Sustainable Aviation Fuels (SAF)

Update to FAA REDAC E&E Subcommittee

To: E&E REDAC Subcommittee

By: Nate Brown

Date: March 19, 2019

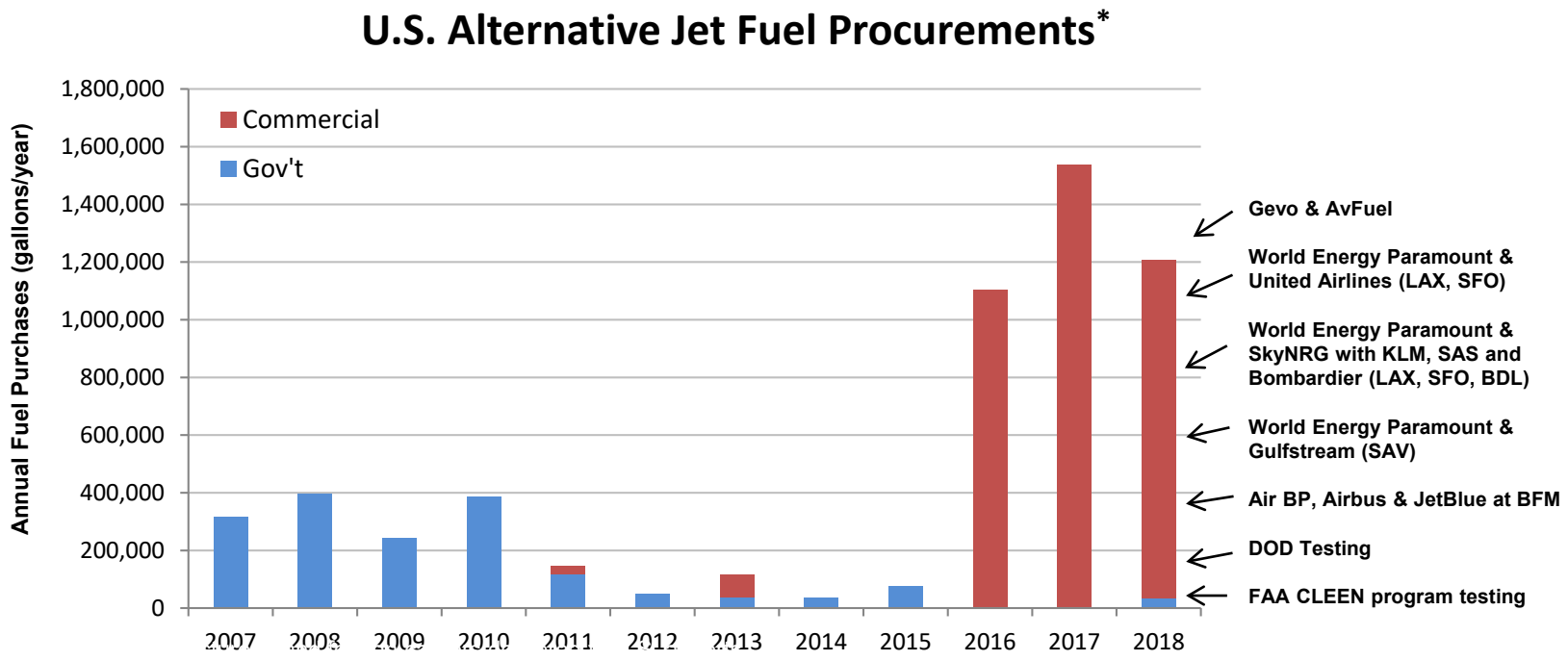
FAA's SAF (a.k.a AJF) R&D Program

Working to Achieve SAF Production

- **Coordination**
  - CAAFI
- **Testing**
  - ASTM Status
- **Analysis**
  - Supply chain analysis and tools
  - ICAO CORSIA

Where we stand?

