



**Commercial Airplanes**

# **Aviation and Sustainable Biofuel**



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**Environmental and Aviation Policy, Boeing Commercial Airplanes**

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# A History of Achieving the Impossible

**Dreams...**

**...First Steps...**

**...Reality**



# A New Vision for Aviation

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**Why Aviation  
Biofuel?**



First industry steps



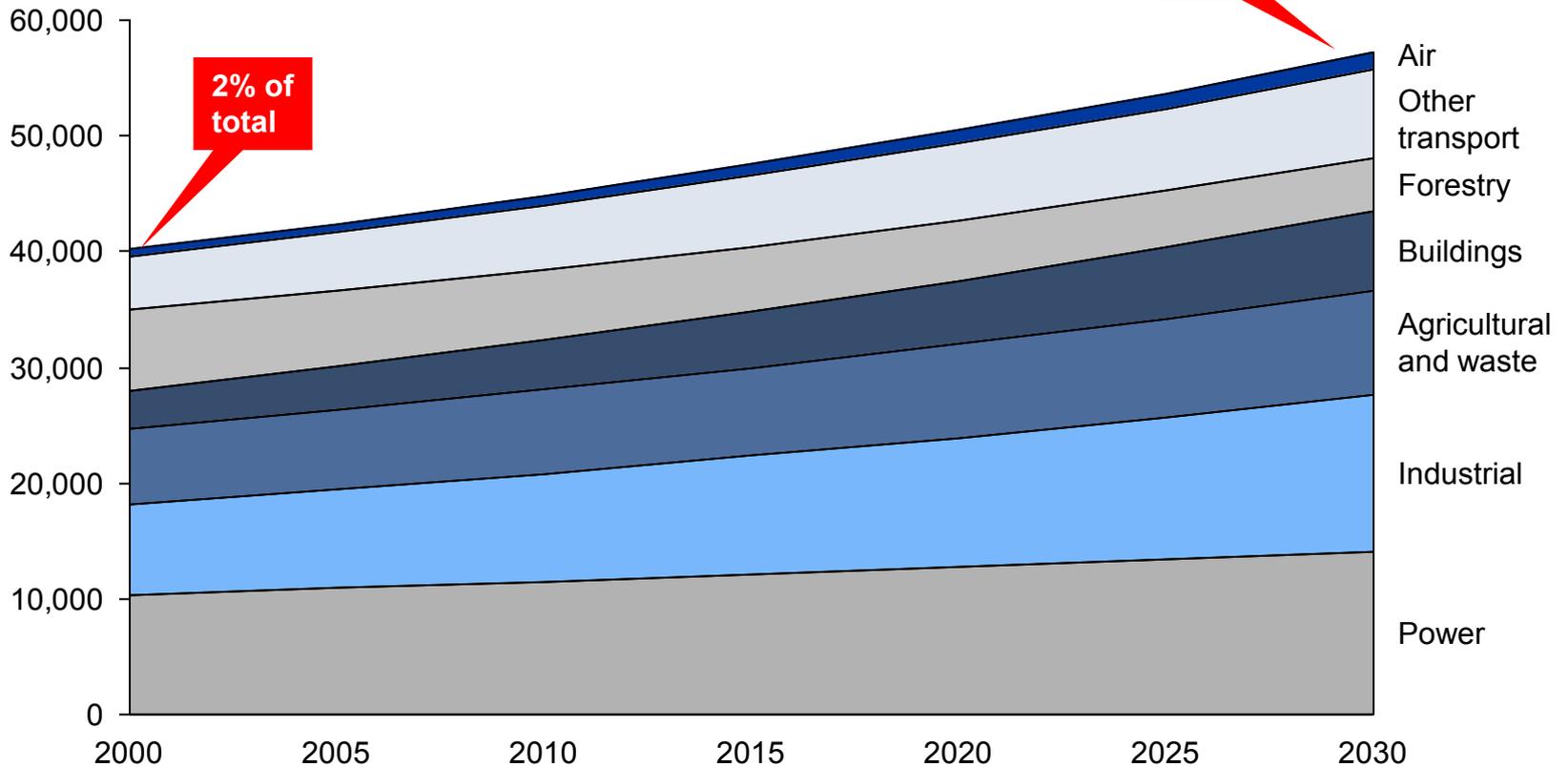
Boeing's Role



