# Aviation and the Environment

*February 2009*

## Demonstrating Commitment with **Action**

# Boeing Commercial Airplanes is committed to the environment

*"As a leader in the industry, Boeing has an obligation to be active in **proposing solutions** to our environmental challenges.*

*We continue to invest significant resources towards **advancing technologies** that will enable the next great leap forward."*

– Scott Carson, President & CEO
Boeing Commercial Airplanes

# The industry is committed to action on climate change

## Aviation Industry Commitment to Action on Climate Change

**As leaders of the aviation industry, we recognise our environmental responsibilities and agree on the need to:**

- build on the strong track record of technological progress and innovation that has made our industry the safest and most efficient transport mode; and
- accelerate action to mitigate our environmental impact, especially in respect to climate change while preserving our driving role in the sustainable development of our global society.

**Therefore, we, the undersigned aviation industry companies and organisations declare that we are committed to a pathway to carbon-neutral growth and aspire to a carbon-free future.**

To this end, in line with the four-pillar strategy unanimously endorsed at the 2007 ICAO Assembly, we will:

1. push forward the development and implementation of new technologies, including cleaner fuels;
2. further optimise the fuel efficiency of our fleet and the way we fly aircraft and manage ground operations;
3. improve air routes, air traffic management and airport infrastructure; and
4. implement positive economic instruments to achieve greenhouse gas reductions wherever they are cost-effective.

**We urge all governments to participate in these efforts by:**

1. supporting and co-financing appropriate research and development in the pursuit of greener technological breakthroughs;
2. taking urgent measures to improve airspace design including civil/military allocation, air traffic management infrastructure and procedures for approving needed airport development; and
3. developing and implementing a global, equitable and stable emissions management framework for aviation through ICAO, in line with the United Nations roadmap agreed in Bali in December 2007.

**Our efforts and commitment to work in partnership with governments, other industries and representatives of civil society will provide meaningful benefits on tackling climate change and other environmental challenges.**

**We strongly encourage others to join us in this endeavour.**

IATA · AIRBUS · BOEING · BOMBARDIER · EMBRAER · Rolls-Royce · Pratt & Whitney

*"…we are committed to a pathway to carbon-neutral growth and aspire to a carbon-free future."*

– ATAG 2008 industry declaration for action on climate change

# Working together to improve air traffic management efficiencies

Boeing and Airbus signed an agreement to work together to ensure global interoperability in air traffic management.

**GOAL:** To accelerate improvements to the world's air transportation management system in order to increase efficiency and eliminate traffic congestion.

*"While our approaches often differ, we are working towards the same goal – to reduce aviation's environmental impact."*

– Scott Carson, President & CEO
Boeing Commercial Airplanes

# The principles that guide Boeing's actions

- **Technology** unlocks the future
- $CO_2$ and **fuel** are the priority
- System efficiency is essential
- **A global approach involves and benefits everyone**

# Our plan and commitments

## Relentlessly pursue manufacturing and life cycle improvements

100%

100% of Boeing major manufacturing sites will maintain ISO 14001 certification.

## Improve performance of worldwide fleet operations

25%

Focus on 25% efficiency improvements in worldwide fleet fuel use and $CO_2$ emissions by 2020.

## Deliver progressive new products and services

15%

Improve $CO_2$ emissions and fuel efficiency by at least 15%

## Pioneer new technology

75%

Devote more than 75% of R&D toward benefiting environmental performance

# Our plan and commitments

Relentlessly pursue manufacturing and life cycle improvements

100%

Improve performance of worldwide fleet operations

25%

Deliver progressive new products and services

15%

**Pioneer new technology**

75%

Devote more than 75% of R&D toward benefiting environmental performance

Boeing Commercial Airplanes

# What is the future of jet fuel?

# Cleaner and cleaner. Less and less.

Jet fuel powers the airplanes that connect people and economies around the world. It also produces carbon dioxide, one of the greenhouse gases at the center of climate change. That's why Boeing Commercial Airplanes is committed to helping develop cleaner fuels and innovating commercial aircraft that use less and less fuel to begin with. Today, saving one pound of fuel means producing three fewer pounds of carbon dioxide. Our industry's contribution to human-produced emissions is small and we are focused on keeping it that way.

2


18

Today, aviation accounts for only about 2 percent of the world's human-produced carbon dioxide emissions—compared with 18 percent from highway vehicles.