- Three years of sustained commercial production and airline use
- 1.2 million gallons in 2018 from multiple producers, users, and airports
- New fuels under evaluation & construction of new facilities under way
- New partnerships announced and General Aviation engaged
- In 2019 expanded production planned and new incentives in CA & OR



2018 CAAFI Biennial General Meeting (CBGM)

- December 4-6, 2018 in Washington, DC
- 200+ attendees
- 3 days of panels, discussions, VIP speakers and networking
- Highlighted tremendous progress and momentum
- Identified priorities and strategies to maintain progress

CAAFI
COMMERCIAL AVIATION ALTERNATIVE FUELS INITIATIVE

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2019 CAAFI Priorities

- **Communicate the Value Proposition of SAJF**
- **Enhance the Fuel Qualification Approach**
- **Develop the U.S. SAJF Supply by Aligning Efforts to Enable Commercial Deployment**
- **Implement Frameworks & Share Best Practices**

CAAFI Administrative Leadership Team:

- Steve Csonka, CAAFI Executive Director
- Chris Tindal, CAAFI Assistant Director
- Kristin Lewis, Volpe
- Peter Herzig, Volpe
- Nate Brown, FAA
- Rich Altman, CAAFI Executive Director Emeritus

CAAFI Team Leads:

- C/Q: M. Rumizen, C/Q
- Sustainability: J. Hileman & N. Young,
- Business: J. Heimlich
- R&D : M. Lakeman, S Kramer, & G. Andac

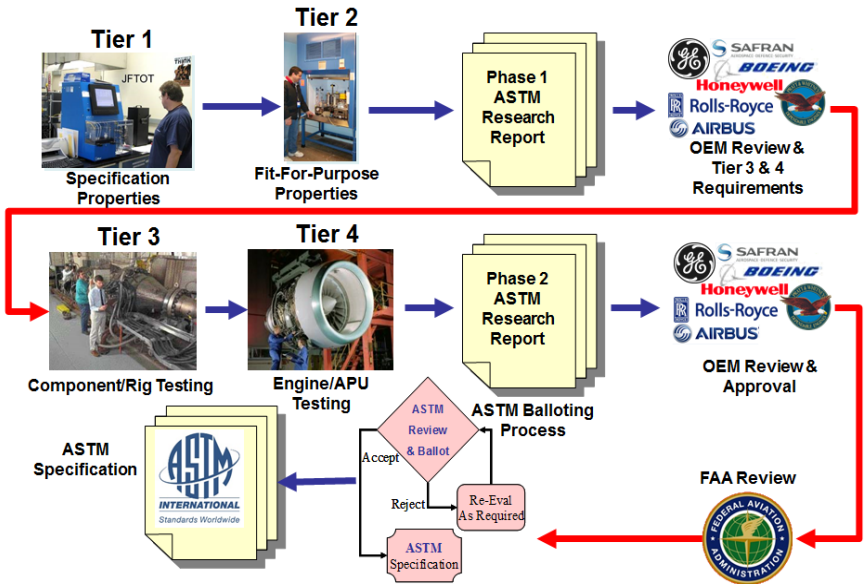
CAAFI Steering Group: AIA, ACI-NA, A4A, GE, Boeing, P&W, ASCENT, DOE, USDA

