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CAAFI 2014 General Meeting & Expo

Mike Epstein

Research & Development Team

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Since the last General Meeting…

* Off-year R&D Team workshop focusing on challenges and opportunities
* Developed white papers
* Developed position papers on R&D challenges and needs
* Developed updated team Mission Statement
* Established Seminars on Alternatives to Petroleum (Jet) – SOAP-Jet webinars

Critical R&D Challenges

Timeframe	White Paper Title	Date	Download
Immediate	Flexible economic and engineering models to evaluate proposed alternative fuel facilities and supply chains	TBD	
Immediate	Alternative fuels specification and testing	March 2013	PDF
Near-term	HEFA Feedstock Cost Reduction	March 2013	PDF
Near-term	Relative Economics of Sustainable Aviation Fuels, versus competing Biocommodities and uses	March 2013	PDF
Near-term	Development and streamlining of crosscutting technologies	TBD	
Near-term	Diversity in biofuel feedstock production	March 2013	PDF
Near-term	Developing efficient and cost-effective use of wastes as feedstocks	March 2013	PDF
Mid- to long-term	Alternate methods of atmospheric CO2 capture	March 2013	PDF
Mid- to long-term	Approaches that Convert CO2 to Drop-In Jet Fuel	March 2013	PDF

Find chart at http://www.caafi.org/information/rdchallenges.html

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SOAP-Jet Webinars

* Intended to increase R&D team function as an information "node" for team members
* First series focusing on DOE CHASE grant recipients
* 2 seminars held so far
* 70-ish attendees at each
* Soliciting input on future topics from team

Breakout Discussion and Next Steps

* White Papers
  * Identified additional updates to add to existing papers
  * Identified potential authors/contributors to desired topics
    * Cross cutting technologies
    * Flexible economic and engineering models
    * Other papers suggested by team
* Communications –
  * Team to provide input on webinar topics
  * Request for LinkedIn page and community
  * Request to share resources and information via web links and discussion boards

Breakout Discussion and Next Steps

* Feedstock Readiness Level (FSRL)
  * Discussed utility of tool –identified utility for purchasers and USDA – helps to stack/rank projects
  * Discussed potential for case studies via integration of FSRL as requirement for NIFA CAP grant reporting
    * Provide case studies
    * Provide expansion opportunity for residues/non-crop feedstocks
    * Use as webinar topic

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Mark Rumizen

Certification-Qualification Team

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Certification-Qualification Breakout Session Overview

* ASTM D4054 Qualification Process Overview
* Pathway Status/Overview
  * Process Descriptions and ASTM Timelines for:

Pathway	Presenter/Organization
DSHC	Fernando Garcia/Amyris
ATJ	Glenn Johnston/GEVO
CH	ARA/Ed Coppola
HDCJ	Jeff Trewella/KiOR
HDO-SK and HDO-SAK	Brice Dally/Virent
FT-SKA	Cliff Moses/Consultant

ASTM D4054 Process

TIER 1

Specification Properties

TIER 2

Fit-For-Purpose Properties

TIER 3

Component/Rig/APU Testing

TIER 4

Engine/APU Testing

ASTM Research Report

OEM Review & Approval

ASTM Balloting Process

ASTM Specification

ASTM Specification

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Catalytic Hydrothermolysis (CH) - Pathway

Biofuels ISOCONVERAION (BIC)Process = CH + Hydrotreating (Chevron Lummus Global)

