

Consideration of MSW to liquid solutions CCSMM by private / public fuel sector collaboration CAAFI

Dear CCSMM,

During the month of October private public participants in a new MSW to Liquids supply chain met with DEEP Waste Management, MIRA and others to describe the opportunity for CT stakeholders to bring forward an opportunity for introducing a significant sustainable option for obtaining benefits from waste stream management in the State. To date this opportunity, now entering commercial practice across the world, had yet to be introduced to the dialogue with all state towns via CCSMM. It has however been presented separately to both DEEP Waste Management and the MIRA Board of Directors and has been discussed with representatives of the City of Hartford

Hence, in response to CCSMM public Engagement Questions and the "Questions for Response" Question # 6. **...solutions that you would like the coalition to know about that do not fit within the focus areas** it is suggested that CCSMM consider the inclusion of MSW to Liquids (sustainable Jet, diesel and Home heating oil) as part of the solutions CCSMM is discussing.

MSW to L pathways have the potential to maximize sustainability for CT by benefitting both environmental carbon and local pollution (HC, SOX and CO). These solutions also provide economic gains through significant revenue generation with the potential for (jobs, growth and rebranding of the state) are an opportunity that can have the broad benefits for social and environmental justice benefits through its execution.

The CAAFI collaboration , submitting this proposal, consists of Airline, Aircraft manufacturing, and Airport interests operating in Connecticut, Sub tier equipment providers who are CAAFI stakeholders support multiple processors globally.. CAAFI was founded in Washington with Connecticut based leadership participation. It is supported financially by the Federal government via the FAA. FAA in turn partners with the Department of Energy , USDA, EPA and DOD in developing solutions for sustainable fuel. at the Federal level.

Specifically the CAAFI coalition and its partners in CT suggest that CCSMM add to its menu of options and information for consideration.

a) a fourth pathway to organics management **section 2b. (Development and siting of infrastructure) an additional item iv. of "sustainable liquid fuel production" .**

b) **inputs specific to under section 4 e) (measures to support new end market development and to attract manufacturers** two attached presentations

In support of its proposed approach please see.

- i. the attached 10/7 presentation to DEEP Waste Management entitled **MSW-to-Liquid Fuels – A Technical, Environmental, & Co-Product Opportunity**
- ii. the attached 10/14 presentation to the MIRA Board of Directors entitled **MSW-to-Liquid Fuels, An Opportunity for MIRA**

Our growing team , CAAFI, Raytheon / Pratt and Whitney, Linde. and airlines operating from Bradley Airport, beginning with FEDex facility there, are depicted in the presentations. We would welcome the opportunity to brief CCSMM .

The most recent attached presentations build upon work done and visits made by candidate suppliers to CCAT (the Connecticut Center for Advanced Technologies under two federal grants) beginning in 2013 to 2014 and the then CRRRA facility in that time period. At that time the technologies discussed were in the demonstration stage. These technologies have now been qualified for jet use and have entered commercial operations. It is anticipated that markets will now grow rapidly in view of global regulatory requirements which govern aviation adopted in 2018 by ICAO, part of the UN that governs global aviation and its effects on the environment. Part of what we intend to do is to develop a CT based case study of how all waste streams in the State can be optimally separated and managed. Under our plan the case study would be part of an effort of a national team featuring the best economic and environmental analysts via a public private partnership in response to an FY21 DOE solicitation expected to be announced before yearend.

Connecticut. though a small State has distinctive competence in Sustainable aviation fuel and related diesel and home heating oil options, The mix does not depend on any one market and hence offers resilience in its product slate. Our supply chain based team is not biased toward any process and has no commercial stake in the success of any processor or contractor that would deal directly with the State, its towns or authorities such as MIRA. We do benefit from your collective success and offer these inputs accordingly.

Thank you for your consideration of Sustainable MSW to Liquid pathways in your deliberations. We look forward to communicating further with CCSMM.