## This is our plan. These are our commitments.

**15%** improvement in fuel efficiency and $CO_2$ emissions for each new generation of airplane

Design innovation is the essence of our DNA as a company. By continually harnessing the power of design, we create game-changing airplanes that are each more environmentally progressive than the last. Because increasing fuel efficiency and reducing $CO_2$ emissions are our priority, every new generation of Boeing commercial aircraft will deliver ever-increasing advances in these areas.

**25%** efficiency improvement in worldwide fleet fuel use and $CO_2$ emissions by 2020

New, more efficient airplanes are only part of the solution. We're working closely with the industry to improve the environmental performance of existing fleet operations. Significant reductions in fuel and $CO_2$ emissions are being achieved through improvements in carrier and airport operations as well as upgraded equipment. Additionally, we're focused on industry and government initiatives to optimize air traffic management systems, which represent a significant opportunity for efficiency improvements.

**75%** of technology research and development will benefit environmental performance

Technology creates new possibilities. We are pioneering new technologies that deliver measurable improvements in environmental performance. Our research and development is focused on improving fuel efficiency, reducing emissions and minimizing noise footprints. We're also pursuing low carbon alternative fuels.

**100%** of manufacturing sites planned for ISO 14001 certification

An airplane's environmental footprint begins well before its first flight. Our focus spans the entire product lifecycle, from design and manufacturing to the recycling of decommissioned aircraft. As an advocate and proven practitioner of Lean+ processes, all of Boeing Commercial Airplanes' manufacturing sites have achieved or will achieve certification under stringent and internationally accepted environmental management standards.

70 | 40

Our progress in using more efficient aerodynamic designs, engines, electronics and processes has improved the fuel efficiency of our commercial airplanes by 70 percent over the past 40 years.

# Actively pursuing renewable energy sources



**ENERGY HARVESTING TECHNOLOGIES**

**Electrodynamic:** Powering light switches with your finger.

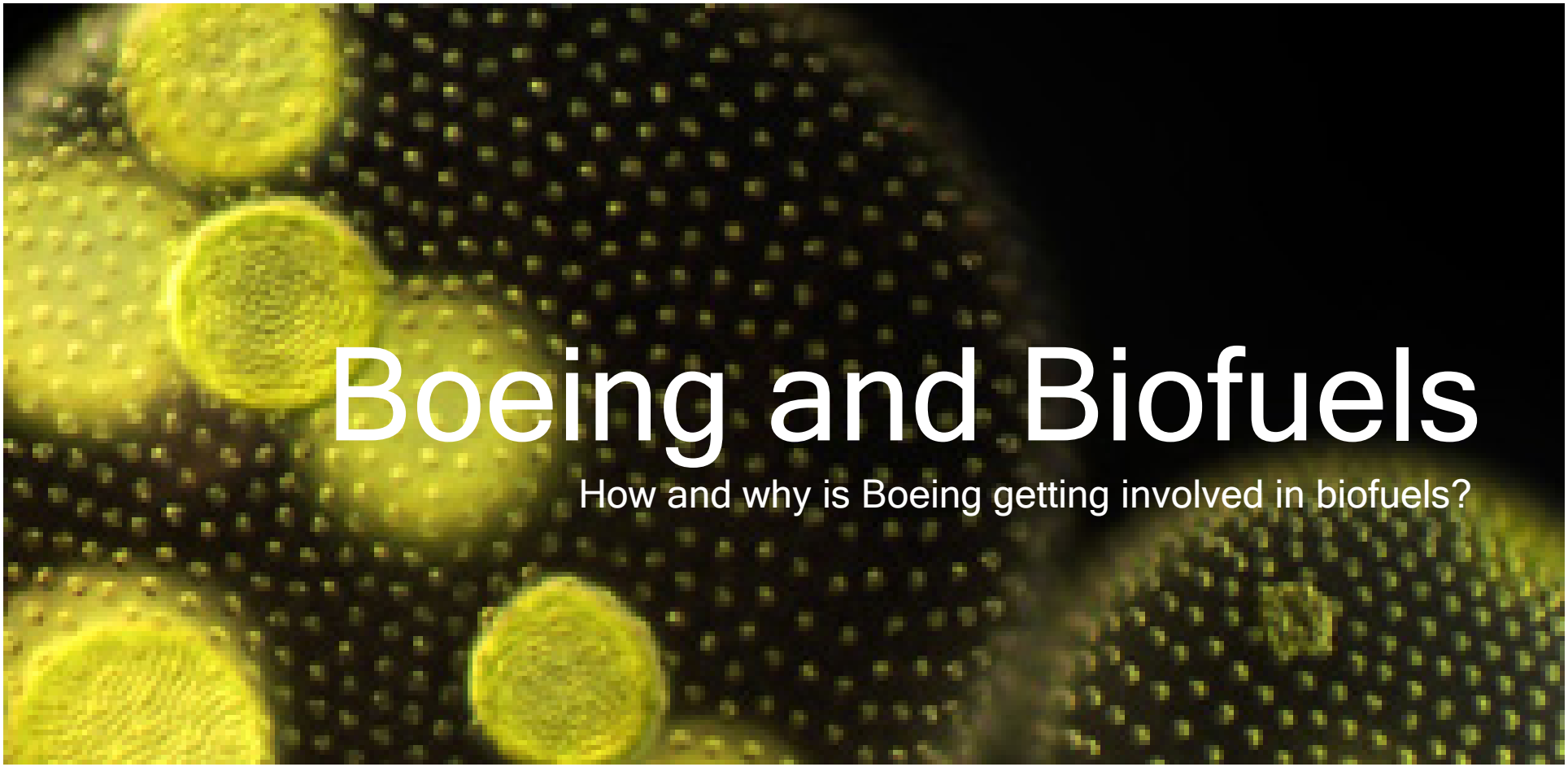
**Thermoelectric:** Using temperature gradients to power dimmable windows.

