage 1: Syngas Production
Organic waste undergoes gasification at 800-1000°C, producing synthesis gas (syngas) composed of hydrogen (H_2) and carbon monoxide (CO). The syngas composition is optimized for Fischer-Tropsch synthesis through steam reforming and water-gas shift reactions to achieve the ideal H_2:CO ratio of 2:1.

Stage 2: Gas Cleaning & Conditioning
Syngas undergoes comprehensive cleaning to remove particulates, tars, sulfur compounds, and other contaminants that would poison Fischer-Tropsch catalysts. Multi-stage scrubbing, filtration, and catalytic reforming ensure ultra-clean syngas suitable for downstream synthesis.

Stage 3: Fischer-Tropsch Synthesis
Clean syngas reacts over iron or cobalt catalysts at 200-350°C and 20-40 bar pressure to form long-chain hydrocarbons. The Fischer-Tropsch process builds hydrocarbon molecules from syngas building blocks, creating a synthetic crude oil composed primarily of linear paraffins and olefins.

Stage 4: Hydroprocessing & Fractionation
The Fischer-Tropsch crude undergoes hydrocracking and hydroisomerization to break long chains into jet fuel range molecules (C8-C16) and optimize cold-flow properties. Fractionation separates the product into naphtha, jet fuel, and diesel fractions.

Stage 5: Quality Control & Blending
The synthetic jet fuel is tested to ensure compliance with ASTM D7566 specifications for Synthesized Paraffinic Kerosene (SPK). The fuel can be used as 100% SAF or blended with conventional jet fuel up to 50% without aircraft modifications.

Technical Specifications

Performance Parameters

Parameter	Specification
SAF Production (per 150 kg/h unit)	25-35 liters/day
Production Efficiency	35-45% (LHV basis)
Fuel Quality	ASTM D7566 (FT-SPK)
Annual SAF Production (8,000h)	9,000 liters/year
Carbon Intensity	10-20 gCO_2e/MJ (80-90% reduction)
Energy Density	43.2 MJ/kg (equivalent to Jet-A)
Freeze Point	< -47°C (ASTM requirement)
Flash Point	> 38°C (ASTM requirement)

Fuel Quality Compliance

ASTM D7566 Annex A1: Fischer-Tropsch Synthesized Paraffinic Kerosene (FT-SPK)

- Approved for up to 50% blending with conventional jet fuel
- Compatible with all commercial aircraft without modifications
- Meets or exceeds Jet-A/Jet-A1 specifications for:
    - Energy density
    - Freeze point
    - Flash point
    - Aromatics content (0-8%)

- Sulfur content (< 15 ppm)

Target Applications

Airlines & Aviation Operators

Problem Solved: Aviation sector faces regulatory pressure to decarbonize (CORSIA, EU ETS, ReFuelEU Aviation) but lacks viable alternatives to jet fuel. Conventional SAF from vegetable oils is expensive (€1.50-2.50/liter) and limited by feedstock availability.

Solution: Waste-to-SAF provides cost-competitive renewable jet fuel from abundant organic waste feedstocks. Airlines can meet sustainability mandates while managing fuel costs and securing supply chain resilience.

Economic Impact: An airline consuming 10 million liters of jet fuel annually can meet 5-10% SAF blending mandates with waste-derived SAF, avoiding €500,000-1,500,000 in carbon compliance costs while improving corporate sustainability ratings.

Airport Waste-to-Fuel Facilities

Problem Solved: Airports generate significant organic waste (food service, landscaping, cargo) requiring expensive disposal while simultaneously purchasing jet fuel from distant refineries.

Solution: On-airport waste-to-SAF facilities convert airport waste into jet fuel for immediate use, creating a circular economy within airport operations. This eliminates waste transportation costs and fuel delivery logistics.

Economic Impact: A major airport generating 50 tonnes/day of organic waste can produce 1.2 million liters of SAF annually, worth €1.0-1.4 million, while saving €400,000-1,200,000 in waste disposal costs.

SAF Producers & Fuel Blenders

Problem Solved: SAF mandates are increasing (2% by 2025, 6% by 2030 in EU) but production capacity is insufficient. Conventional SAF pathways (HEFA, ATJ) face feedstock constraints.

Solution: Waste-to-SAF technology provides scalable SAF production using abundant, low-cost feedstocks. Multiple X-150 units can be aggregated to create commercial-scale SAF production facilities.

Economic Impact: A 20-unit facility producing 180,000 liters/year of SAF generates €180,000-216,000 in fuel sales revenue plus €480,000-1,440,000 in waste tipping fees, with premium pricing for certified sustainable fuel.