Kind Regards,

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MSW-to-Liquid Fuels Technical, Environmental, & Co-Product Opportunity

**Presentation for CT Department of Energy and Environmental Protection (DEEP)
October 7, 2020**

**Rich Altman, Executive Director Emeritus
Commercial Aviation Alternative Fuels Initiative (CAAFI)**



Agenda

- * **Who we are**
 - * CAAFI – a private / public sustainable fuel supply chain coalition facilitator
 - * Linde / Praxair – CT based major subsystem supplier to processors
- * **Liquid Sustainable Fuels from MSW**
 - * Technical options: Two example processes for MSW-to-fuels
 - * ASTM approval processes governing SAF* ASTM 4054, ASTM 7566
 - * Recognized Processors showing interest via visit or current inquiries
- * **Environmental impacts of processes ground to flight (EPA view) and local**
- * **Co-products (by-products) to provide resilience**
- * **Recommended “location specific” questions for a proposed RFI (or equivalent) from DEEP**
(* SAF - Sustainable Aviation Fuel)
- * **Federal Support for developing answers?**

CAAFI* Private / Public Coalition

Facilitating Sustainable Fuel Supply Chain Development Since 2006

* Commercial Aviation Alternative Fuels Initiative born in CT and Washington D.C. early 2007.



Air Transport World
Global Innovation Award



Airline / Military
partnership



Paris Airshow with
USDA Secretary Vilsack



The New Linde



Linde at a glance

- Formed in 2018 by the merger of **Praxair, Inc. (CT)** and Linde AG (Germany)
- ~ 80,000 employees worldwide
- ~\$15 million in charitable giving (2018)
- A 100+ year history of technical leadership in gas production and processing
- Wide experience in POx systems, including MSW gasification (PUROX) system in 1990s
- **technology for Fulcrum/Reno MSW-to-jet fuel project Defense Procution Act (DPA)**



MSW to L Sustainable Fuel Co-Products

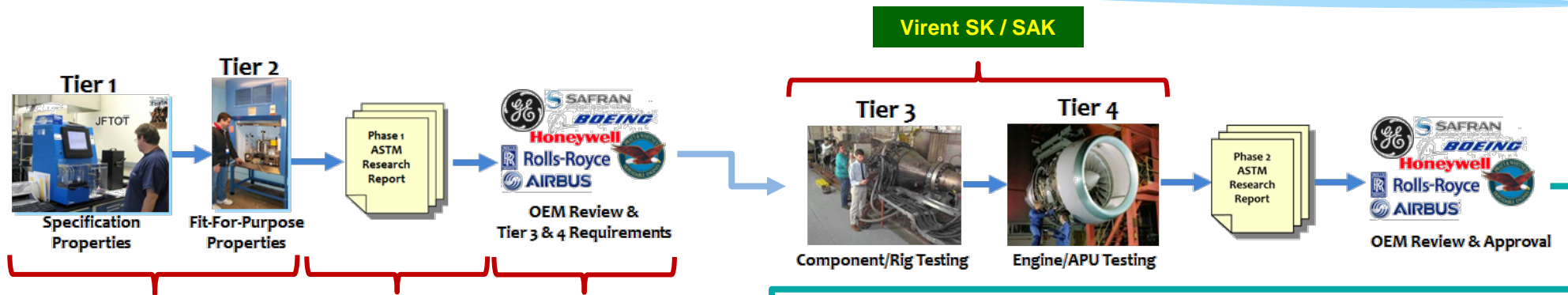
- **Sustainable Aviation Fuel (SAF) - International use of fuel regulated by United Nations (60% of usage)**
- **Sustainable Green Diesel - EPA RFS2 Regs**
- **Sustainable Home Heating Oil - Majority in New England – EPA Regs.**
- **Non-food (corn) sustainable Ethanol**



Resilient product stream , credit (e.g. EPA RFS2 / RINS), up to 6X revenue vs. electricity