Feed Stocks

Triglycerides
Plant oils
Tallow
Algal oils
Fatty acids

Water

CH Conversion

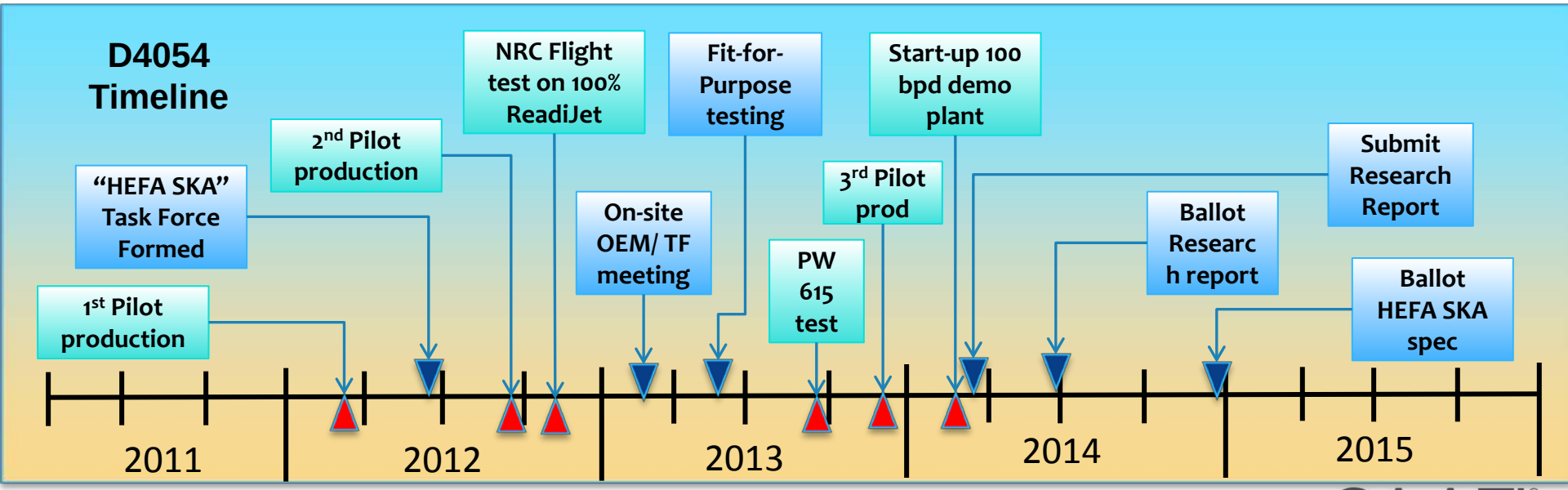
Intermediate Products

n-paraffins
Iso paraffins
Cycloparaffins
Aromatics
Olefins
Organic acids

Hydrogen

Hydrogenation Fractionation

Jet Fuel
"Drop-in"
ASTM D1655
Equivalent
w/o blending



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Breakout Session Overview

- Concepts for Facilitating OEM Review of Alternative Fuel Property and Test Data
  - "OEM Review Panel"
- FAA R&D Initiatives
  - Possible Funding Sources for Support of ASTM Certification
- Round Table Discussion of D4054 Certification Process:
  - Challenges, Lessons Learned, Process Improvements
  - Fuel Producers and OEMS
  - Review of Survey Results

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Key Issues and Recommendations

* Key Issue No. 1
  * Lack of management/coordination of ASTM D4054 Process for alternative fuel certification projects
    * creates conflicting demands for OEM resources to review data and perform tests
    * Makes business planning difficult for alt fuel producers due to uncertain schedule and costs
* Recommendation No. 1
  * Establish Single Focal Point as D4054 Facilitator
    * Track/Monitor D4054 Task Force Progress
    * Coordinate Data Review and Testing by OEMs
    * Establish Schedules and Prioritize Projects
    * Requires Funding

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Key Issues and Recommendations

* Key Issue No. 2
  * Funding of OEM Support of Alternative Fuel D4054 Certification Projects
    * Component/Rig/Engine Testing & Research Report Review
    * D4054 Process Improvements
      * Advanced Analytical Methods in Lieu of Engine Testing
    * USAF Funding Support Drastically Reduced
* Recommendation No. 2
  * Recognition that OEMs Cannot Fund Entire Support Effort
  * Consider D4054 Support in FAA R&D Programs
  * Communicate Customer Support of D4054 Alternative Fuel Projects to OEM Management
    * Airlines & DOD

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Key Issues and Recommendations

* Key Issue No. 3
  * ASTM D4054 Process too Lengthy and Costly
  * Extensive Fuel Property and Engine/Aircraft Testing
  * Repeating Same Tests Regardless of Compositional Similarities With Previous Fuel Approvals
* Recommendation No. 3
  * Establish Staged Gate Approach
  * Approve Smaller Blend Percentages (1% - 5%)
    * Reduce D4054 Certification Test Requirements
  * Increase Blend Percentage with Service & Production Experience

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Jim Hileman & Nancy Young

Environmental Team

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CAAFI Environment Team: Developing Tools & Means to Address Environmental Issues

January 29, 2014

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COMMERCIAL AVIATION
ALTERNATIVE FUELS INITIATIVE

Nancy Young and Jim Hileman
Co-Leads of CAAFI Environment Team

Refresher on the Environmental Imperative

* Overall Objectives for Alternative Fuel Deployment
  * Energy Security/Supply Reliability
  * Commodity Competitor to Petroleum
  * Environmental Benefit (our focus)

* Environmental Benefit
  * Life Cycle Greenhouse Gas (GHG) Emissions Improvements
  * Potential to Reduce Emissions with Air Quality Impact
  * Sustainability More Broadly: Do Not Induce Other Environmental Problems
    * Water use, land use, food-basket competition, etc.