Economic Analysis

Cost Structure

Levelized Cost of SAF (LCOS): €0.80-1.20/liter

Cost Component	Value
Capital Expenditure (CAPEX)	€2,000,000 - 3,000,000 per unit
Installation & Commissioning	20-25% of equipment cost
Annual Operating Costs (OPEX)	€80,000 - 120,000 per unit
Maintenance	€30,000 - 45,000 per year
Consumables (catalysts, chemicals)	€25,000 - 40,000 per year
Labor (0.75 FTE per unit)	€35,000 - 50,000 per year
Utilities (electricity, water)	€15,000 - 25,000 per year

Revenue Streams

Primary Revenue:

- **SAF Sales**: €9,000-13,500/year per unit (9,000 liters at €1.00-1.50/liter)
- **Tipping Fees**: €24,000-72,000/year (1,200 tonnes at €20-60/tonne)
- **Carbon Credits**: €20,000-40,000/year (premium for aviation decarbonization)

Secondary Revenue:

- **Co-Product Sales** (naphtha, diesel): €5,000-10,000/year
- **Biochar Sales**: €24,000-48,000/year (120 tonnes at €200-400/tonne)
- **Renewable Fuel Certificates**: €9,000-18,000/year

Total Annual Revenue: €91,000 - 201,500 per unit

Simple Payback Period: 10-15 years (improving as SAF prices increase and mandates tighten)

Note: Economics improve significantly at scale. A 20-unit facility achieves €1.8-4.0 million annual revenue with economies of scale reducing per-unit costs by 20-30%.

Environmental Impact

Carbon Intensity

The X-150 SAF system achieves **10-20 gCO_2e/MJ carbon intensity**, representing an **80-90% reduction** compared to conventional jet fuel (89 gCO_2e/MJ). This calculation includes:

- **Biogenic carbon neutrality**: Organic waste feedstock is carbon-neutral
- **Waste diversion credit**: Avoiding landfill methane emissions
- **Process emissions**: Energy consumption for synthesis and upgrading
- **Land-use change**: Zero (waste feedstock, no dedicated crops)

Comparison with SAF Pathways

SAF Pathway	Carbon Intensity	Feedstock	Cost
HEFA (vegetable oils)	20-40 gCO_2e/MJ	Vegetable oils, animal fats	€1.50-2.50/L
ATJ (alcohol-to-jet)	15-30 gCO_2e/MJ	Sugars, starches	€1.20-2.00/L
FT-SPK (gas-to-liquid)	5-15 gCO_2e/MJ	Natural gas + CCS	€1.00-1.80/L
X-150 SAF (waste gasification)	**10-20 gCO_2e/MJ**	**Organic waste**	**€0.80-1.20/L**

Regulatory & Certification

Aviation Fuel Standards

ASTM D7566: Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons

- **Annex A1**: Fischer-Tropsch Synthesized Paraffinic Kerosene (FT-SPK)
- **Blending Limit**: Up to 50% with conventional jet fuel
- **Approval**: Certified for all commercial and military aircraft

DEF STAN 91-091: UK Ministry of Defence aviation fuel standard (equivalent approval)

Sustainability Certification

CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation):

- Eligible SAF pathway under ICAO CORSIA framework
- Achieves > 10% lifecycle emissions reduction threshold
- Qualifies for CORSIA compliance credits

EU Renewable Energy Directive (RED II):

- Qualifies as advanced biofuel (Annex IX Part A - waste feedstock)
- Double counting for renewable energy targets
- Eligible for renewable transport fuel obligations

ReFuelEU Aviation (EU SAF mandate):

- Counts toward 2% SAF mandate (2025), 6% (2030), 70% (2050)
- Eligible for sub-mandate for synthetic fuels

Case Studies

Airport Waste-to-SAF Pilot - Canary Islands

Project: On-airport waste-to-fuel demonstration facility
Capacity: 2x X-150 SAF units (70 liters/day total)
Feedstock: Airport food service waste + landscaping residues
Results:

- 18,000 liters annual SAF production
- €21,600 annual fuel sales revenue (€1.20/liter)
- €60,000 annual waste tipping fee revenue
- 32 tonnes CO_2 avoided annually
- Successful ASTM D7566 certification
- Demonstration of airport circular economy model

Regional SAF Production - Kenya

Project: Agricultural waste-to-SAF for regional aviation
Capacity: 10x X-150 SAF units (350 liters/day total)
Feedstock: Agricultural residues from coffee and tea processing
Results:

- 90,000 liters annual SAF production
- €108,000 annual fuel sales revenue

- €300,000 annual waste tipping fee revenue
- 160 tonnes CO_2 avoided annually
- Supporting regional airline sustainability commitments
- Creating rural employment and waste management infrastructure

