SAJF Commercialization Progress Overview

MN Working Lands Meeting

Discussion Session:

Markets for innovative oil seed crops

- Overview of perspectives from CAAFI and Aviation

Steve Csonka, Executive Director, CAAFI

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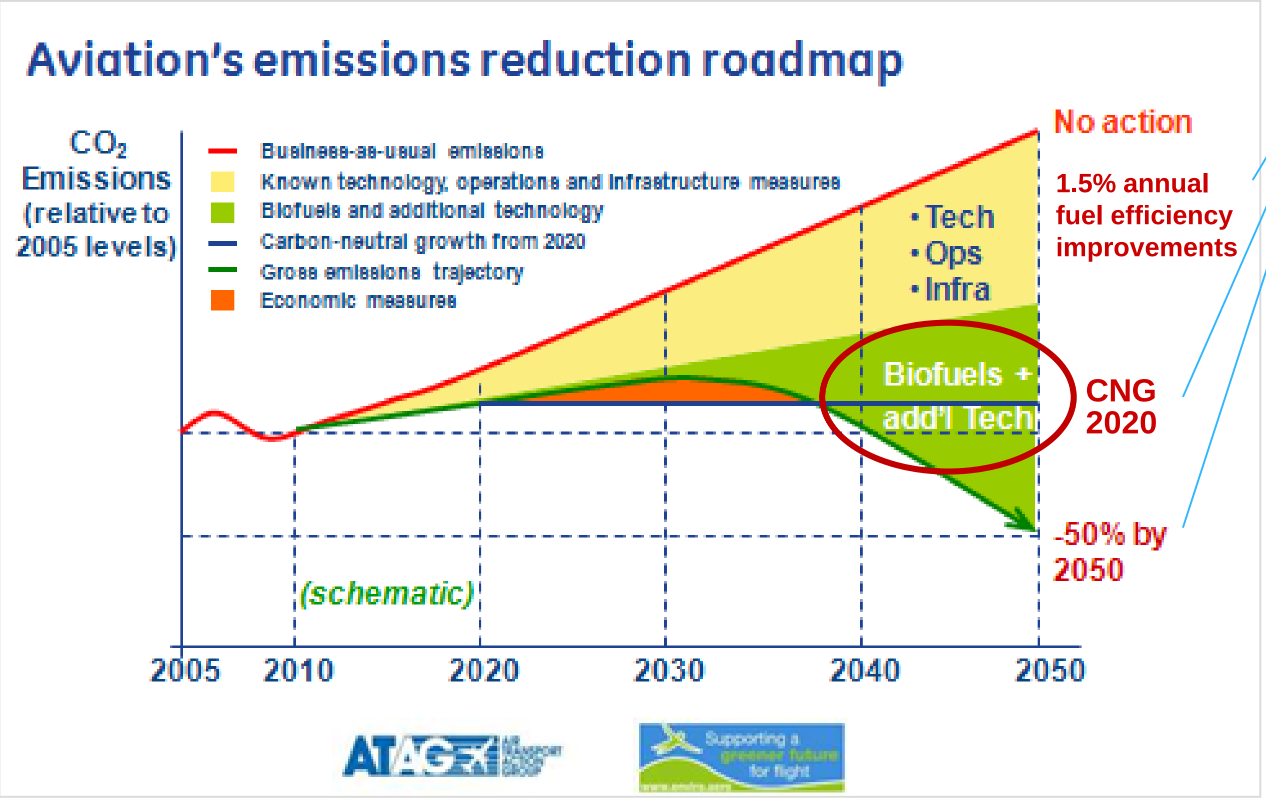
COMMERCIAL AVIATION
ALTERNATIVE FUELS INITIATIVE

15Dec'17

Commercial Aviation's CO_2 commitments
To decouple carbon growth from demand growth

Biofuels a key component of GHG containment strategy



These 3 industry commitments are currently being converted into regulation through an ICAO/CAEP "basket of measures":