Testing: Alternative Jet Fuel Approvals

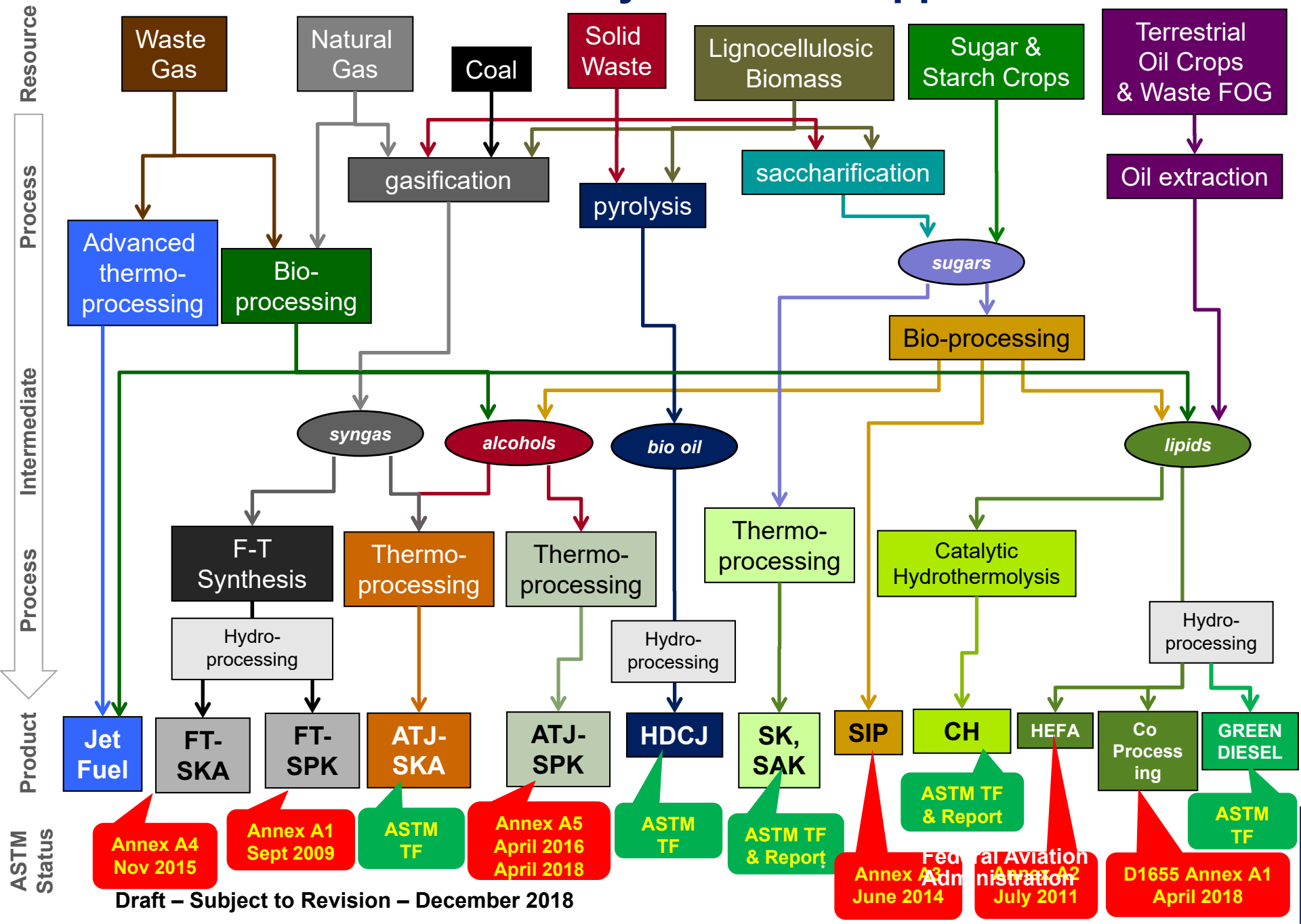
ASTM International manages jet fuel specification

FAA and Defense support evaluation of AJFs

- **D4054 Clearing House: Certification & qualification testing; data gathering & review; new test method development**
- **Since 2009, five fuels included in the AJF specification ASTM D7566 w/ spec expansions**
- **Co-processing added to ASTM D1655**
- **Lipids, sugars and biomass feedstocks**
- **Five pathways under evaluation; more anticipated**