# Global CO2 Emissions



**Emissions by sector, 2000-2030**  
Millions tons CO<sub>2</sub> equivalent/year



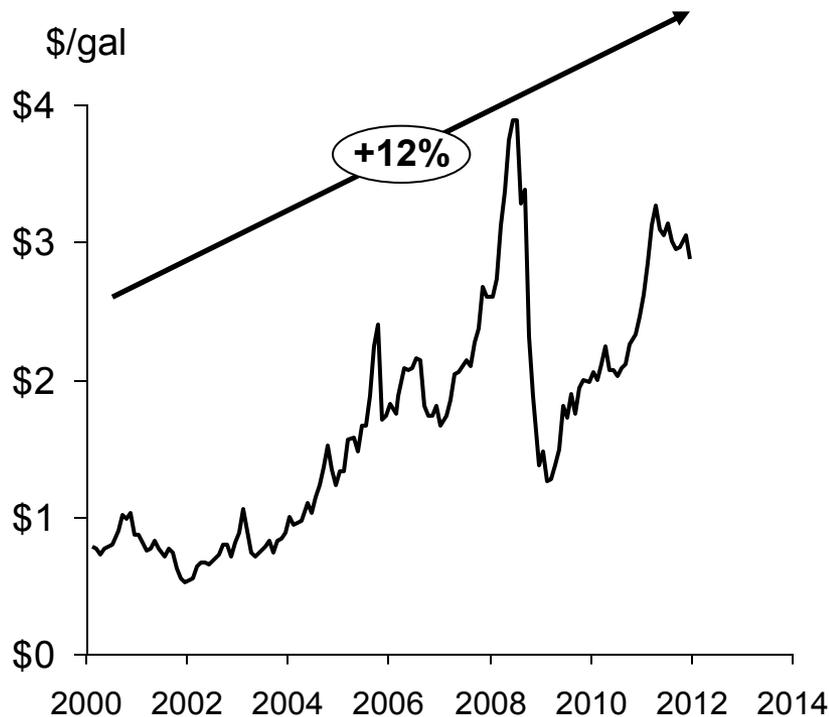
**Small but growing share of emissions**

Source: IPCC

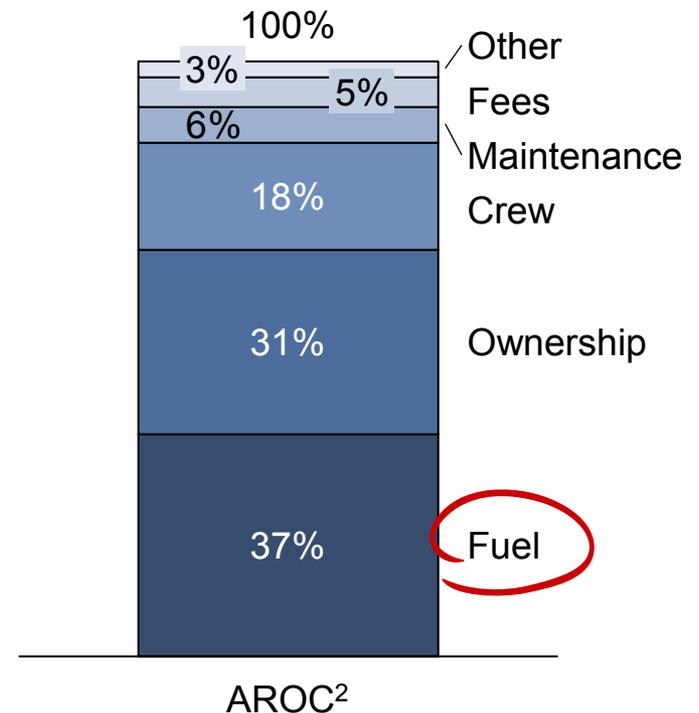
# Fuel largest airline cost and rising



## Rising fuel prices<sup>1</sup>



## Airline operating costs



Sources: EIA

1. US Gulf Coast Jet 2. Airline Related Operating Costs based on US Majors 777-200ER fleet

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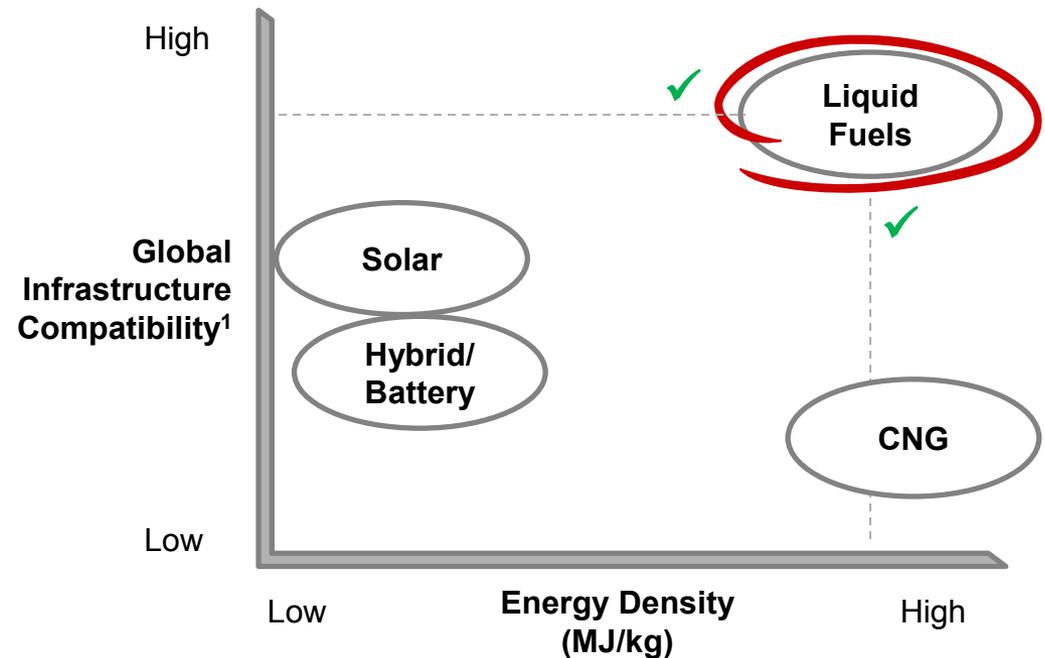
# Energy Options for Aviation