* CO_2 Standards
* MBMs – will monetize carbon

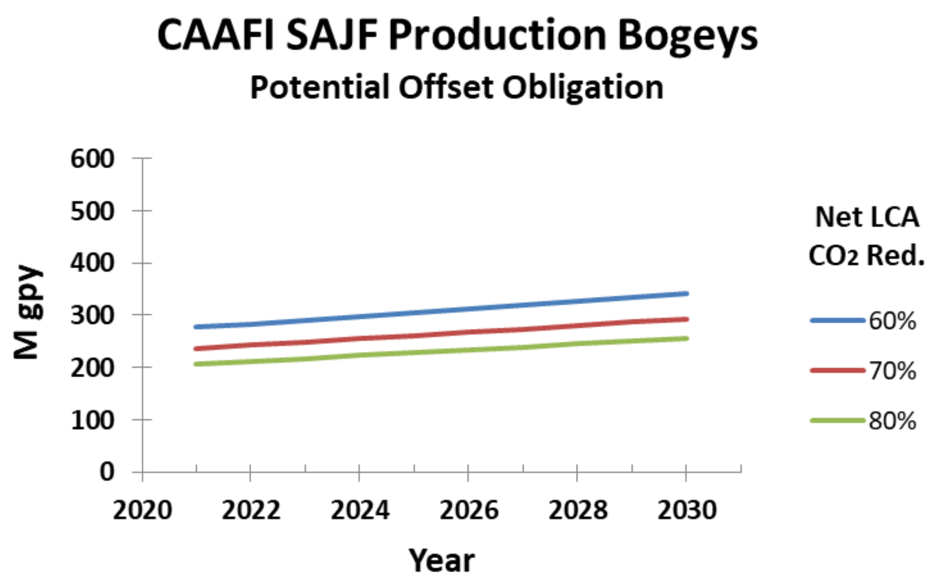
Similar commitment from BizAv & DOD

How much SAJF is needed (USA)?

Total US jet fuel supply (satisfying all uses: Com'l, DoD, BizAv, GA):

- 2016: 1.61 M bpd = 24.814 B gpy (Worldwide >87 B gpy)
- 2017: trending at 1.65 M bpd (+2.5%)

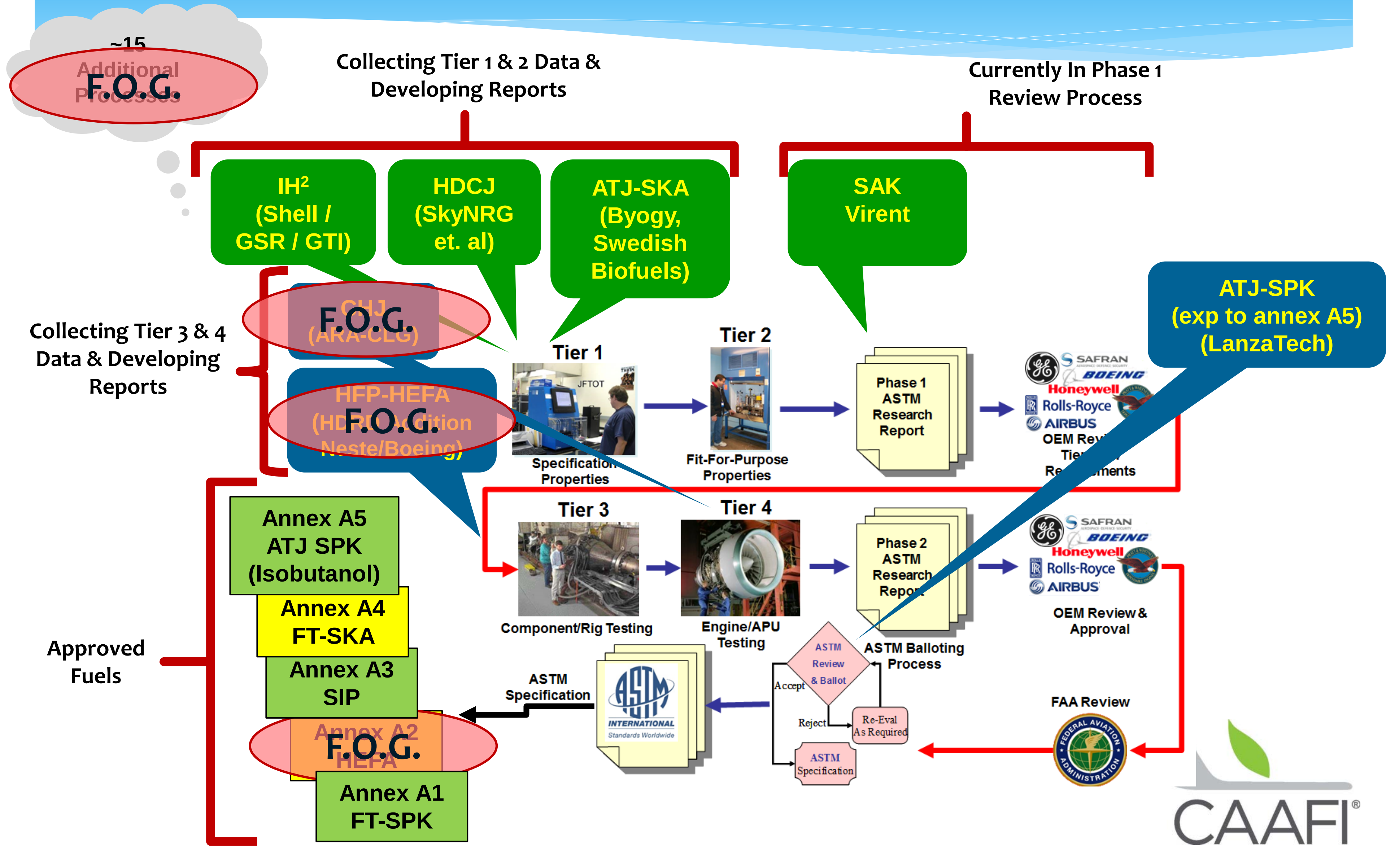
CAAFI Bogey set by implementation targets of CNG2020 (CORSIA)