SAF via ASTM Passage key to full Market access

ASTM 4054 Process Required for ASTM 7566 Approval for Use



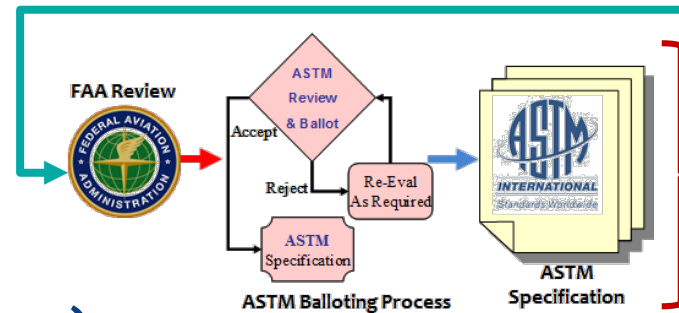
Global Bioenergies
Isobutene to jet

Indian
CSIR-IIP

ATJ-SKA
(Swedish
Biofuels)

HFP-HEFA
(HDRD or
Green Diesel)

Shell IH²



Annex A7
HHC-HEFA

Annex A6
CHJ

Annex A5
ATJ-SPK
(Isobutanol &
ethanol)

Annex A4
FT-SKA

Annex A3
HFS-SIP

Annex A2
HEFA-SPK

Annex A1
FT-SPK

* 7 approved pathways (D7566 Annexes)

* 6 in-process (dark green boxes)

* >15 in pipeline

* 2 refinery co-processing concepts

* 2 candidate types interested in MIRA repurposing

D1655 Co-Processing

FT Biocrude

Lipids / FOG

MSW to L Processors Engaged with CARRA/MIRA

Proven Technology, Commercial Experience, Qualified Fuels