Sustainability: Focus & Achievements to Date

* Developed Sustainability "Impact Matrix" and Guidance
  * Identified indicators (areas of concern) and relevant metrics for reflecting potential impact
  * Overview of existing regulatory and voluntary sustainability regimes
  * "Impact Matrix" defines the potential impact risk and metrics along the alternative fuel supply chain
* Developed Environmental Progression
  * Puts "environmental readiness" on a scale with feedstock readiness and fuel readiness

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Capture Indicators

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Impact Matrix
Assessing Potential for Environmental Impact

Indicator	Economic Operator				
	Feedstock Producer	Feedstock Processor	Fuel Producer	Fuel Blender/ Distributor	Fuel End User
Energy Use (Balance)	High	Medium	High	Low	High
Greenhouse Gases	High	Low	High	Low	High
Air quality	Medium	Low	High	Medium	High
Biodiversity	High	Medium	Medium	Low	Low
Land Use	High	Low	Medium	Low	Low
Water quality (Pollutants, Eutrophication)	High	Low	Medium	Low	Low
Freshwater use (Consumption)	High+	Low	High	Low	Low
Soil quality	High	Low	Low	Low	Low
Potential Impact Severity (color) →		Low	Medium	High	

+ most likely related to irrigation for first generation biofuels, less likely for advanced biofuels

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Motivation for Environmental Progression

* What environmental analyses might be expected and/or required for alternative jet fuel production?
* When in pathway development can/should analyses be performed?
* NOT prescriptive of outcomes (no thresholds)
* Aligned Environmental Progression with Fuel Readiness Level and Feedstock Readiness Level

Environmental Progression

Environmental Progression	Risk Assessment	Risk Management
Basic Principles	initial screening ↓ estimates, rigorous study ↓ comprehensive analysis	Best management practices developed ↓ permitting ↓ reporting, continuous improvements
Concept Formulated		
Proof of Concept		
Preliminary Technical Evaluation		
Scale up Validation of Initial Assessments		
Full-scale Feedstock Impact Evaluation		
Full-scale Fuel Producer Impact Evaluation		
Commercialization		
Sustainable Feedstock and Fuel Supply Established		

GHG Life Cycle Analysis: Focus & Achievements to Date

* Confirmed We Know the Steps and How to Apply Them to Aviation (building on "Framework & Guidance for Estimating Greenhouse Gas Footprints of Aviation Fuels")

* Integrated Jet Fuel into the Argonne National Labs' GREET Model

* Initial comparison of LC GHG results using different tools and under different regulations

Focus on Continued & Verifiable Aviation GHG Emissions Improvement

* Industry Commitments to CO_2 reduction
* State-Specific & Regional Initiatives
  * e.g., FAA goal for carbon neutral growth
  * e.g., European Union Emissions Trading Scheme
  * e.g., U.S. requirement for federal/military procurement of fuels
    * Can only procure alternative fuels with lifecycle emissions better than or equal to conventional fuels (EISA Section 526)
* States Are Working on a Global Agreement for Addressing Aviation GHG Emissions through the International Civil Aviation Organization (ICAO)
  * Includes carbon neutral growth from 2020 goal
  * ICAO CAEP Alternative Fuels Task Force
  * Working on a potential global market-based measure