The offsetting of growth in International operations could result in targeting **annual, incremental production of 200-400 M gpy of neat SAJF**

Volume can change significantly with assumptions, as well as demand from International carriers for US uplift

SAJF qualification status



Select "additional processes"
Targeted for additional cost reductions

	Approach	Feedstock	Notes
D7566	1) IHI: HD HCs	HC from other bio-sources	
	2) SBI: CGC PICFTR	F.O.G. - biodiesel	Shell partnership[1]
	3) Forge: Thermal Deoxyg.	F.O.G.	Demo plant being built in Ontario
	4) Tyton: CCL	F.O.G.	
	… 11+ more using various other feedstocks and conversion processes		
D1655	1) Co-processing	F.O.G.	Chevron, BP, Phillips66
	* Successfully balloted. Sets the stage for other entities to follow, by sending biocrude to the refineries for finishing, e.g.:		
	2) Co-processing	Biocrude	Fulcrum

1 This now gives Shell a footprint with cellulose (IH2), sugars (Virent), and F.O.G.

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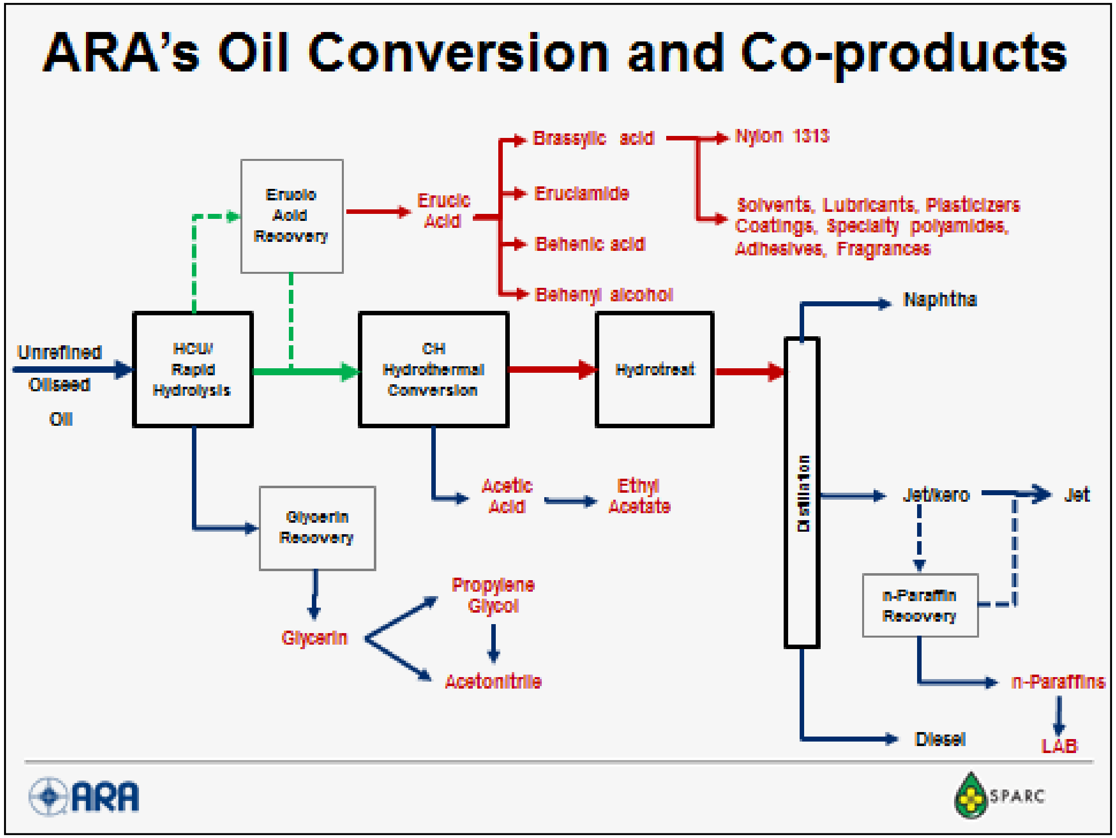
Conversion-cost-focus is only part of need

- Techno-economic assessments don't address total value
- Expectation that viability will be enabled via other revenue (feed / proteins), other services, and integration with existing facilities and industries



SAJF offtake agreements

Beyond numerous demonstration programs

neat quantities

AltAir Fuels* + UNITED = Up to 5 M gpy from 2016 (LAX)