- 2019 visit / MIRA evaluation
- Partnered with Shell / British airways in UK, MSW to SAF
- Production facility in development Natchez, MS (using wood residuals)
- Qualified Jet fuel



- Request for visit evaluation 7/20 to CAAFI / Linde
- Formed LanzaJet spinoff with ANA, Mitsui, Suncor – commercializing ATJ in Soperton, GA
- Qualified Jet fuel via alcohol intermediate



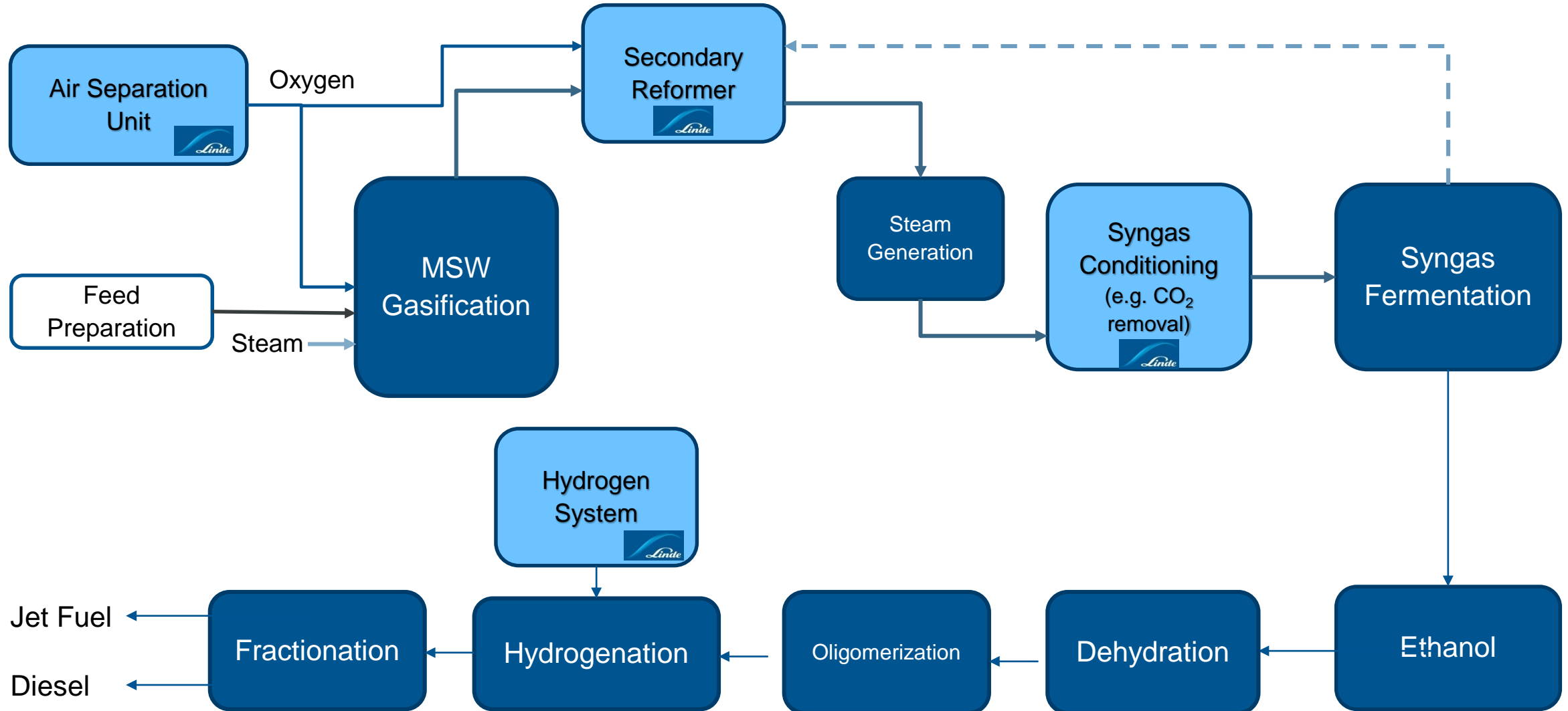
- Production facility in Edmonton, Canada – production of ethanol and methanol
- US EPA approved Renewable Fuel Standard RINS eligible
- Bid DEEP proposal pre 2015 for MSW-to-L pathway
- City of Edmonton and Canadian customers
- Qualified Jet fuel potential via Alcohol intermediate