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Installation & Commissioning

Site Requirements

Footprint: 400-600 m^2 per unit (including feedstock storage, Fischer-Tropsch reactor, hydroprocessing, fuel storage)

Utilities:

- Electrical connection: 400V 3-phase, 40 kW
- Water supply: 3-5 m^3/day (cooling, steam generation)
- Fuel storage: 10,000-20,000 liter capacity (above-ground tanks)

Safety:

- Fuel handling and storage per NFPA 30 (Flammable and Combustible Liquids Code)
- Process safety management for high-pressure synthesis
- Fire suppression systems
- Vapor recovery and emissions control

Environmental:

- Emissions compliance: EU IED 2010/75/EU
- Fuel quality testing laboratory
- Wastewater treatment for hydroprocessing

Timeline

Phase	Duration
Site Preparation & Safety	6-8 weeks
Equipment Delivery	20-24 weeks (from order)
Installation	10-12 weeks
Commissioning	4-6 weeks
Fuel Certification	4-8 weeks
Total Project Duration	11-15 months

Scale-Up Scenarios

Modular Expansion

X-150 SAF units can be aggregated for commercial-scale production:

Small Scale (5 units):

- Production: 45,000 liters/year
- Feedstock: 6,000 tonnes/year
- Revenue: €450,000-1,000,000/year
- Applications: Regional airports, niche airlines

Medium Scale (20 units):

- Production: 180,000 liters/year
- Feedstock: 24,000 tonnes/year
- Revenue: €1.8-4.0 million/year
- Applications: Major airports, SAF blenders

Large Scale (100 units):

- Production: 900,000 liters/year

- Feedstock: 120,000 tonnes/year
- Revenue: €9-20 million/year
- Applications: Dedicated SAF production facilities, airline fuel supply agreements

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Service & Support

Maintenance Program

Preventive Maintenance Schedule:

- **Daily**: Automated monitoring, fuel quality testing
- **Weekly**: Visual inspections, ash removal, catalyst monitoring
- **Monthly**: Fischer-Tropsch reactor performance analysis
- **Every 4,000 hours**: Catalyst regeneration or replacement
- **Annual**: Comprehensive system overhaul, pressure vessel inspection, fuel certification testing

Service Packages:

- **Basic**: Remote monitoring, spare parts supply, technical support
- **Standard**: Basic + annual on-site maintenance visit + fuel quality testing
- **Premium**: Standard + guaranteed uptime (>85%), emergency response (<48h), catalyst management, ASTM certification support

Fuel Quality Assurance

Comprehensive quality control program:

- Continuous process monitoring and optimization
- Batch testing per ASTM D7566 requirements
- Third-party certification for CORSIA/RED II compliance
- Traceability and chain-of-custody documentation
- Annual recertification audits

Next Steps

Project Development Process

1. **Feasibility Assessment** (4-6 weeks)
    - SAF market analysis and offtake agreements
    - Waste characterization and availability
    - Site evaluation and safety assessment
    - Preliminary economic modeling
2. **Proposal & Engineering** (8-10 weeks)
    - Detailed process design and safety engineering
    - Financial modeling and project economics
    - Permitting strategy (fuel production, emissions, safety)
    - Fuel certification pathway planning
    - Formal proposal and contract negotiation
3. **Project Execution** (11-15 months)
    - Equipment manufacturing and testing
    - Site preparation and safety systems installation
    - Installation and commissioning
    - Fuel production and ASTM certification
    - Performance testing and handover

Contact Information

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Regional Partners:

- **Asia Pacific**: Life PTMA (Indonesia), Akira Asai Corporation (Japan)
- **South Asia**: Tata Power (India)
- **Europe**: Equation Labs (Spain)
- **Africa**: GIZ partnerships across 6 countries

Appendix: Technical Diagrams

System Schematic

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[Waste Feedstock] → [Gasifier] → [Gas Cleaning] → [Fischer-Tropsch
Synthesis] → [Hydroprocessing] → [SAF Product]
                          ↓              ↓                    ↓
↓
                    [Biochar]    [Tar Reforming]      [Synthetic Crude]
[Naphtha/Diesel]
```

Energy Balance

Input: 150 kg/h organic waste (4.5 MWh/day LHV)

Output:

- SAF: 30 liters/day (1.1 MWh LHV, 24% efficiency)
- Co-products (naphtha, diesel): 10 liters/day (0.4 MWh LHV)
- Biochar: 15 kg/h (carbon sequestration)

Consumption:

- Process energy: 1.5 MWh/day
- Hydrogen for hydroprocessing: 0.3 MWh/day

Losses: 50-55% (stack losses, process inefficiencies, heat rejection)

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