+ World Fuel Services, Gulfstream = 3 yr agreement 30/70 blend

+ SkyNRG Nordic, KLM = 3 yr agreement Enabling LAX flts

air bp, OSL OSLO AIRPORT, SAS, Lufthansa Group = Bioports on demand: Halmstad, Arlanda, Bromma, Goteborg

NESTE + GENEVE AÉROPORT = 1% of GVA supply

Fulcrum BIOENERGY + CATHAY PACIFIC = 37.5M gpy

+ UNITED = 90-180 M gpy

+ air bp = 50 M gpy

10 yr agreements

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* AltAir also continues supplying fuel for multiple trial and research activities

SAJF offtake agreements

Beyond numerous demonstration programs

neat quantities

RED ROCK BIOFUELS	+	Southwest	=	3 M gpy each, 7 yrs (Bay Area, CA)
	+	FedEx	=	
TOTAL | AMYRIS	+	CATHAY PACIFIC, CHINA AIRLINES	=	A350 deliveries 10% blend (ex-TLS)
SG Preston	+	jetBlue	=	10M gpy, 10 yrs (JFK)
	+	QANTAS	=	4M gpy, 10 yrs (LAX)
DG Energy	+	GE Aviation	=	0.5M gpy, 10 yrs

These offtakes/efforts represent >250 M gpy, and account for the total production slate of the first several commercialization efforts

Other recent announcements

effort

gevo	+	Lufthansa	=	MOU
	+	Virgin australia	=	Brisbane Supply Demonstration
VELOCYS	+	BRITISH AIRWAYS	=	MSW-based FT-SPK evaluations
	+	In negotiation	=	BTL #1, Natchez, MS 1,400 bpd
NESTE	+	American Airlines	=	HFP-HEFA collaboration
AGRISOMA	+	QANTAS	=	Carinata supply development
Multiple Producers TBA (1/1/4+)	+	World Fuel Services	=	Full production slate offtakes

Commercialization in-development

Renewable Diesel & Jet from F.O.G.