**Piezoelectric:** A vibration-powered wireless sensor

**The Spectrolab solar cell:** Concentrating solar power to make it cost-effective

**FUEL CELLS**

The Boeing Fuel Cell Demonstrator, achieved the first manned mission where straight-level flight was powered solely by a hydrogen fuel cell.


Boeing and Biofuels
How and why is Boeing getting involved in biofuels?

# Sustainable biofuels – Boeing's plan and approach

*Achieve near-term market viability of sustainable biofuels for commercial aviation*

## Demonstrate Technical Capability

**Flight and Engine Tests**

**Fuels Development**


**Feedstock Feasibility**

## Drive Commercial Viability

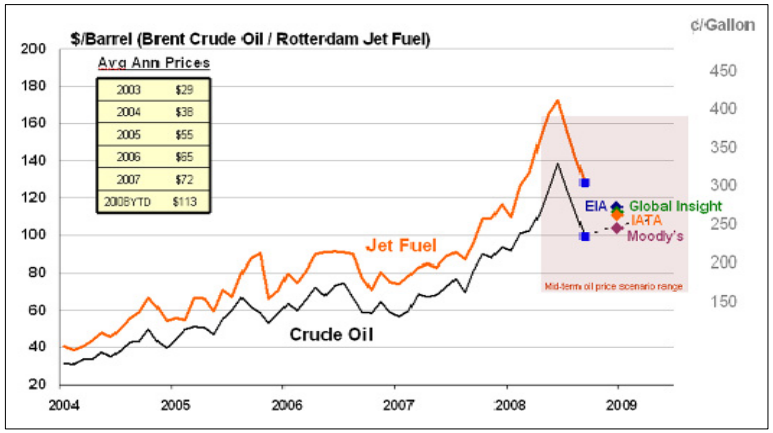
**Demand Driven**

**Education**

**Public Policy**

# There are two significant aviation industry challenges

- Fuel price and availability




- Need to reduce life cycle greenhouse gas emissions

Source: 2008 average annual oil price forecasts as of Sept 2008 (Global Insight, EIA) and June 2008 (Moody's, IATA)