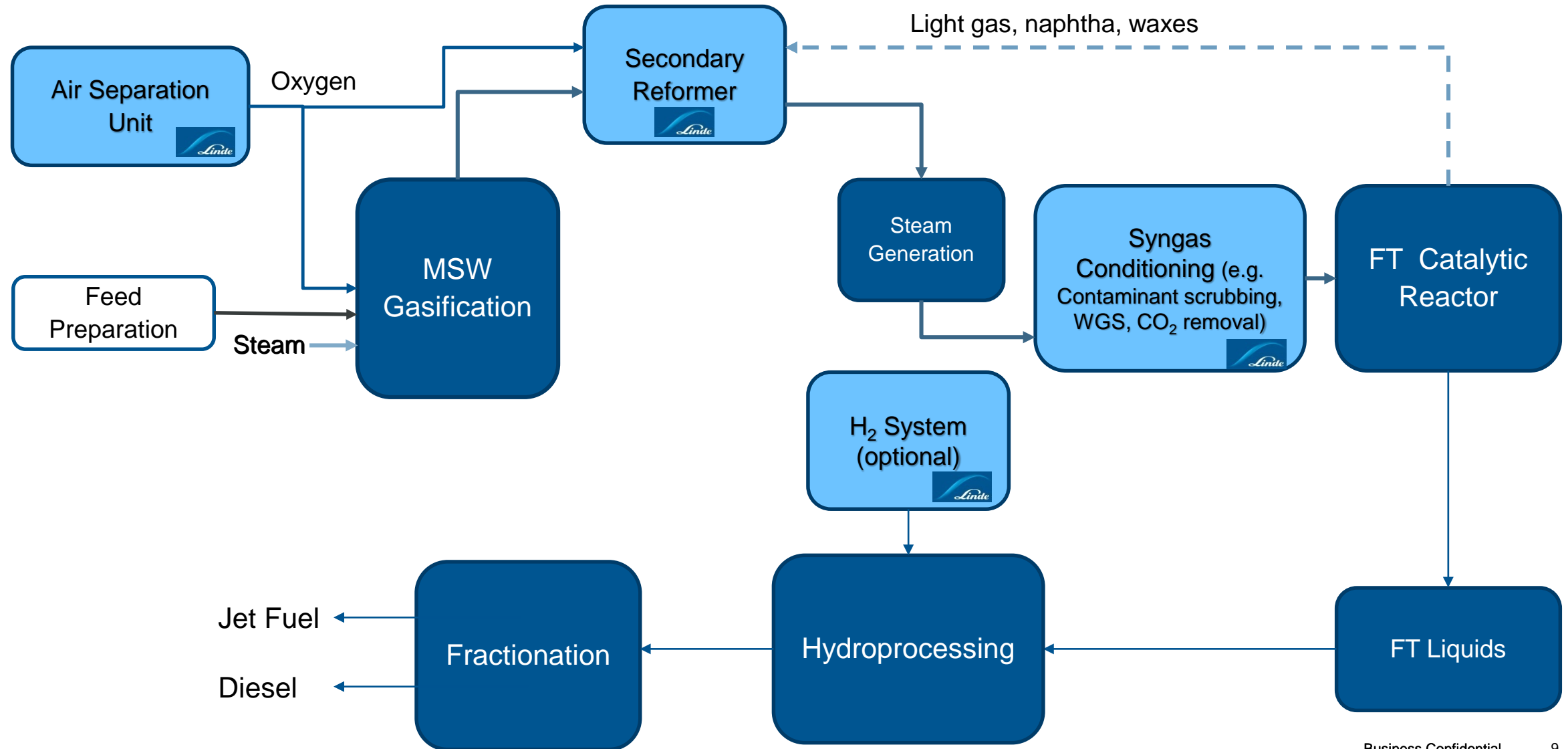
- Visited MIRA pre 2015
- Initiated project with Japan Airlines thanking CAAFI MIRA for guidance
- Licensee of USG DPA processor Fulcrum
- Qualified Jet Fuel. Fulcrum EPA/RFS approved.