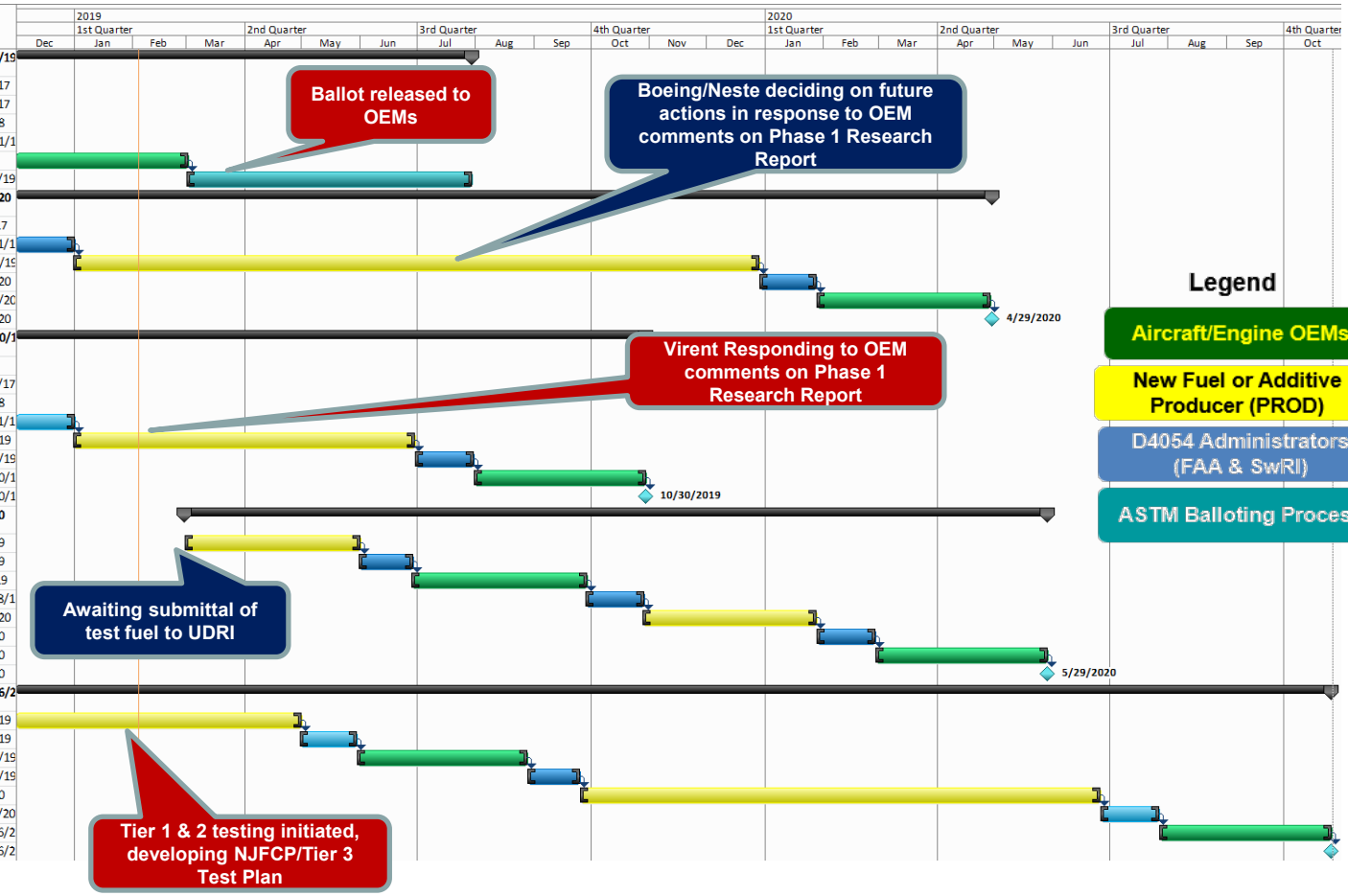


Alternative Jet Fuel Pathways & D7566 Approval Status



D4054 Clearinghouse
Forecasted Fuel Evaluation Schedule

ID	Task Name	Start	Finish
1	**ARA CHJ**	**Mon 8/8/16**	**Mon 7/29/19**
2	Step 3 - Phase 1 OEM Review	Mon 8/8/16	Wed 3/1/17
3	Step 4 - Phase 1 OEM Feedback	Wed 3/1/17	Wed 3/1/17
4	Step 5 - Phase 2 Testing & Report	Wed 3/1/17	Thu 2/1/18
5	Step 6 - Entry Screening	Thu 2/1/18	Wed 10/31/1
6	Step 7 - OEM Engineering Review	Wed 10/31/1	Fri 3/1/19
7	Ballot	Fri 3/1/19	Mon 7/29/19
8	**HFP-HEFA**	**Mon 6/12/17**	**Thu 4/30/20**
9	Step 3 - Phase 1 OEM Review	Mon 6/12/17	Sat 9/30/17
10	Step 4 - D4054 Admin	Sat 9/30/17	Mon 12/31/1
11	Step 5 - Phase 2 Testing & Report	Mon 12/31/1	Sun 12/29/19
12	Step 6 - Entry Screening	Sun 12/29/19	Tue 1/28/20
13	Step 7 - OEM Engineering Review	Tue 1/28/20	Wed 4/29/20
14	Ballot	Thu 4/30/20	Thu 4/30/20
15	**Virent SAK**	**Wed 6/28/17**	**Wed 10/30/1**
16	Step 1 - Phase 1 Testing & Report	Wed 6/28/17	Fri 9/1/17
17	Step 2 - Entry Screening	Fri 9/1/17	Mon 10/2/17
18	Step 3 - Phase 1 OEM Review	Mon 1/22/18	Fri 3/16/18
19	Step 4 - Phase 1 OEM Feedback	Fri 3/16/18	Mon 12/31/1
20	Step 5 - Phase 2 Testing & Report	Mon 12/31/1	Sun 6/30/19
21	Step 6 - Entry Screening	Sun 6/30/19	Wed 7/31/19
22	Step 7 - OEM Engineering Review	Wed 7/31/19	Wed 10/30/1
23	Ballot	Wed 10/30/1	Wed 10/30/1
24	**IHI Bb-oil**	**Thu 2/28/19**	**Fri 5/29/20**
25	Step 1 - Phase 1 Testing & Report	Thu 2/28/19	Fri 5/31/19