- **Emerald** (DPA recipient, HDRD focus)
- **AltAir build-out (3-5X)**
- **Diamond Green** (expansion underway)
- **SG Preston** (duplicate facility plan)
- **ARA licensing build-out** (multiple efforts)
- **UOP licensing - new / refinery retrofit**
- **Neste, REG, UPM, … potential pivots to HDRD / HEFA**
- **Unlocking of renewable diesel and refinery co-processing**

Greater than 1B GPY capacity by 2021 !?!

… necessitates serious engagement with purpose grown oilseed & FOG development / expansion

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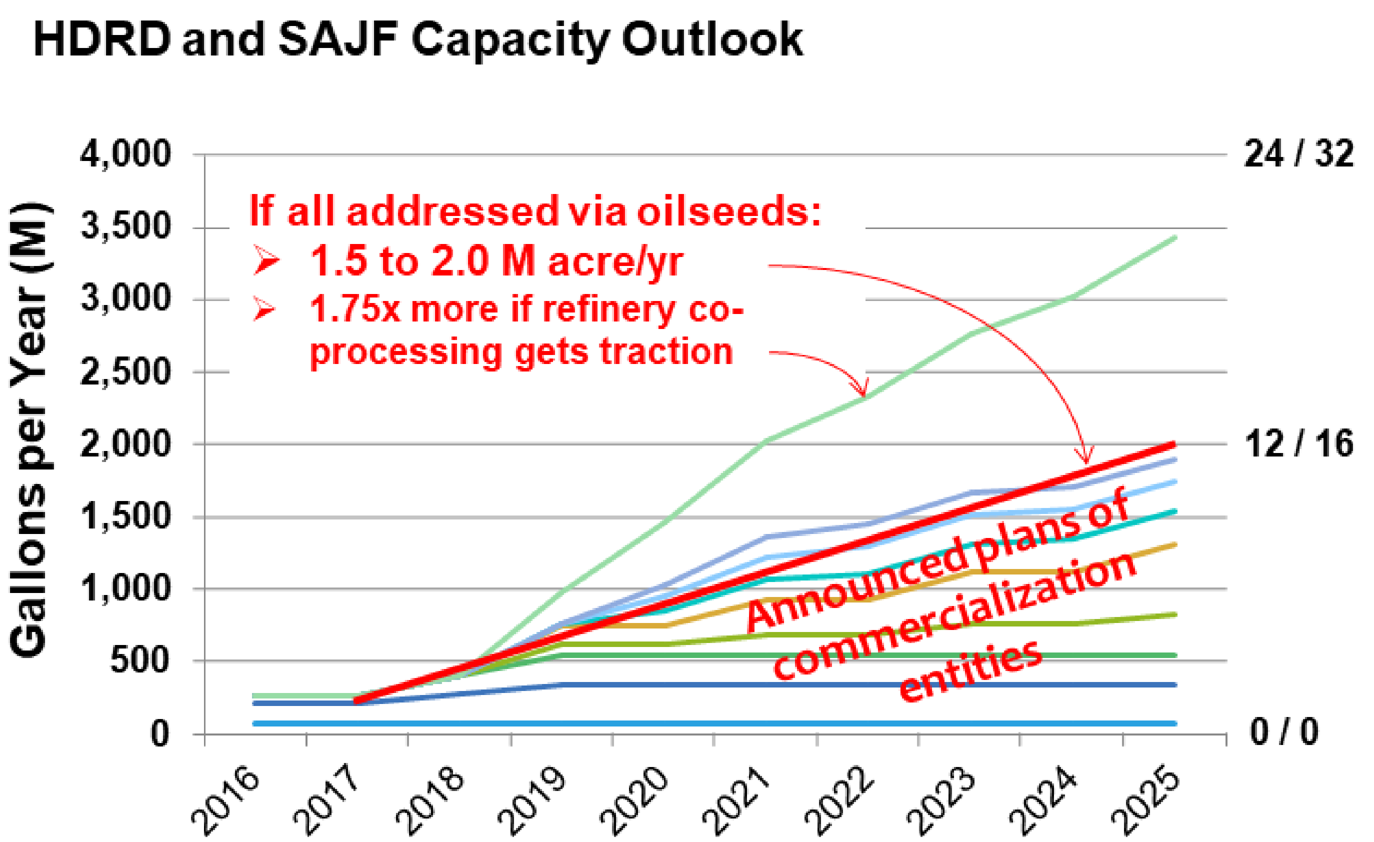
Commercialization intent - F.O.G.