# Summary of major initiatives

- Accelerated certification timeline

- Flight test program



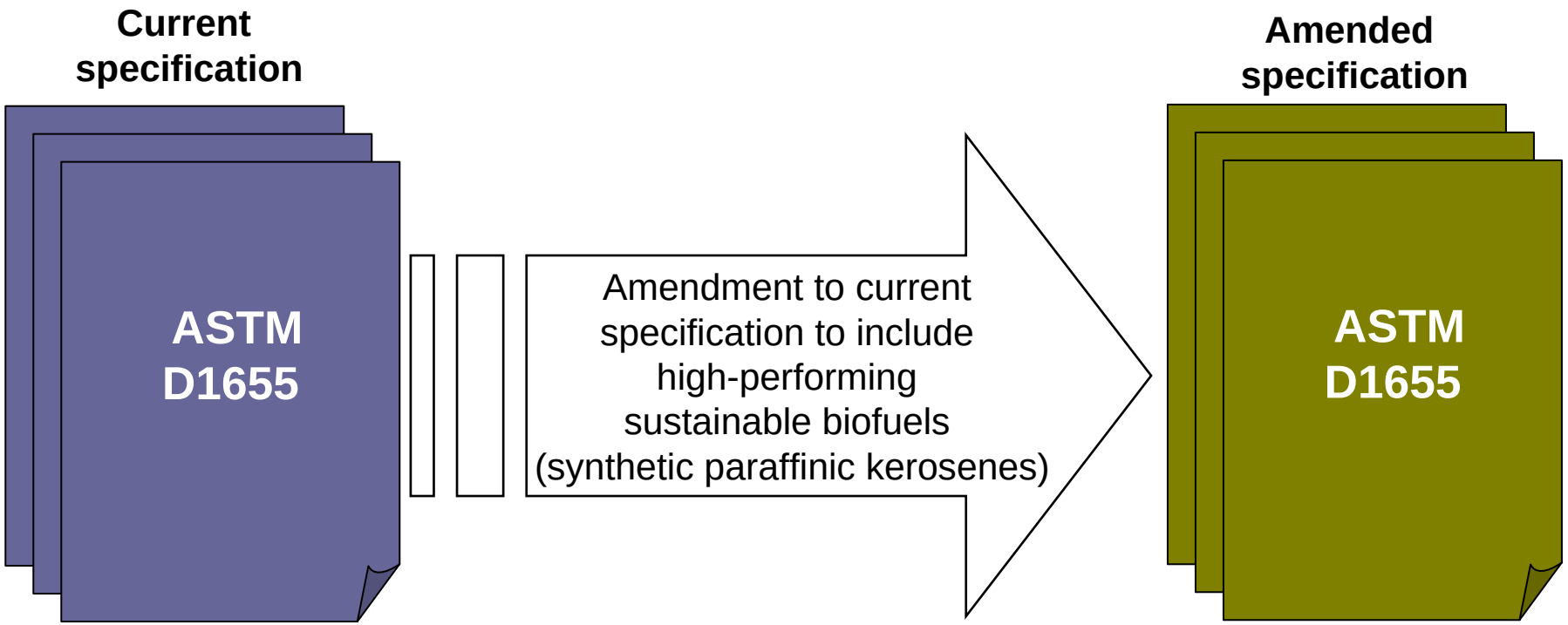
- Commercialization via **Sustainable Aviation Fuel (SAF) Users Group**

AIR NEW ZEALAND · AIR FRANCE · Virgin atlantic · ANA All Nippon Airways · JAL · KLM · cargolux · GULF AIR · SAS Scandinavian Airlines

# Summary of major initiatives

- Accelerated certification timeline

# Certification should focus on fuel performance – not on processing methods



# Summary of major initiatives

- Flight test program


# First flight test with sustainable biofuels for commercial aviation


**February 2008**

# Making progress:
# The 2nd sustainable biofuel flight test

AIR NEW ZEALAND

BOEING

Rolls-Royce


**December 2008**

# First North American sustainable biofuel flight test


**January 2009**

# First sustainable biofuel flight test in Asia


**January 2009**

# Summary of major initiatives

- Commercialization via **Sustainable Aviation Fuel (SAF) Users Group**

# Sustainable Aviation Fuel (SAF) Users Group Commitment to Sustainable Options

## Sustainable Aviation Fuel Users Group
## Our Commitment to Sustainable Options

As aviation leaders, our business is to bring people, cultures, and economies together. We recognize the need for dynamic, new innovation to help reduce aircraft greenhouse gas emissions beyond existing advances, while continuing to increase the socio-economic good that air travel provides to the world.

Whilst we recognize the need to drive further efficiency gains through technological solutions and operational efficiencies, we also have an opportunity to deliver significant environmental and social benefits as we seek to lower the carbon intensity of our fuels overall by supporting the development, certification, and commercial use of lower carbon renewable fuels, derived from environmentally and socially sustainable sources.

