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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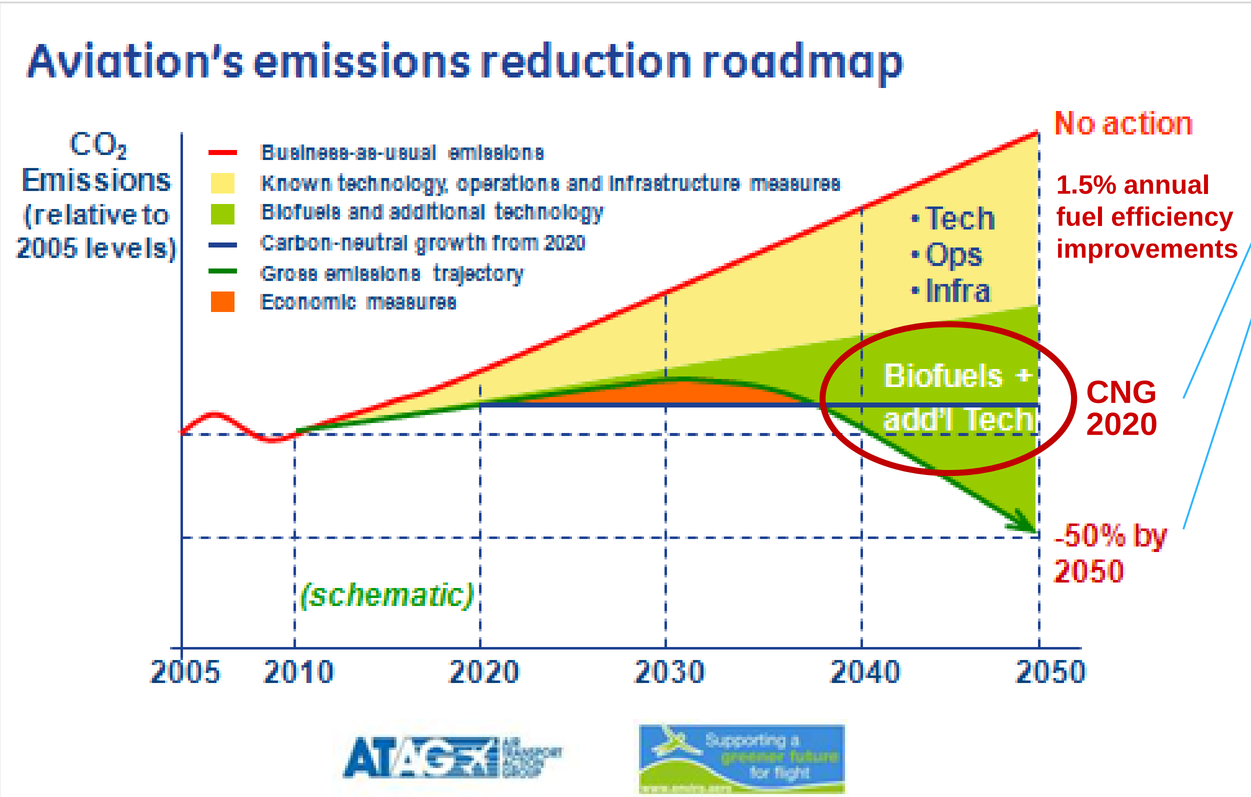
COMMERCIAL AVIATION
ALTERNATIVE FUELS INITIATIVE

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":