MSW to ATJ via Syngas Fermentation (e.g. LanzaTech/LanzaJet)



MSW to Fischer Tropsch Diesel/Jet (e.g. Fulcrum, Velocys)



MSW-to-L CT Supply Chain Engaged / Benefiting

Sustainable Jet Fuel Market in Place / Strong private sector engagement



- Airbus and airline customer demand
- Interest for Middletown jet production and ground vehicles
- Participated in 2020 visits
- Committed SAF offtaker (Red Rock @ Oakland)
- Demand for BDL supply (diesel and Jet)
- Visits to MIRA
- Member of A4A, CAAFI sponsor
- Major supplier to multiple process candidates
- Subsystems and Hydrogen supply
- Danbury based
- Participated in 2020 visits
- Part of pre – 2015 dialogue
- Airlines don't buy fuel, the airlines do; but airports are collaborating to address LAQ and GHGs. SAF major lure to attract international airlines.
- 3X job multiplier for attracting international service to Bradley
- Fixed Base Operator could blend SAF with conventional Jet
- Discussions have taken place with Bombardier, JetBlue, and Amazon w.r.t. their interests in being additional offtakers at Bradley



Potential for U.S. SAF Feedstock Sources

Targets of opportunity that do not compete for food or land use change

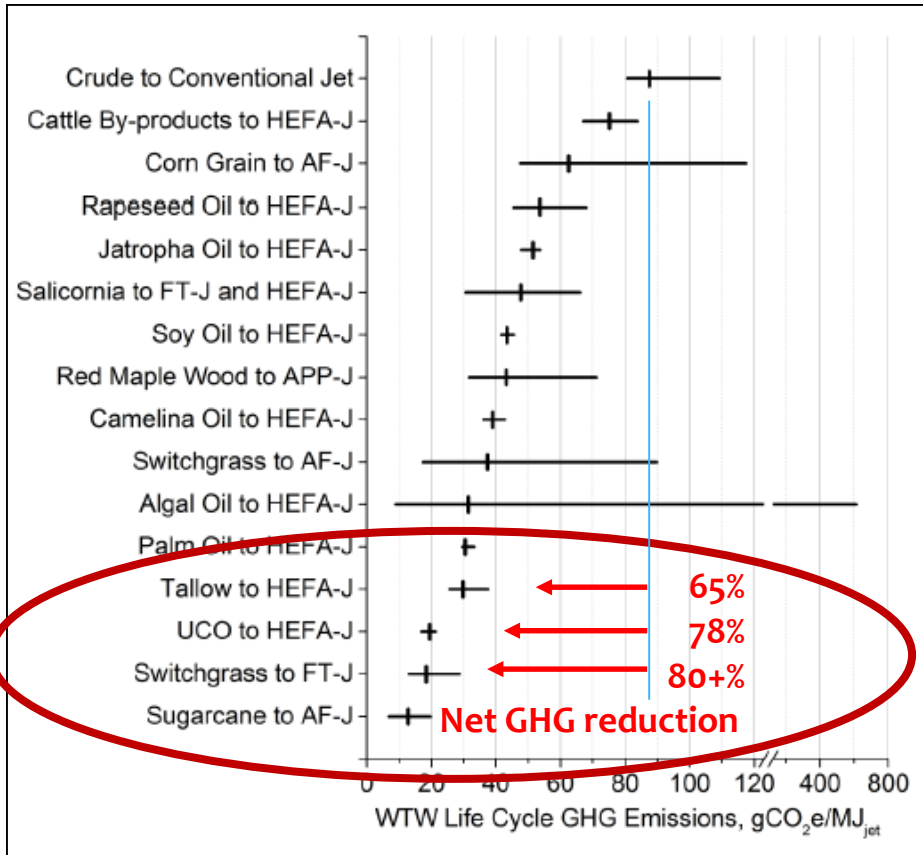
SAF from various feedstocks (GPY, using standard conversions and product slates)*

“Waste” streams

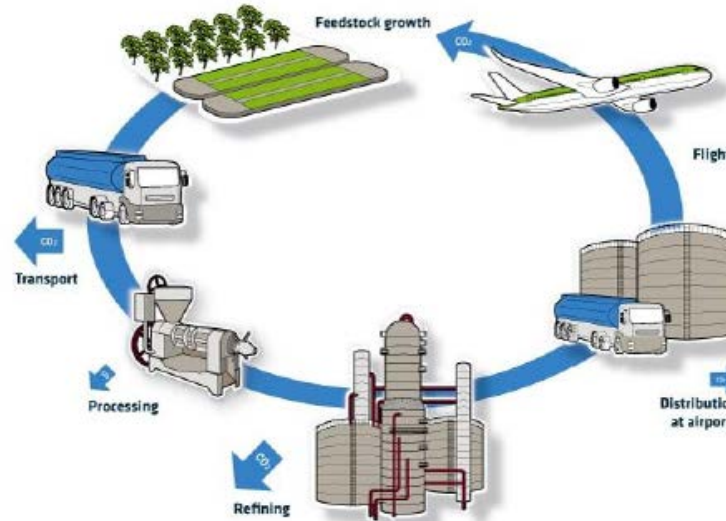
3.8 B	Wet Waste (manures, sanitary, misc streams)
3.1 B	MSW (municipal solid waste: wood, paper, yard, plastics, textiles, food)
6.1 B	Agricultural residues (primary crop residues only, 31% removal)
0.4 B	Forestry residues (30% of production uncommitted)
0.8 B	F.O.G. (Fats oils and greases: estimates vary significantly, up to 3.0B)
1.3 B	Industrial off-gases (steel, aluminum, petroleum)
x.x B	Other (C&D waste, telephone poles, rail ties, invasive tree removal)
<u>~15.6+B</u>	Current Total Potential (approx. 58% of total 2019 U.S. jet fuel demand)

* Derived from US Department of Energy Billion ton study

Achieving net Lifecycle GHG Reductions with SAF



Sustainable Aviation Fuel



Acquiring the majority of our carbon from the atmosphere, via biology or recycling, and turning it back into fuel