26	Step 2 - Entry Screening	Fri 5/31/19	Fri 6/28/19
27	Step 3 - Phase 1 OEM Review	Fri 6/28/19	Sat 9/28/19
28	Step 4 - Phase 1 OEM Feedback	Sat 9/28/19	Mon 10/28/1
29	Step 5 - Phase 2 Testing & Report	Mon 10/28/1	Tue 1/28/20
30	Step 6 - Entry Screening	Tue 1/28/20	Fri 2/28/20
31	Step 7 - OEM Engineering Review	Fri 2/28/20	Fri 5/29/20
32	Ballot	Fri 5/29/20	Fri 5/29/20
33	**Shell IH2**	**Thu 2/1/18**	**Mon 10/26/2**
34	Step 1 - Phase 1 Testing & Report	Thu 2/1/18	Tue 4/30/19
35	Step 2 - Entry Screening	Tue 4/30/19	Thu 5/30/19
36	Step 3 - Phase 1 OEM Review	Thu 5/30/19	Wed 8/28/19
37	Step 4 - Phase 1 OEM Feedback	Wed 8/28/19	Wed 9/25/19
38	Step 5 - Phase 2 Testing & Report	Wed 9/25/19	Fri 6/26/20
39	Step 6 - Entry Screening	Fri 6/26/20	Mon 7/27/20
40	Step 7 - OEM Engineering Review	Mon 7/27/20	Mon 10/26/2
41	Ballot	Mon 10/26/2	Mon 10/26/2

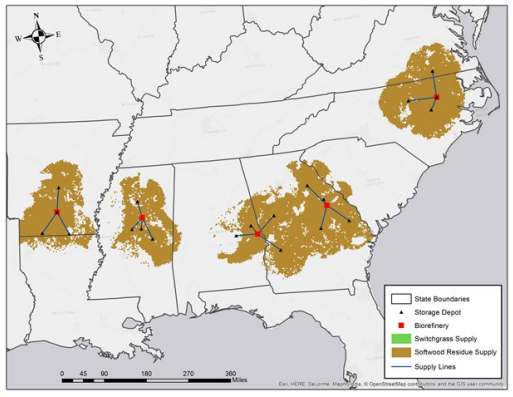


Mark Rumizen
March, 2019

Alternative Jet Fuel Supply Chain Analysis & Tools

Understand benefits, costs and potential supply

- Considering entire supply chain via multiple aspects:
  - Feedstock production
  - Techno-economics of pathways
  - Existing infrastructure
  - Community assets
  - Transportation routes and capacity
  - Economic Impacts
- Three regional studies:
  - Inland Pacific Northwest
  - Hawaii
  - Southeast/Tennessee
- Developing open source tools for evaluation of supply chains
  - Economics; Community assets; Supply chain Risk Sharing; Logistics