* CO2 Standards
* MBMs – will monetize carbon

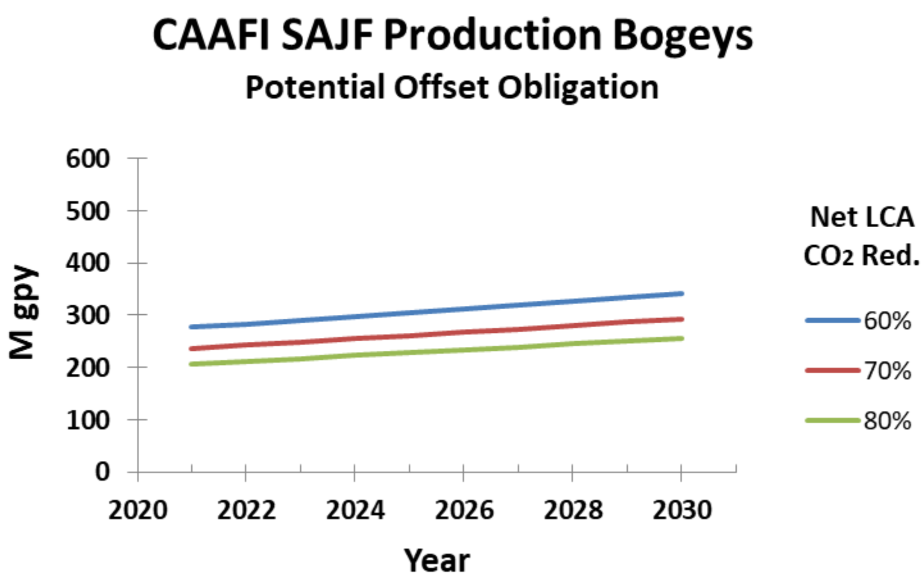
Similar commitment from BizAv & DOD

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

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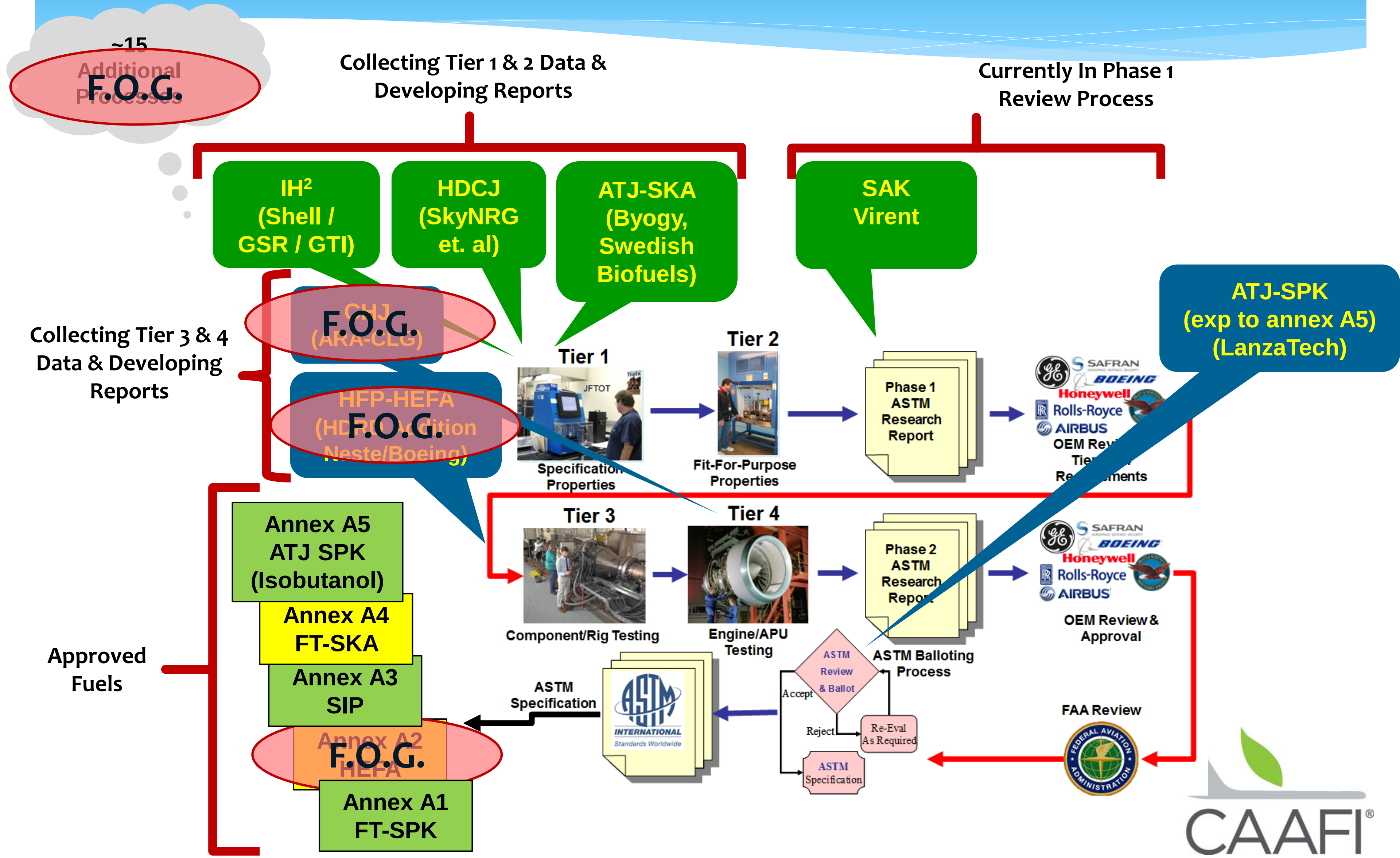
SAJF qualification status