- Policy rewards reductions >50%
- Many solutions in the 60-80% range
- Some solutions achieve >100% via carbon sequest'n or other emission reduction

MSW-to-Liquids Global Environmental Policy

- * Driven by industry-sought reductions for Life Cycle Green House Gases (CO₂ specifically)
 - * Confirmed by various regulations and policy incentives
 - * International – ICAO CORSIA – CORSIA Eligible Fuels*
 - * Federal – US RFS-2 RINS eligible
 - * State – Low Carbon Fuel Standard eligible (currently CA/OR)
 - * Abroad – Supporting policy (EU ETS), blending mandates, ...
- * SAF also enable reduction in tailpipe emissions of PM, SO_x and CO (criteria pollutants at airports - Those governed by EPA and ICAO Rules)

* Carbon Offsetting and Reduction Scheme for International Aviation

MSW to L – Local Environmental Considerations

- * Approach and Evidence of Outcomes for Local Criteria Pollutant Control (e.g. CO, SO_x, PM_{2.5})
- * Water usage for Cooling and approach (e.g. closed loop circulation? Quantified needs)
- * Clean up Method and effectiveness (e.g. gasification clean-up)
- * Utility off take needs (electricity from grid or maintain portion of MIRA infrastructure).
- * Third Party environmental assessment History (e.g. site specific RFS 2 certification experience)

RFI Issuance (or State equivalent) recommended

MSW-to-Liquids, Queries to Processors (RFI)

- * Waste stream purity needs (sets separation and non-organic management needs)
- * Site foot print needs / quantity managed
- * Height needs for processor facilities (eg. Needed for Brainard airport restrictions)
- * Experience and Approach to addressing environmental Justice issues
- * Engaged Federal and private sector funding (for sustainable solutions) to date

Engaged Federal Support for Sustainable MSW - L

- * EPA / RFS 2 Renewable Index Credits for Projects granted
- * Federal Loan guarantees for sustainable fuel products from USDA section 9003 programs approved
- * DOE / DOD / USDA funded Defense Production Act Projects Executed (e.g. MSW to L Fulcrum, Nevada).
- * Planned DOE Federal Opportunity Announcement FY 21'- CAAFI facilitating team to optimize steam separation / all streams management (Central CT case study in advocacy)
- * Public works funding support from CT delegation expected

CAAFI Government Stakeholders facilitating Opportunities

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MSW-to-Liquid Fuels Opportunity for MIRA?

**Presentation to Materials Innovation and Renewables
Authority Board
October 4 , 2020**

**Rich Altman, Executive Director Emeritus
Commercial Aviation Alternative Fuels Initiative (CAAFI)**



Agenda

- * **What is the Opportunity? Why better than MSW to Electricity?**
- * **Who are the Potential Processors? Engaged CT Stakeholders?**
- * **Environmental impacts of processes ground to flight (EPA view) a**
- * **Recommended “location specific” questions for a proposed RFI (or equivalent) from DEEP? From MIRA?**
- * **Economics - Federal Support for Capex? / for Operations?**