## Energy Requirements

	Global Infrastructure Compatibility	High Energy Density
Road	✗	✗
Rail	✗	✗
Sea	✓	✗
Sky	✓	✓

## Energy Options<sup>2</sup>



## Liquid Fuels Only Realistic Near Term Option

1. Defined as the combination of airport and airplane technology compatibility.
2. Sources (see appendix for detail): CNG/Liquid Fuels: C. Ronneau (2004), Energie, pollution de l'air et developement durable, Louvain-la-neuve: Presses Universitaires de Louvain. Battery: Stanford University, Global Climate and Energy Project. *A Technical Assessment of High-Energy Batteries for Light-Duty Electric Vehicles*. GCEP Energy Assessment Analysis Fall 2006

# Alternative Liquid Fuels



## Example Fuels

### Traditional Fossil



- Petro jet-A
- Diesel

### Alternative Fossil Fuels



- Coal to liquid
- Gas to liquid

### 1<sup>st</sup> Generation Biofuel



- Ethanol
- Biodiesel

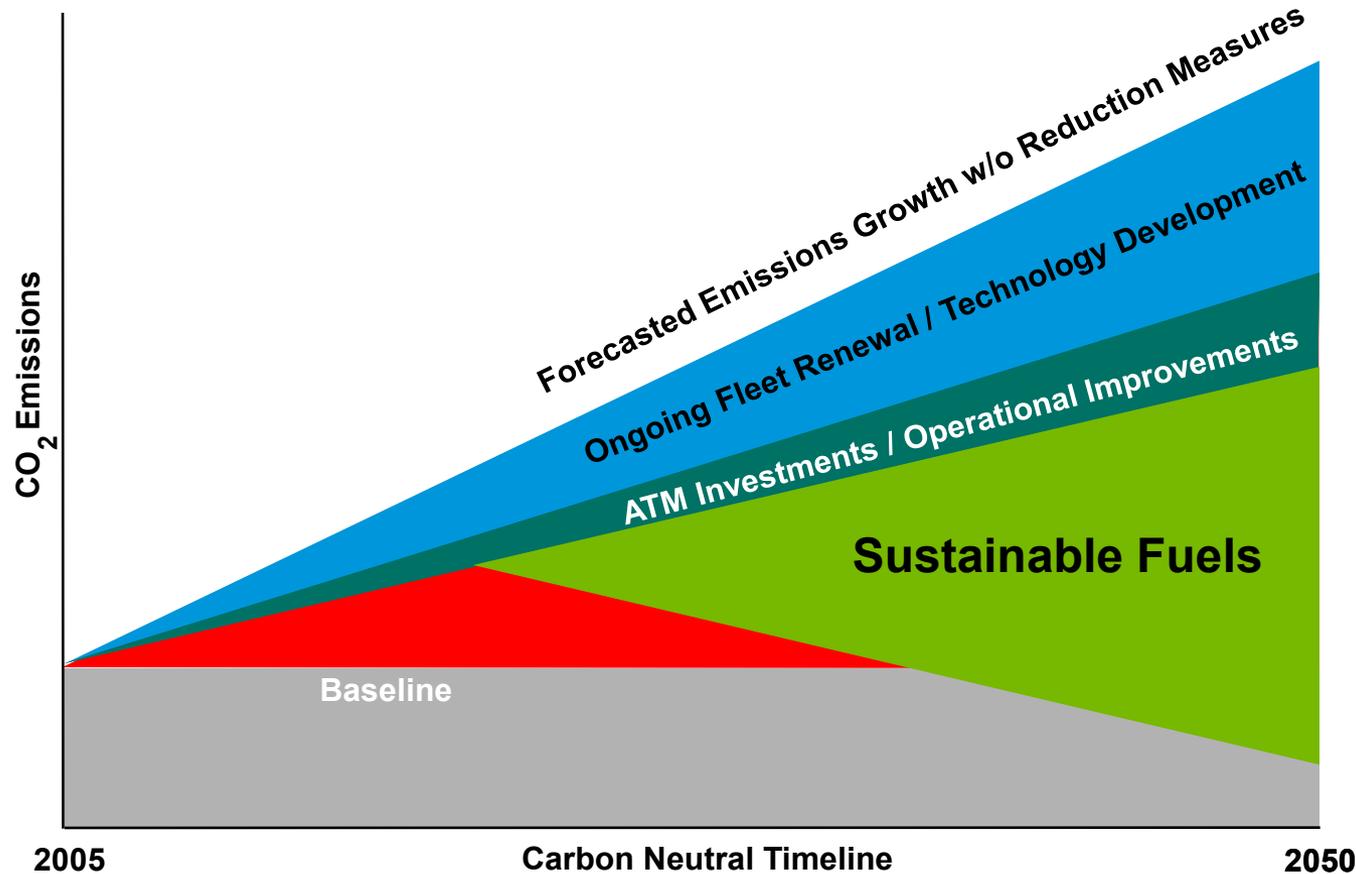
### Advanced Biofuel



- “Drop-in” Sustainable aviation fuel
- Renewable diesel

**Boeing focused on advanced biofuel**

# Boeing's Strategy for Reducing Emissions



## Use less fuel

- Efficient airplanes
- Operational efficiency

## Change the fuel

- Lower lifecycle CO<sub>2</sub>
- No infrastructure modifications
- “Sustainable Biofuel”