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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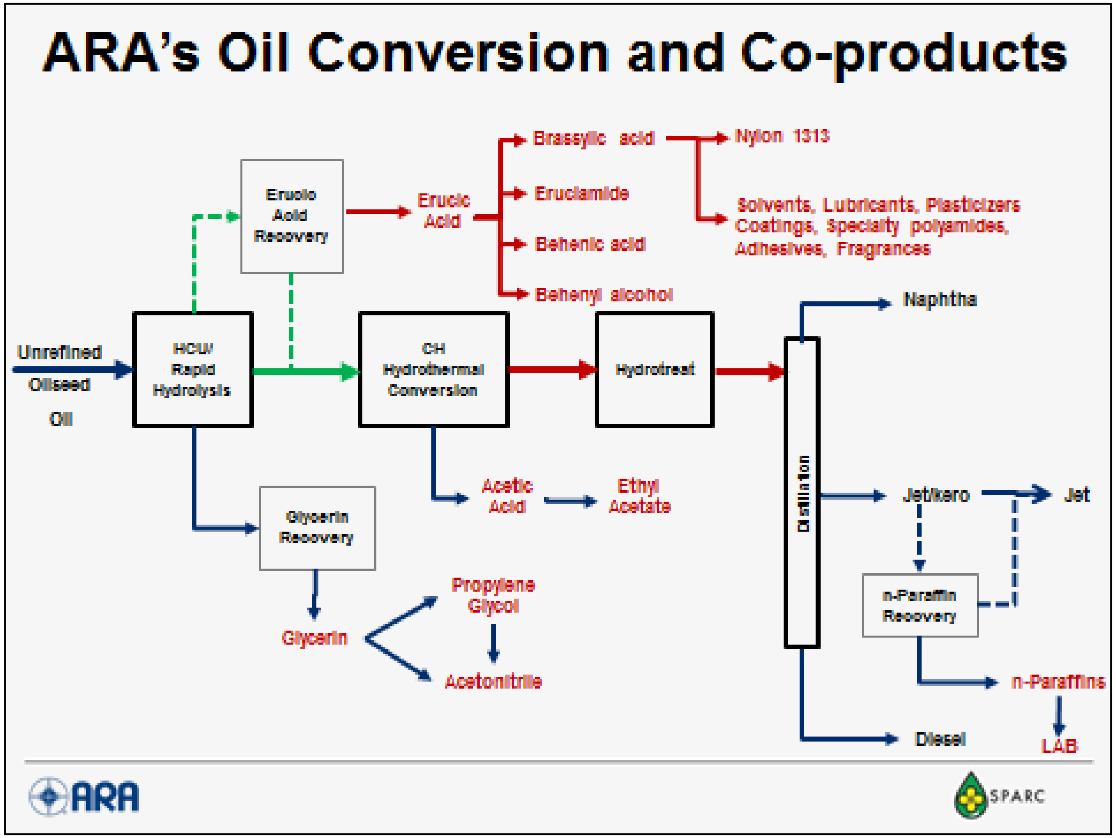
Conversion-cost-focus is only part of need