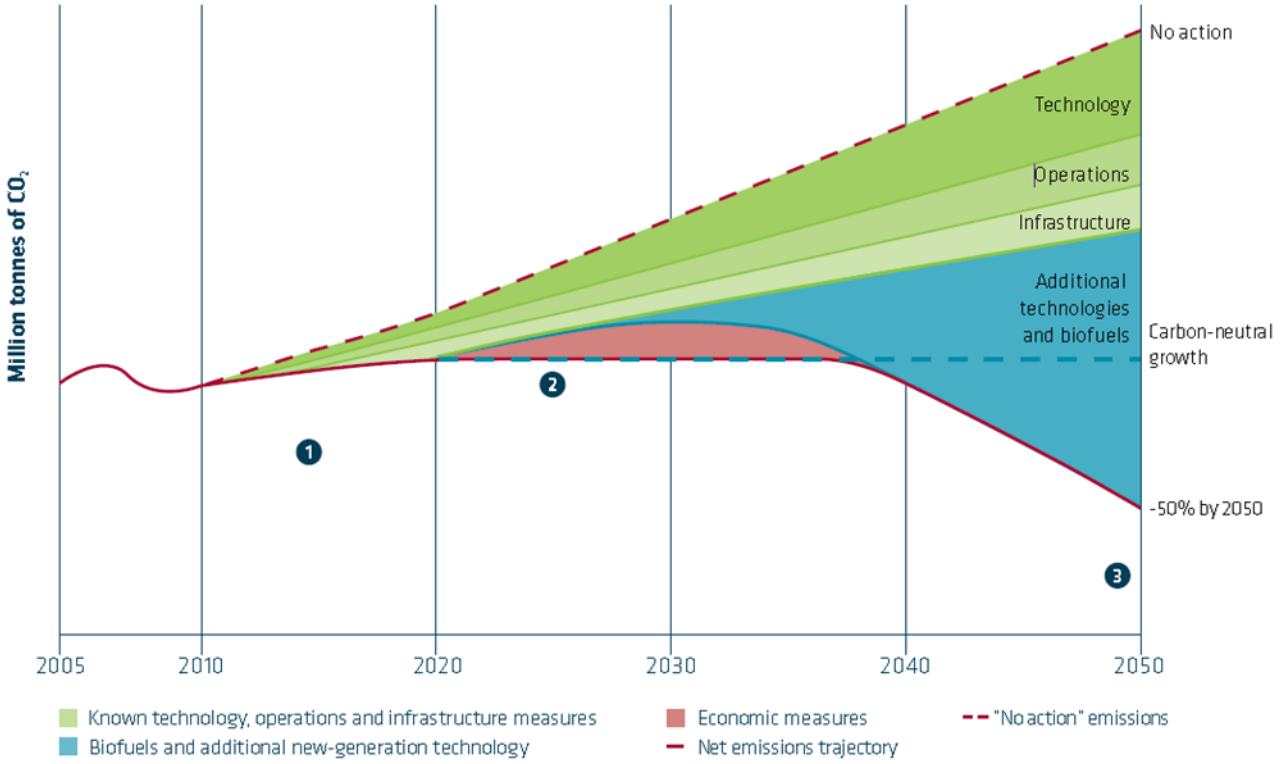
How Do We Meet Our Targets? Technology, Alt Fuels, Operations & Infrastructure

MAPPING OUT THE INDUSTRY COMMITMENTS

❶ improve fleet fuel efficiency by 1.5% per year from now until 2020

❷ cap net emissions from 2020 through carbon neutral growth

❸ by 2050, net aviation carbon emissions will be half of what they were in 2005



(Schematic, indicative diagram only)

Source: Air Transport Action Group (ATAG) "A sustainable flightpath towards reducing emissions" (2012). http://atag.org/component/downloads/downloads/203.html

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Aviation Has a Unique Need for Future Acceptance of GHG LCA Results Across Borders

* Obviously, Aircraft Are Mobile Sources that Cross Borders
* System of CO2 Monitoring, Reporting & Verification needed for Global Aviation CO2 Programs
* GHG LCA Results Will be a Key Part of any Global Scheme
* Need Means for "Mutual Recognition" Among States and Perhaps, Ultimately, Harmonization
* Key Starting Point: Understand the Differences Between LCA Regulatory Approaches and Tools

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Jan 2014 Environment Team Workshop

Goal and Process

* Examine variations in life cycle greenhouse gas (GHG) emissions due to:
  * Using different Life Cycle Analysis (LCA) methods, tools, and data
  * Meeting varied purposes and regulatory regimes
* Goal:
  * Identify elements that lead to variations in LC GHG emissions results
  * Develop actions that could be taken to improve our understanding
* Process:
  * Briefings explored how life cycle GHG emissions varied with different tools and purposes
  * Group discussion led to creation of an LCA Issue Matrix spreadsheet (that is still under development)

