TEAM 57

Optimized Supply Chain Management and Aerospace Integration of Sustainable Aviation Fuel (SAF)

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AE 2 ISE

Introduction / Background

- **Context:** The aviation industry contributes 2–3% of global CO_2 emissions. Sustainable Aviation Fuel (SAF) is the most immediate solution but faces high feedstock costs and complex logistics.
- **Objective:** To design a cost-effective "Waste-to-Wing" logistics network for collecting Used Cooking Oil (UCO) in Saudi Arabia and converting it into SAF, integrating Industrial Engineering (supply chain) with Aerospace Engineering (combustion performance).

Problem Statement

- **Logistics Gap:** Current UCO collection is fragmented and expensive.
- **Technical Uncertainty:** Large-scale adoption is hindered by the lack of an optimized collection network and uncertainty regarding SAF combustion performance in jet engines.
- **Goal:** Create a system that minimizes logistics costs while ensuring the fuel meets ASTM D7566 safety standards.

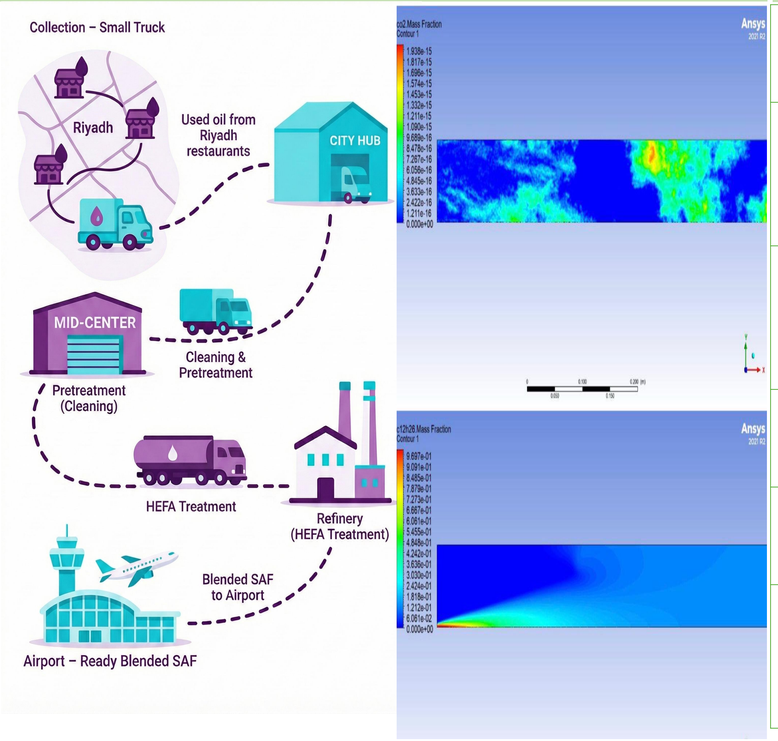
Constraints & Specifications

- **Constraints:**
  - **Budget:** ≤ 6,000 SAR (Actual: 0 SAR).
  - **Time:** Driver shifts ≤ 10 hours; Delivery lead time ≤ 48 hours.
  - **Safety:** SAF Blend ≤ 50% (HEFA-SPK).
- **Specifications:**
  - **Coverage:** ≥ 50% of KSA Population (Riyadh, Jeddah, Dammam).
  - **Efficiency:** Fleet utilization ≥ 80%.
  - **Sustainability:** Lifecycle CO_2 reduction ≥ 20% vs Jet A-1.

Prototype Design (The Digital Twin)

- **Description:** A high-fidelity "Digital Twin" integrating a Gurobi MILP Optimization Model (ISE) with ANSYS Fluent CFD Simulations (AE).
- **The Network (3-Tier System):**
1. **First Mile:** Small trucks (SR5) collect raw UCO from restaurants.
2. **Consolidation:** Mid-size trucks move oil to City Megahubs for pretreatment.
3. **Line-Haul:** Large tankers transport pretreated oil to the refinery.

Prototype Visuals

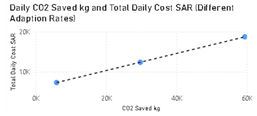


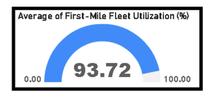
Specifications Met

Specification	Target	Achieved
Cost Efficiency	< 3.00 SAR/L	**0.163 SAR/L** ✅
Fleet Utilization	≥ 80%	**93.78%** ✅
Sustainability	≥ 20%	**21.5% Red.** ✅
Coverage	≥ 1%	**1.48%** ✅
Delivery Time	≤ 48 Hours	**< 24 Hours** ✅

Testing & Validation

Daily SAF Liters Output	Daily Transferred Pretreated UC...	Daily Transferred Raw UCO Liters	Total Daily cost in SAR	Cost Per Restaurant Visit (SAR)	Cost Per Liter (SAR)
54.66K	68.32K	75.91K	12.37K	10.19	0.16





The Daily Logistic Plan

City	First-Mile Trucks	First-Mile Type	Shuttle Trucks (Mid)	Shuttle Type	Line-Haul Trucks (Large)	Line-Haul Type
DMM	2	SR5	1	MR10	1	LT30
JED	7	SR5	1	MR10	1	LT36
RUH	9	SR5	1	MR15	1	LT30

City	Average of Utilization (%)	Storage Tanks in Mid-city Hub	Mid-City Hubs Count	Sum of Daily UCO Volume (L)
RUH	92.04	2	1	37,276.79
DMM	93.30	1	1	8,397.32
JED	95.99	2	1	30,236.61
Total	**93.78**			**75,910.71**

Conclusions

- The project successfully delivered a "Digital Twin" for SAF logistics. The hybrid supply chain is economically viable (0.16 SAR/L) and technically safe, meeting all ASTM D7566 standards and supporting Saudi Vision 2030.