"Declared" nameplate capacities: significant opp'ty



Production Acreage Required
(million acres)
at 200 / 150 gal/acre

Significantly more at lower yields of some targeted oilseeds

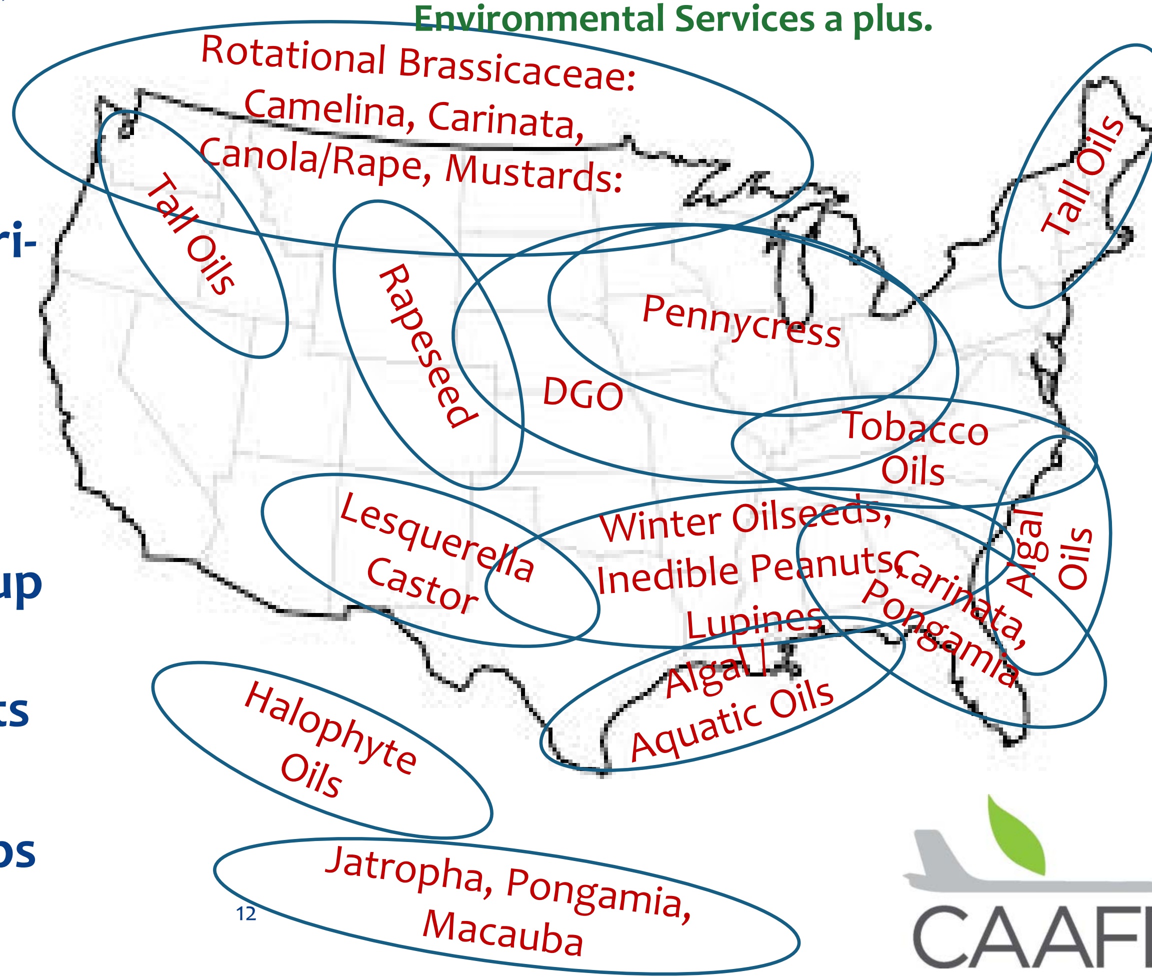
Ignores 0.5B gpy additional expected biodiesel production!