Jan 2014 Environment Team Workshop

LCA Issue Matrix

Does the "element" contribute to differences in LC GHG emissions results for this "fuel pathway"? YES | MAYBE | NO Does the "element" impact a "fuel pathway's" qualification under a reduced LC GHG emissions policy (e.g., RFS2)? YES | MAYBE | NO		Fuel Pathways													
		Soybean HEFA (good for comparison)	Rapeseed HEFA (relatively large N2O)	Jatropha HEFA	Camelina HEFA (rotation crop)	Tallow/FOG HEFA (waste product)	Algae HEFA	Forestry waste F-T	Forestry waste HDCJ (pyrolysis)	Ag waste F-T	Energy grass F-T	Natural Gas F-T	Sugar cane Alcohol To Jet	Sugar cane bagasse HDCJ (pyrolysis)	Waste gas (CO) Alcohol To Jet
Elements	***Baseline for Comparison***														
	Average barrel or marginal barrel of conv fuel	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Geographical basis of baseline (domestic or international)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Is LC value relative to a threshold or an absolute lc value?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Data sources														
	Emission factors (e.g., grid electricity)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Process efficiencies	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Differences in farming practices	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	N2O emissions factor	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Emissions factor time scale (GWP 30, 100, 500 years)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Time window for normalizing long term emissions	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Transportation logistics	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Accounting														
	Oil-Meal system co-product allocation	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Lignincellulosic system co-product allocation	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Refinery/Facility energy co-product allocation (liquid fuels, electricity, heat, steam)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	System Boundary (attributional versus consequential analysis)														
	Direct land use change	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Indirect land use change	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Time window for emissions allocation (from LUC)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Inclusion of building infrastructure (i.e., refinery)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Including consequences of alt fuel production	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Displacement by alt fuel co-products	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	Is a waste still a waste if you don't waste it?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

Jan 2014 Environment Team Workshop

LCA Issue Matrix

Does the "element" contribute to differences in LC GHG emissions results for this "fuel pathway"? YES | MAYBE | NO Does the "element" impact a "fuel pathway's" qualification under a reduced LC GHG emissions policy (e.g., RFS2)? YES | MAYBE | NO	Fuel Pathways														
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Elements															
Baseline for Comparison															
Average barrel or marginal barrel of conv fuel	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Geographical basis of baseline (domestic or international)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Is LC value relative to a threshold or an absolute lc value?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Data sources															
Emission factors (e.g., grid electricity)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Process efficiencies	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Differences in farming practices	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
N2O emissions factor	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Emissions factor time scale (GWP 30, 100, 500 years)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Time window for normalizing long term emissions	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Transportation logistics	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Accounting															
Oil-Meal system co-product allocation	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Lignincellulosic system co-product allocation	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Refinery/Facility energy co-product allocation (liquid fuels, electricity, heat, steam)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
System Boundary (attributional versus consequential analysis)															
Direct land use change	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Indirect land use change	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Time window for emissions allocation (from LUC)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Inclusion of building infrastructure (i.e., refinery)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Including consequences of alt fuel production	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Displacement by alt fuel co-products	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Is a waste still a waste if you don't waste it?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

"Elements" that could lead to variations in LC GHG emissions results

Workshop focused on identifying these "elements" (preliminary list shown here)

Jan 2014 Environment Team Workshop

LCA Issue Matrix

Does the "element" contribute to differences in LC GHG emissions results for this "fuel pathway"? YES | MAYBE | NO Does the "element" impact a "fuel pathway's" qualification under a reduced LC GHG emissions policy (e.g., RFS2)? YES | MAYBE | NO	Fuel Pathways													
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Elements														
Baseline for Comparison														
Average barrel or marginal barrel of conv fuel	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Geographical basis of baseline (domestic or international)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Is LC value relative to a threshold or an absolute lc value?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Data sources														
Emission factors (e.g., grid electricity)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Process efficiencies	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Differences in farming practices	?	?	?	?	?	?	?	?	?	?	?	?	?	?
N2O emissions factor	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Emissions factor time scale (GWP 30, 100, 500 years)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Time window for normalizing long term emissions	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Transportation logistics	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Accounting														
Oil-Meal system co-product allocation	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Lignincellulosic system co-product allocation	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Refinery/Facility energy co-product allocation (liquid fuels, electricity, heat, steam)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
System Boundary (attributional versus consequential analysis)														
Direct land use change	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Indirect land use change	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Time window for emissions allocation (from LUC)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Inclusion of building infrastructure (i.e., refinery)	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Including consequences of alt fuel production	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Displacement by alt fuel co-products	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Is a waste still a waste if you don't waste it?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