**Sustainable aviation biofuel is an essential growth enabler**

# Boeing Supports “Drop-In” Fuels



- Meets fuel performance requirements
- Requires NO change to airplanes or engines
- Requires NO change to infrastructure
- Can be mixed or alternated with today’s Jet-A fuel



**A new way of making the same fuel**

# Sustainability is Critical to Success



## Key Sustainability Requirements<sup>1</sup>



Doesn't contribute to indirect impacts



Positive GHG impact



3<sup>rd</sup> party standards and audits<sup>2</sup>

## Benefits



Assurance of environmental benefit



Socio-economic



Moral license



Credit opportunity<sup>3</sup>



1. Other requirements include land use changes, water use, land rights, labor rights 2. Examples include RSB, FSC, etc. 3. Examples include EU ETS avoidance and US RINs

# A Way Forward

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Why Aviation  
Biofuel?



**First industry steps**



Boeing's Role



# State of Aviation Biofuel Industry



## ✔ Technically viable



ASTM and Def Stan approved

High quality standard

## ✔ In demand



Airline support

In commercial use

Strong US Military Demand

## ✘ Sufficient supply



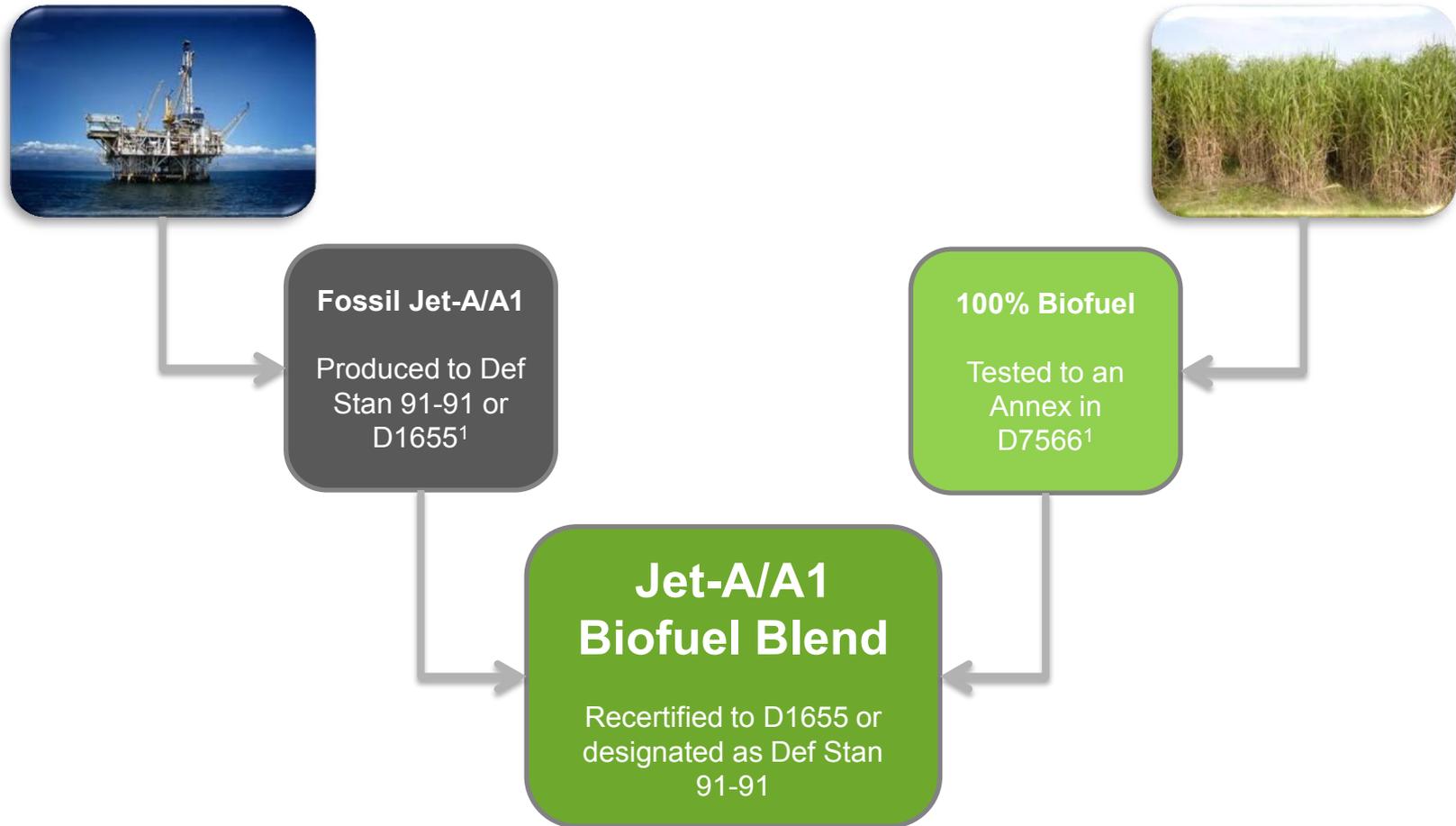
Refinery capacity small

Price premium

Limited sustainable feedstock

**Supply is the main challenge**

# Biofuel and the Jet Specifications

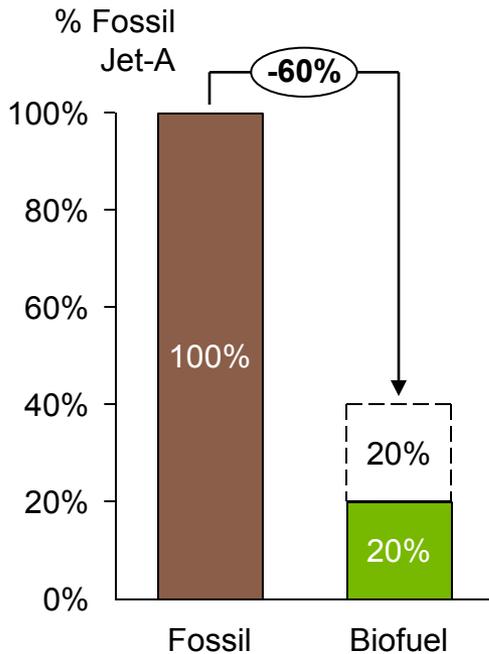


1. ASTM D1655 and D7566 standards covers a wide variety of fuel properties and specify which tests should be conducted to verify these

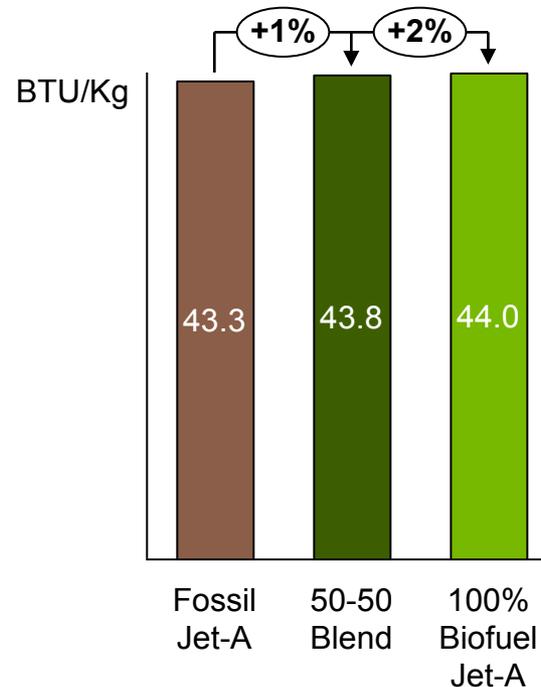
# Biofuel Technical Properties



## Lower GHG Emissions<sup>1</sup>



## Higher Energy<sup>2</sup>



## Stricter Standard

	Fossil <sup>3</sup>	Bio <sup>4</sup>
Min	✗	✓
% Aromatics	✗	✓
Water	✗	✓
Halogens	✗	✓
Metals	✗	✓
Nitrogen	✗	✓

## Biofuel as good or better than traditional fossil

Source: Joint Boeing, UOP, USAF research report, v5.0

Note: Based on currently approved ASTM fuels

1. GHG, Greenhouse Gas. Based Jatropa study in Brazil. 2. As seen from early testing results and field trials. 3. ASTM D1655 4. ASTM D7566