Images: University of Tennessee & University of Hawaii

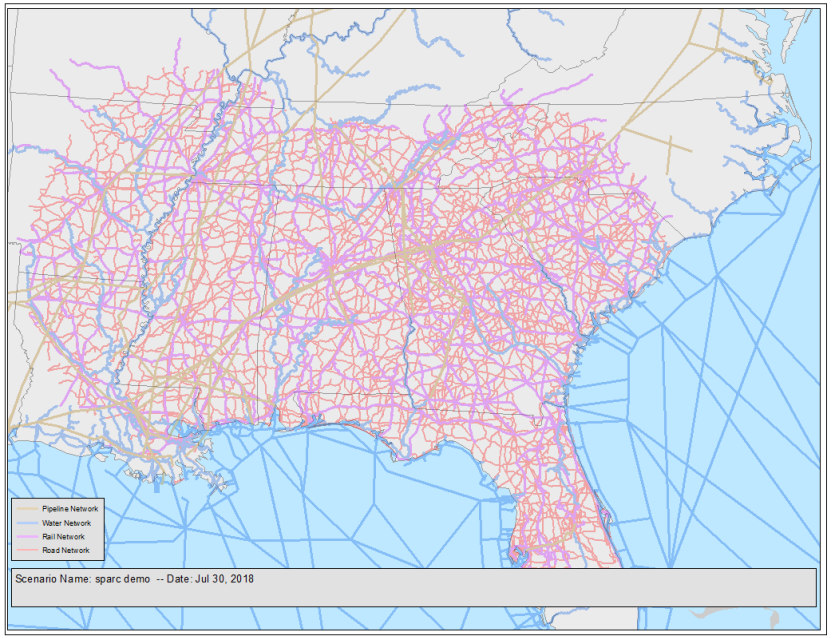
Research Team:

- ASCENT: Washington State U., MIT, Purdue, U. Tennessee, U. of Hawaii, Penn State U.
- U.S. DOT Volpe Transportation Center, DOE Argonne National Lab & National Renewable Energy Lab (NREL)

Volpe - Freight and Fuels Transportation Optimization Tool (FTOT)

- **Problem: Understand transportation needs and impacts of AJF scenarios**
  - Transportation costs, infrastructure requirements, and emissions depend on mode choice and routing.
  - A supply-chain-level optimization approach to mode choice and routing of feedstocks and products can help assess viable options and identify likely geographic patterns of AJF supply.

- **Solution: FTOT**
  - Optimizes routings and flow of materials over multimodal GIS network for national or regional analyses.
  - Regional study in collaboration with Southeast Partnership for Advanced Renewables from Carinata (SPARC)



WSU - Community Assets and Attribute Model (CAAM)

- **Problem: Identify project sites with the best chance of success**
  - Need for a mechanism to simplify identification of suitable locations for project siting, and to suggest appropriate engagement strategies post-selection that will enhance likelihood of project success.
- **Solution: CAAM**
  - Community Asset scores to determine how well any county performs on key community capitals: social, human, political, cultural
  - Strategic engagement approaches based on these scores and supplemental data

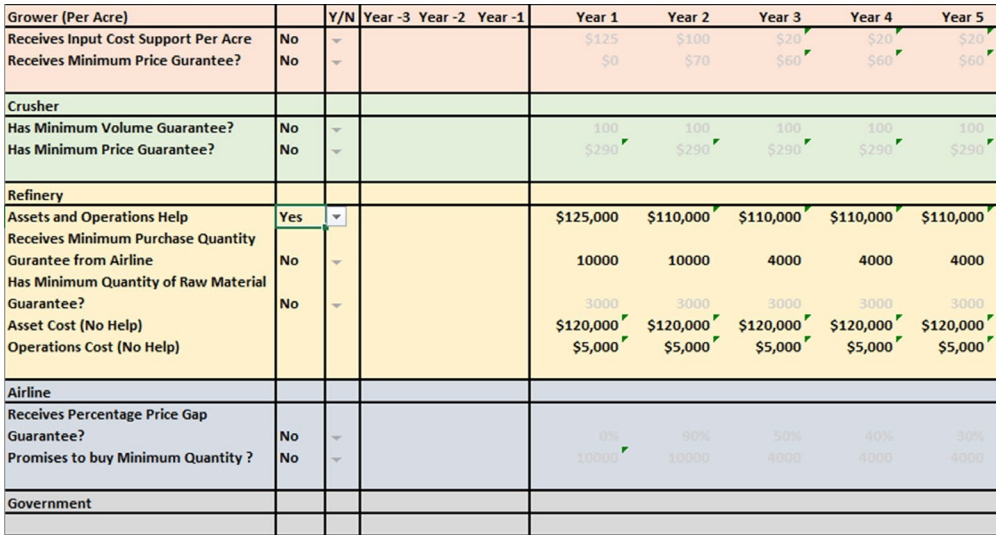
Step 1:
- Initial CAAM/Capital Scores to identify potential communities
- Based on CAAM what can we determine about county?