Feedstock-to-Fuel Pathways

Jan 2014 Environment Team Workshop

LCA Issue Matrix

Does the "element" contribute to differences in LC GHG emissions results for this "fuel pathway"?
YES | MAYBE | NO

Does the "element" impact a "fuel pathway's" qualification under a reduced LC GHG emissions policy (e.g., RFS2)?
YES | MAYBE | NO

Elements	Fuel Pathways														
	Soybean HEFA (good for comparison)	Rapeseed HEFA (relatively large N2O)	Jatropha HEFA	Camelina HEFA (rotation crop)	Tallow/FOG HEFA (waste product)	Algae HEFA	Forestry waste F-T	Forestry waste HDCJ (pyrolysis)	Ag waste F-T	Energy grass F-T	Natural Gas F-T	Sugar cane Alcohol To Jet	Sugar cane bagasse HDCJ (pyrolysis)	Waste gas (CO) Alcohol To Jet
Baseline for Comparison														
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Geographical basis of baseline (domestic or international)														
Is LC value relative to a threshold or an absolute lc value?														
Data sources														
Emission factors (e.g., grid electricity)														
Process efficiencies														
Differences in farming practices														
N2O emissions factor														
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System Boundary (attributional versus consequential analysis)														
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Time window for emissions allocation (from LUC)														
Inclusion of building infrastructure (i.e., refinery)														
Including consequences of alt fuel production														
Displacement by alt fuel co-products														
Is a waste still a waste if you don't waste it?														

Questions of Interest:

- **Does the "element" contribute to differences in LC GHG emissions results for this "fuel pathway"?**
- **Does the "element" impact a "fuel pathway's" qualification under a reduced LC GHG emissions policy (e.g., RFS2)?**
- **Following workshop input, we will refine questions to better reflect different purposes for conducting life cycle GHG analysis**

Jan 2014 Environment Team Workshop

LCA Issue Matrix

Does the "element" contribute to differences in LC GHG emissions results for this "fuel pathway"? YES | MAYBE | NO Does the "element" impact a "fuel pathway's" qualification under a reduced LC GHG emissions policy (e.g., RFS2)? YES | MAYBE | NO	Fuel Pathways														
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Direct land use change														
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Time window for emissions allocation (from LUC)														
Inclusion of building infrastructure (i.e., refinery)														
Including consequences of alt fuel production														
Displacement by alt fuel co-products														
Is a waste still a waste if you don't waste it?														

Seeking answer to each Question for each Element and Fuel Pathway

YES | MAYBE | NO

Jan 2014 Environment Team Workshop

LCA Issue Matrix

Does the "element" contribute to differences in LC GHG emissions results for this "fuel pathway"? YES | MAYBE | NO Does the "element" impact a "fuel pathway's" qualification under a reduced LC GHG emissions policy (e.g., RFS2)? YES | MAYBE | NO	Fuel Pathways														
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N2O emissions factor															
Emissions factor time scale (GWP 30, 100, 500 years)															
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Accounting															
Oil-Meal system co-product allocation															
Lignincellulosic system co-product allocation															
Refinery/Facility energy co-product allocation (liquid fuels, electricity, heat, steam)															
System Boundary (attributional versus consequential analysis)															
Direct land use change															
Indirect land use change															
Time window for emissions allocation (from LUC)															
Inclusion of building infrastructure (i.e., refinery)															
Including consequences of alt fuel production															
Displacement by alt fuel co-products															
Is a waste still a waste if you don't waste it?															

Will use YES | MAYBE | NO answers to identify and prioritize elements that lead to variations in LC GHG emissions results

"Element" Categories

Workshop discussion focused on four categories of "elements" that could lead to LC GHG variation:

* Baseline for Comparison / What is the Question you are Answering?
* Data sources
* Allocation
* System Boundary (in a loose sense, this is a question of attributional versus consequential analysis)

Ongoing Work

* Sustainability guidance and impact matrix are living documents and we continue to seek input on how to improve their utility
* Complete LCA Impact Matrix and solicit input from experts to answer the questions such that we create a prioritized list of "elements" to be addressed
* Conduct a 1.5 day CAAFI Environment Team meeting in early 2015


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