MSW to L Sustainable Fuel Opportunity

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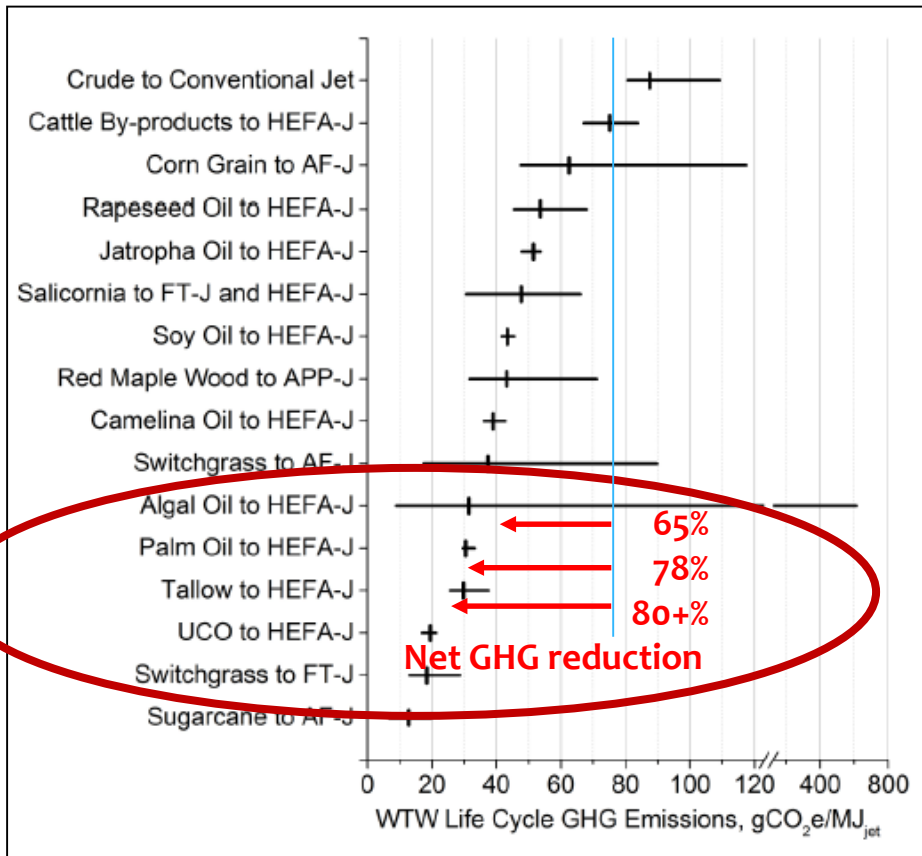
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CAAFI is Processor and Process Neutral!

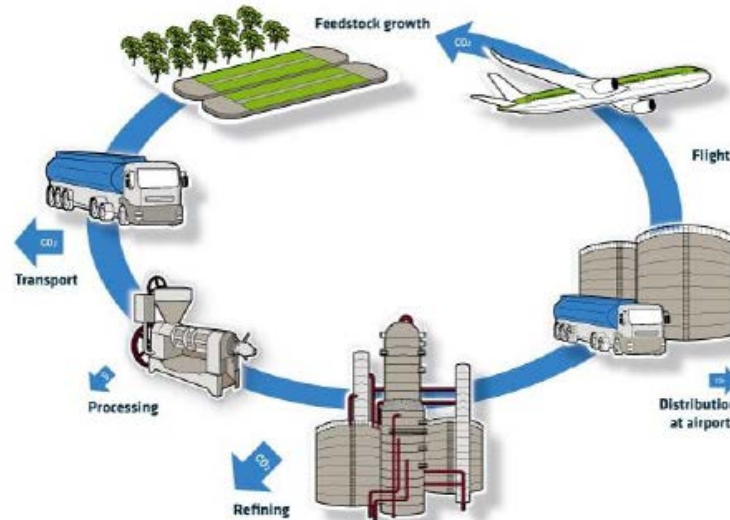


Lifecycle GHG Reductions Driving SAF* Adoption

Rules set by ICAO (International), EPA (US domestic), EU (European)



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Acquiring the majority of our carbon from the atmosphere, via biology or recycling, and turning it back into fuel

- Policy rewards reductions >50%
- Many solutions in the 60-80% range
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MSW to L – Questions for Competitors

- ❖ Approach to Local Criteria Pollutant Control (e.g. CO, SO_x, PM_{2.5})
- ❖ Water usage and approach for Cooling
- ❖ Clean up approach (e.g. gasification)
- ❖ Utility off-take needs (from grid?).
- ❖ RFS 2 or RSB certification status
- ❖ Waste stream purity needs (sets separation, non-organic management)
- ❖ Site foot print needs / quantity managed
- ❖ Height needs for processor facilities
- ❖ Experience and Approach to addressing environmental Justice issues
- ❖ Engaged Federal and private funding to date
- ❖ Local job creation projection

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