* 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

Producer	+	Partner	=	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, air bp, KLM, OSL Oslo Airport, SAS, Lufthansa Group	=	3 yr agreement Enabling LAX flts
			=	Bioports on demand: Halmstad, Arlanda, Bromma, Goteborg
NESTE	+	GENÈVE 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

* 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

Producer		Partner		Announcement
gevo	+	Lufthansa	=	MOU
gevo	+	Virgin australia	=	Brisbane Supply Demonstration
VELOCYS	+	BRITISH AIRWAYS	=	MSW-based FT-SPK evaluations
VELOCYS	+	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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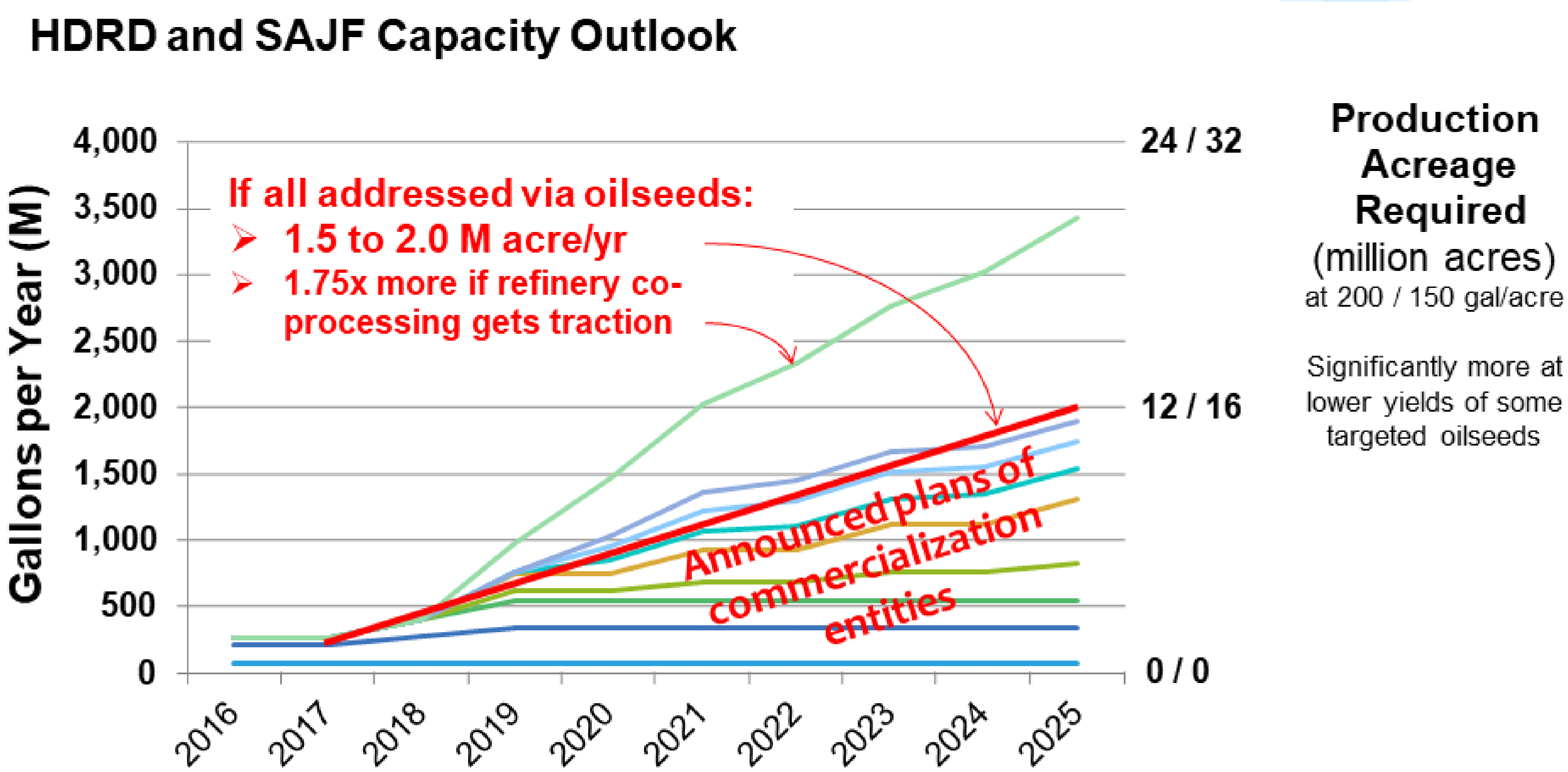
Commercialization intent - F.O.G.