Lipid feedstocks

Potentially enabling of significant production …

- **Multiple conversion processes (3+ 3 additional)**
- **Multiple feedstock developers**
- **Multiple producers**
- **Multiple low LUC/ILUC agri-based feedstocks, plus:**
  - **White Grease, Poultry Fat, Tallow**
  - **UCO / Yellow Grease**
  - **Brown Grease, Biosolids**
- **Easier supply chain scale-up leveraging biodiesel and HDRD production concepts**
- **Lowered H2 cost & availability (from NG) helps**

Targeting most sustainable solutions:
Low, or Zero, impact LUC/ILUC & F-v-F solutions; Environmental Services a plus.



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Winter "cover" oilseeds

Huge production potential without ILUC…

- Carinata below freeze line
  - 12-20 M acres
- Pennycress above freeze line, in regions with sufficient precipitation
  - 40+ M acres
- Camelina above freeze line, perhaps targeted at lower precip regions
- All need further varietal and agronomic development

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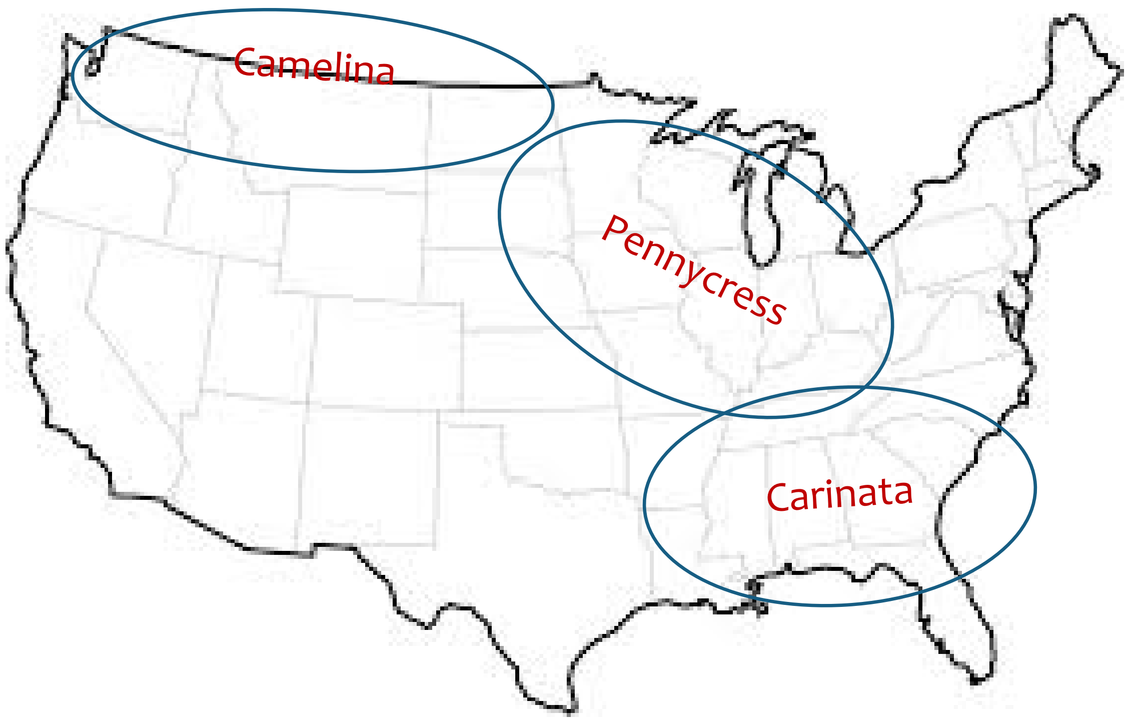

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2018 CBGM, Washington DC, 04-06Dec

In conjunction with:

- **ASCENT Yr 5 Symposium**
- **NJFCP YE meeting**
- **State Initiative Stakeholders Forum**

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FUELING SOLUTIONS FOR SECURE & SUSTAINABLE AVIATION

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