Step 2:
- Supplement CAAM with other available or collected data

Step 3
- Based on CAAM and supplemental data:
- What strategies can be utilized to enhance likelihood of project success?

PSU - Supply Chain Risk Tool

- **Problem: Address supply chain transparency**
  - AJF supply chains have multiple partners (e.g., farmers, pre-processors, refineries, airlines) who may not understand the business challenges faced by others. Perception exists that other supply chain partners may benefit at another's expense is an obstacle in AJF supply chains taking off.
- **Solution: An interactive cash flow tool of all supply chain partners**
  - Provide an understanding for all supply chain partners of the constraints and risks in the supply chain.
  - Transparent Excel based tool with multiple risk-sharing mechanisms
  - They can be switched off and on, dialed up or down.
  - A faster pace of establishment of AJF supply chains.



Grower (Per Acre)		Y/N	Year -3 Year -2 Year -1	Year 1	Year 2	Year 3	Year 4	Year 5
Receives Input Cost Support Per Acre	No			$125	$100	$20	$20	$20
Receives Minimum Price Gurantee?	No			$0	$70	$60	$60	$60
Crusher								
Has Minimum Volume Guarantee?	No			100	100	100	100	100
Has Minimum Price Guarantee?	No			$290	$290	$290	$290	$290
Refinery								
Assets and Operations Help	Yes			$125,000	$110,000	$110,000	$110,000	$110,000
Receives Minimum Purchase Quantity Gurantee from Airline	No			10000	10000	4000	4000	4000
Has Minimum Quantity of Raw Material Guarantee?	No			3000	3000	3000	3000	3000
Asset Cost (No Help)				$120,000	$120,000	$120,000	$120,000	$120,000
Operations Cost (No Help)				$5,000	$5,000	$5,000	$5,000	$5,000
Airline								
Receives Percentage Price Gap Guarantee?	No			0%	90%	50%	40%	30%
Promises to buy Minimum Quantity ?	No			10000	10000	4000	4000	4000
Government								

Alternative Fuels and CORSIA

CORSIA Eligible Fuels (CEF) provide a secondary means to comply

- Lifecycle GHG Emissions Savings from CEF Reduces Individual Airline Operator Offset Obligation
- CEFs can be either:
  - "CORSIA Sustainable Aviation Fuel": renewable or waste-derived aviation fuel that meets the CORSIA Sustainability Criteria
  - "CORSIA Lower Carbon Aviation Fuel": fossil-based aviation fuel that meets the CORSIA Sustainability Criteria
- All fuels must comply with:
  - Lifecycle GHG emissions analysis (LCA) methodology
  - Sustainability requirements: (1) >10% relative LCA benefit; (2) protection for high carbon stock land
  - Sustainability certification requirements
  - SAF purchase monitoring, reporting & verification
- ICAO to Consider Additional Sustainability Criteria Before 2021 Implementation