"Declared" nameplate capacities: significant opp'ty



Ignores 0.5B gpy additional expected biodiesel production!

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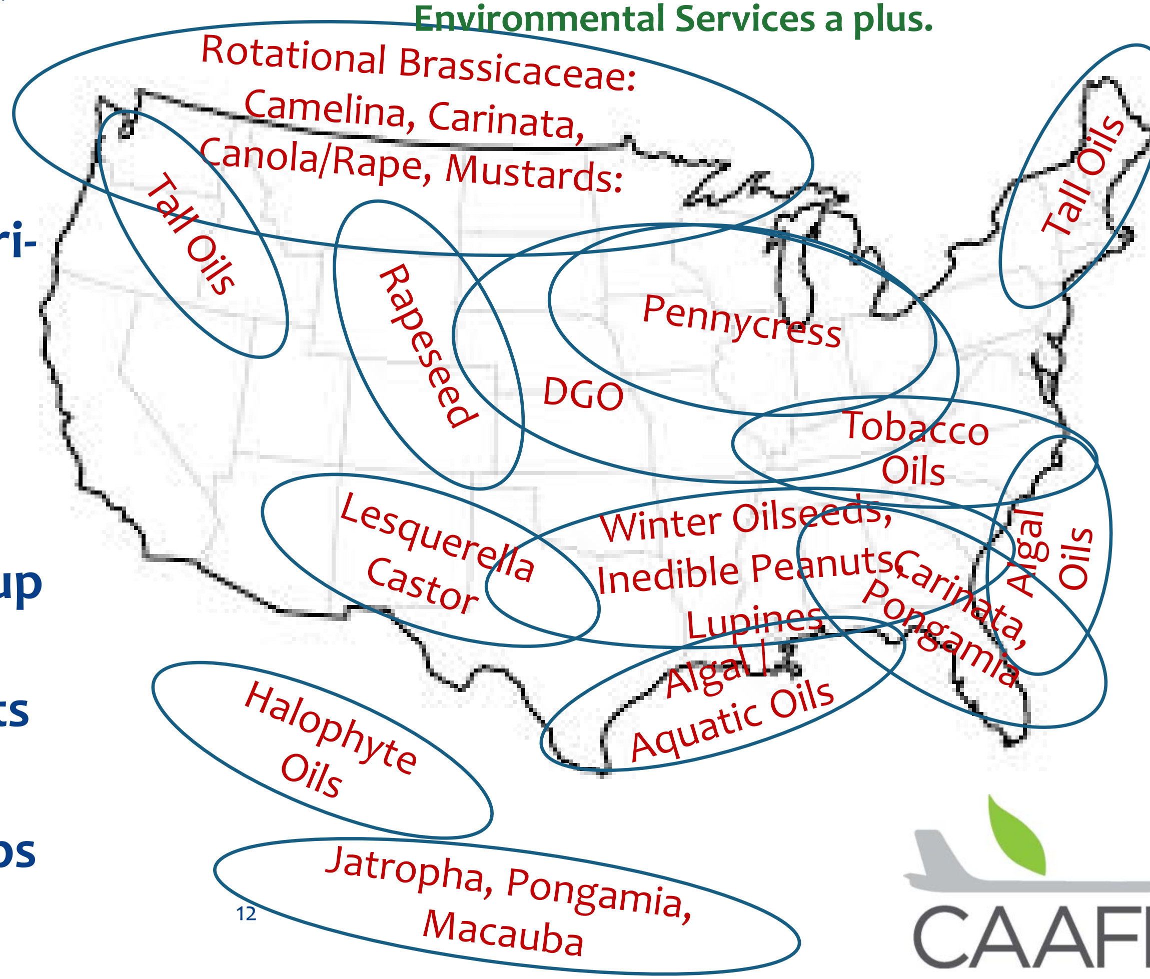
Lipid feedstocks
Potentially enabling of significant production …