# Broad Demand for Aviation Biofuel



Test Flights  
2008 - 2011

Early commercial flights<sup>1</sup>  
2011-2012

Ongoing operation  
2012+



NAVY



AIR NEW ZEALAND



AEROMEXICO



**“If you build it, we will buy it”**

*-Bill Ayer  
Former Alaska Airlines  
CEO on biofuel*

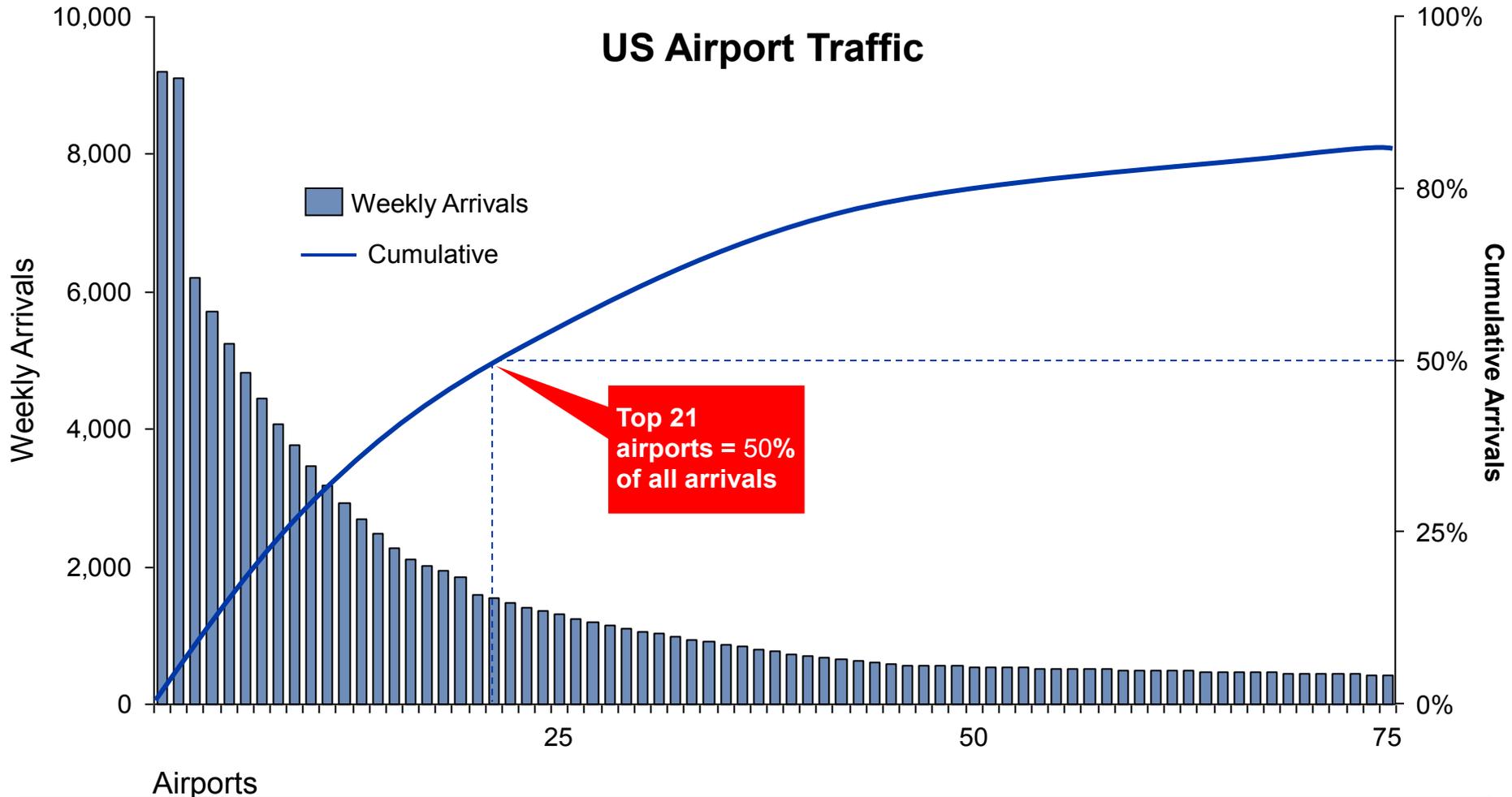
**“The biggest obstacle we’ll  
have to achieving our targets  
is simply supply”**

*-David Cush  
Virgin America CEO on  
biofuel targets*

**Demand is not a constraint**

1. 1, 525 as of February 2012

# Distribution for Aviation Biofuel



**Aviation has highly concentrated distribution**

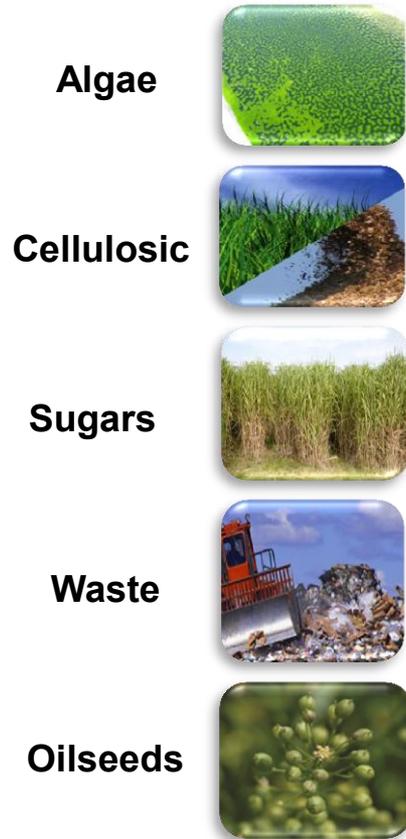
Source: OAG August 2010

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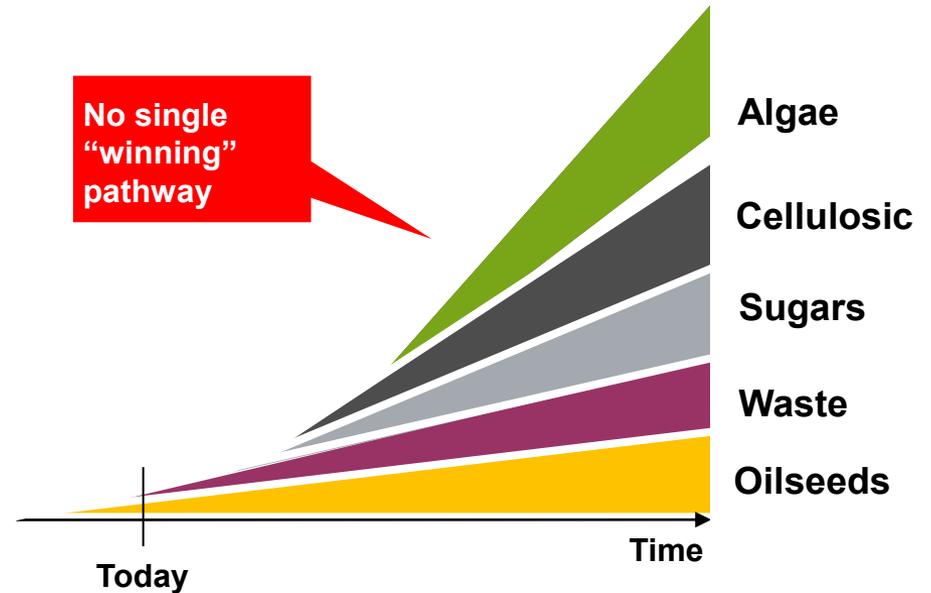
# Sources for Aviation Biofuel