CAEP/11 AFTF accomplishments

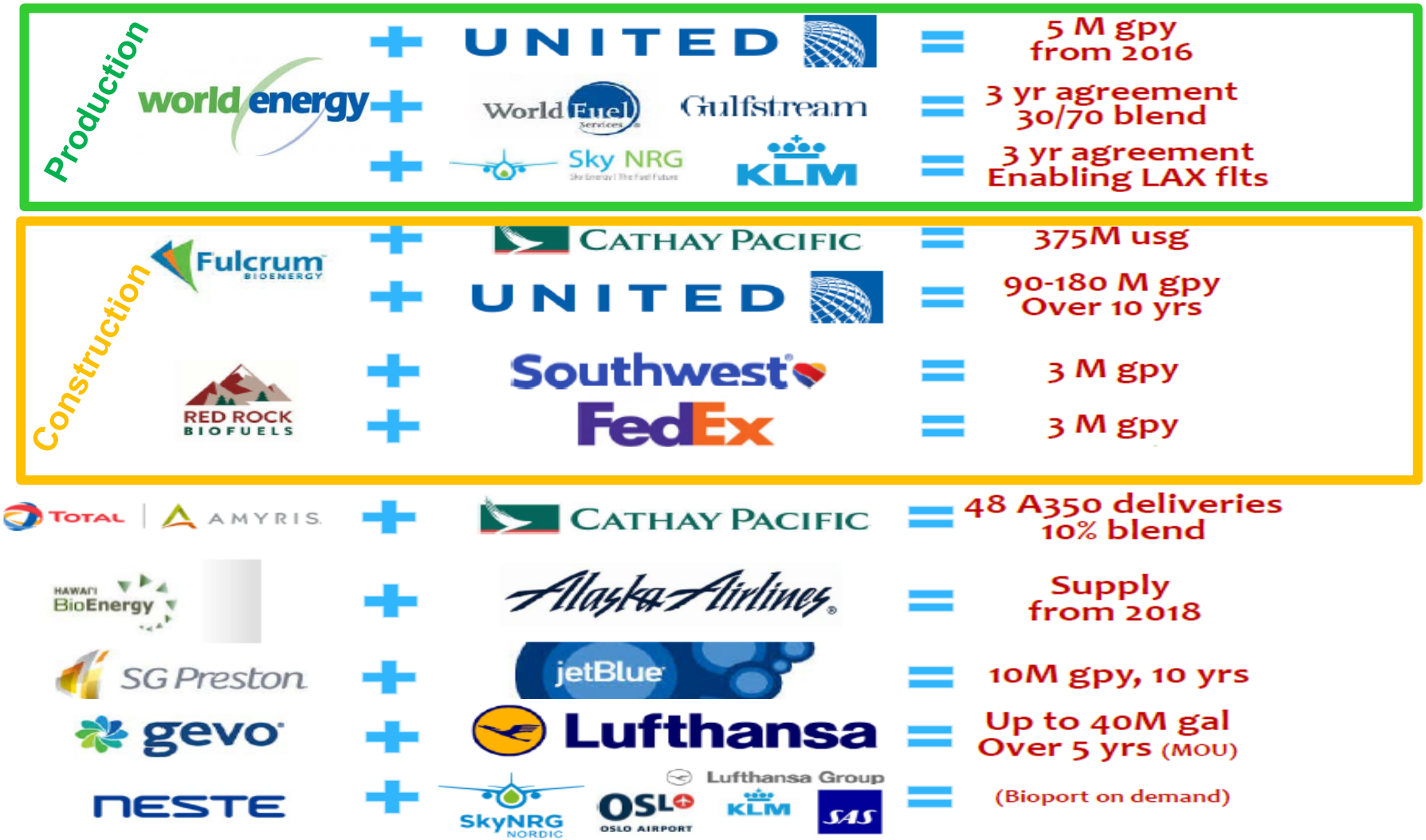
- Greenhouse gas life cycle analysis (LCA) methodology (MIT)
- Default Core LCA values (MIT)
- Induced land use change (ILUC) methodology (Purdue)
- Default ILUC values (Purdue)
- Sustainability criteria for GHG, carbon in land (Volpe)
- Policy analysis on SAF deployment (MIT, Purdue)
- Fuel production scenarios to support 2050 trends assessment (MIT)

CAEP/12 Fuels Task Group (FTG) Work Program

- Default ILUC values & methodology refinement
- Default core LCA values & methodology refinement
- Emissions credits methodology refinement
- Sustainability - additional/strengthened criteria
- Sustainability Certification Scheme (SCS) requirements
- Forward projection of fuel availability – leverage work on CORSIA emission unit availability & costs
- Understanding emissions credits / ILUC permanence
- Analysis to support guidance on policies & approaches for deployment of SAF

Where are we headed?

Potential for 250+ million gallons/year in five years



Questions

Potential CORSIA Sustainability Criteria

Work is ongoing on additional criteria within ICAO CAEP

Sustainable = environmental +
social +
economic

greenhouse gas (1) +
carbon in the land (2) +
water quality (?) +
soil quality (?) +
air quality (?) +
conservation (?) +
waste / chemicals (?) +
human and labor rights (?) +
land use rights (?) +
water use rights (?) +
local and social development (?) +
food security (?)