- **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.



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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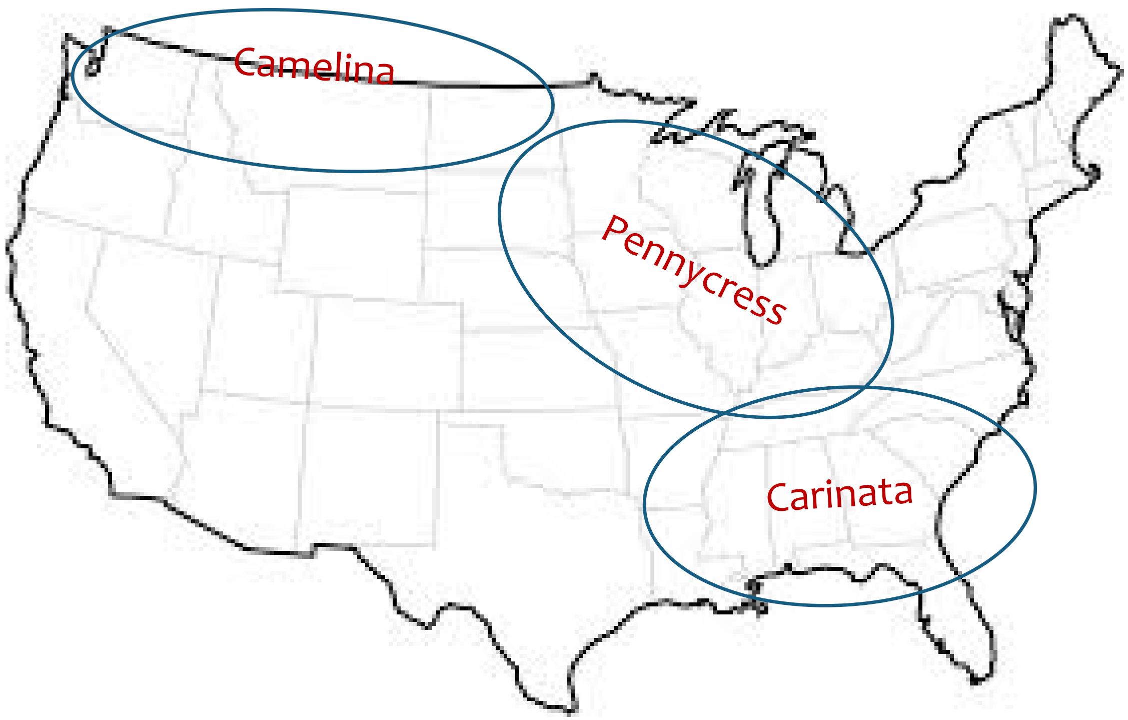

2018 CBGM, Washington DC, 04-06Dec

In conjunction with:

ASCENT Yr 5 Symposium
NJFCP YE meeting
State Initiative Stakeholders Forum

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SECURE & SUSTAINABLE AVIATION

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