## Sources of Fuel



## Expected Availability



Marketplace will determine future mix of fuel sources

# Boeing's Role in Making Biofuel a Reality

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Why Aviation  
Biofuel?



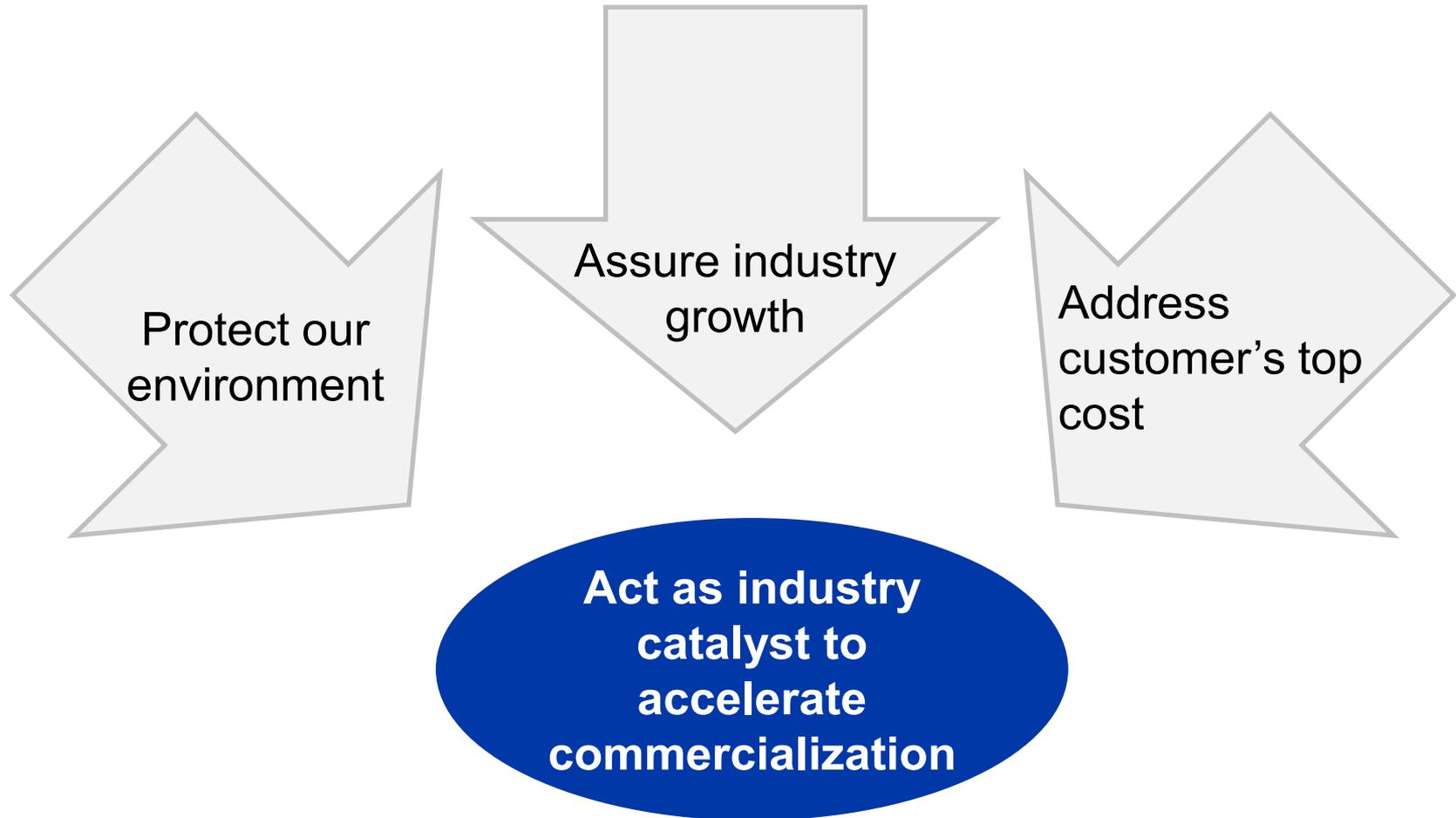
First industry steps



**The Boeing Role**



# Boeing Role



# Boeing Goals and Actions



## Boeing goals

1% aviation fuel by 2015  
(~600M gallons)

3-5 large refineries<sup>1</sup>

1.5M hectares of sustainable  
energy crops<sup>2</sup>

Near price parity with traditional  
Jet-A



## Core activities

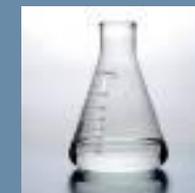
Support  
and  
Advocacy



Feedstock  
and Pathway  
R&D



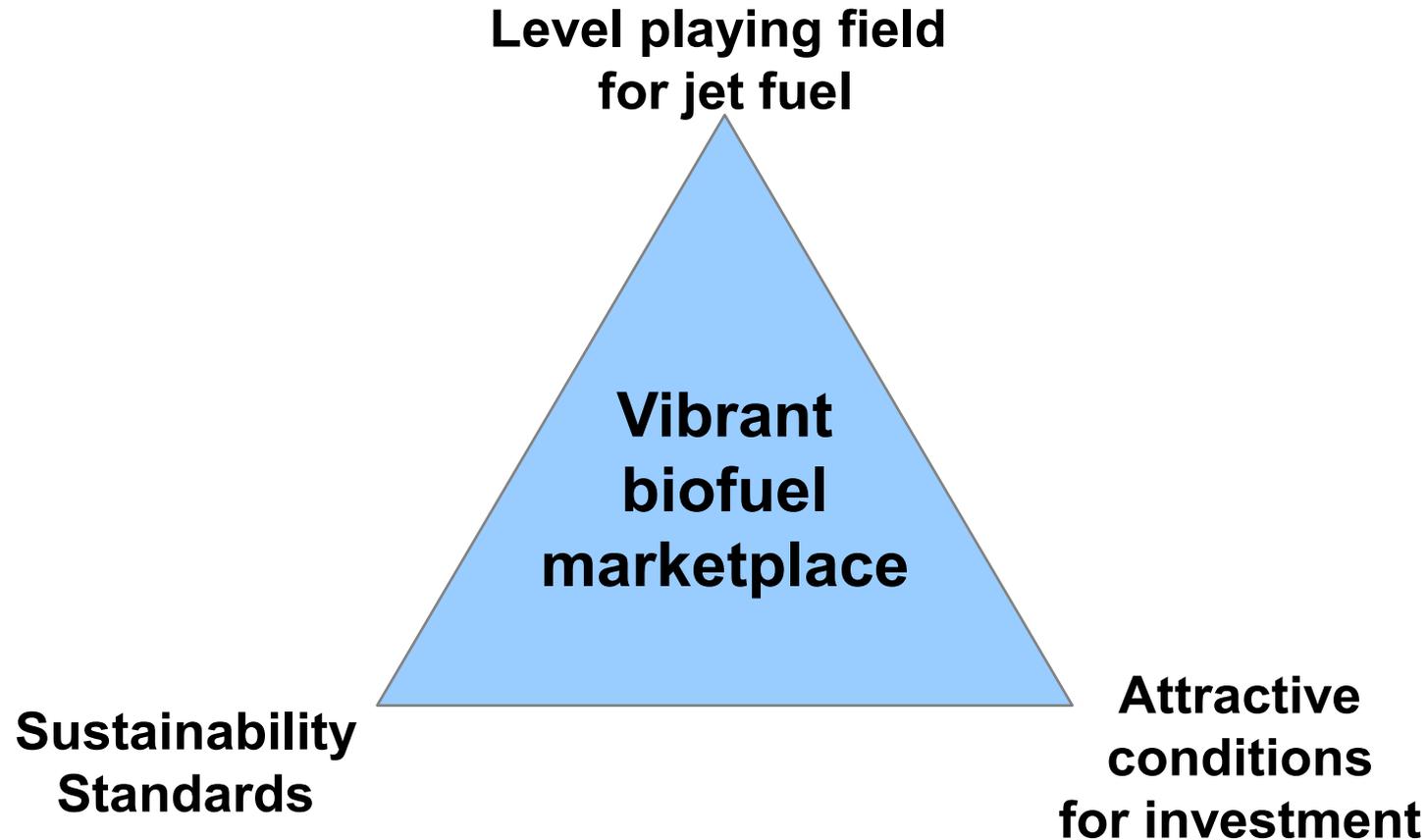
Fuels  
approval



**Ultimate goal is to catalyze a vibrant commercial market**

1. Based on refinery size near 150M gal/yr 2. Based on jatropha, but exact feedstock mix will vary

# Biofuel Global Policy Goals



# Boeing Global Biofuel Engagements



## Recent and Active Biofuel Projects



## Outcomes

- ASTM & DEF STAN approval
- SAFUG<sup>1</sup> established
- Commercial flights from June, 2011
- Focused regional research projects
- Biofuel roadmaps published

1. Sustainable Aviation Fuel Users Group

# Moving From Dreams to Reality



## Aviation Biofuel Progress

- ASTM approval for commercial use
- Regional assessments
- Favorable policy developments
- Commercial flights continue

## Next Steps

- Continued emphasis on sustainability
- ASTM approval for Alcohols-to-Jet
- Research - expanded feedstocks/pathways
- Commercial production scale-up

**Great progress. Superior fuel. Early in the journey.**