Therefore, we, the undersigned air carriers and other aviation industry organizations declare our commitment to advance the development, certification, and commercial use of drop-in sustainable aviation fuels. Collectively, we represent, approximately 15% of commercial aviation fuel demand, and in assessing the sustainability and commercial use of a bio-derived aviation fuel, the following considerations at a minimum should be addressed by verifiable means:

1. Jet fuel plant sources should be developed in a manner which is non-competitive with food and where biodiversity impacts are minimized; in addition, the cultivation of those plant sources should not jeopardize drinking water supplies.
2. Total lifecycle greenhouse gas emissions from plant growth, harvesting, processing, and end-use should be significantly reduced compared to those associated with jet fuels from fossil sources.
3. In developing economies, development projects should include provisions or outcomes that improve socio-economic conditions for small-scale farmers who rely on agriculture to feed them and their families, and that do not require the involuntary displacement of local populations.
4. High conservation value areas and native eco-systems should not be cleared and converted for jet fuel plant source development.

These criteria should be consistent with, and complementary to emerging internationally-recognized standards such as those being developed by the Roundtable on Sustainable Biofuels.

We agree to work with leading organizations and individuals in the biofuels arena, not limited to the aviation industry, to develop a world-leading fact base on sustainable aviation fuels, which will:

1. Provide a body of peer-reviewed research and best practices, including fuel lifecycle emissions assessments, which will support the practical application of common sustainability criteria to the development, certification, and commercial use of sustainable aviation fuels
2. We will work in conjunction with the Version Zero report of the Roundtable on Sustainable Biofuels as a basis for sustainability research and certification efforts. The Working Group will identify and research feedstock-specific sustainability indicators and criteria to contribute to the Roundtable.
3. Support the development of government policies which promote the development, certification, and commercial use of sustainable, lower carbon aviation fuels.

We are committed to working in partnership where appropriate with governments, other industries and representatives of civil society on credible and feasible actions in response to global climate change concerns and other socio-economic challenges.

We strongly encourage other aviation industry participants to join us in working together to help accelerate the development, certification, and commercial use of environmentally and socially sustainable aviation fuel.

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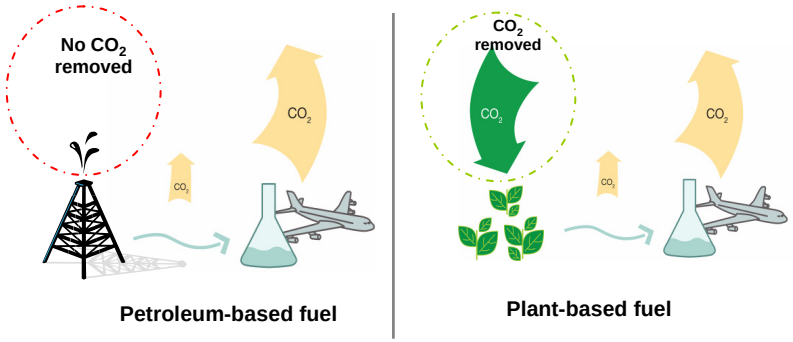
Focus on Sustainability
Are all biofuels equal? What are the best and worst sources?

# Sustainability considers: environmental, economic and social impacts



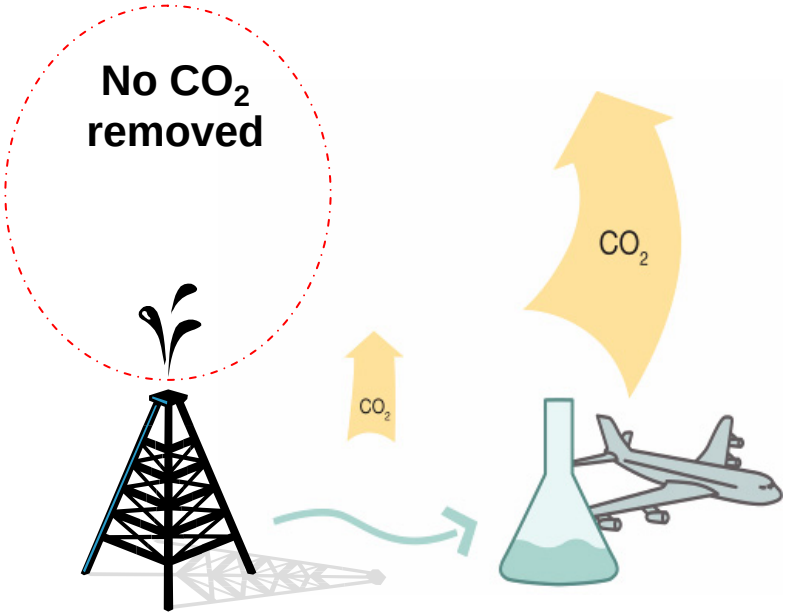

Lower $CO_2$ lifecycle

Does not compete with food or promote deforestation

Promotes local and regional solutions and economies

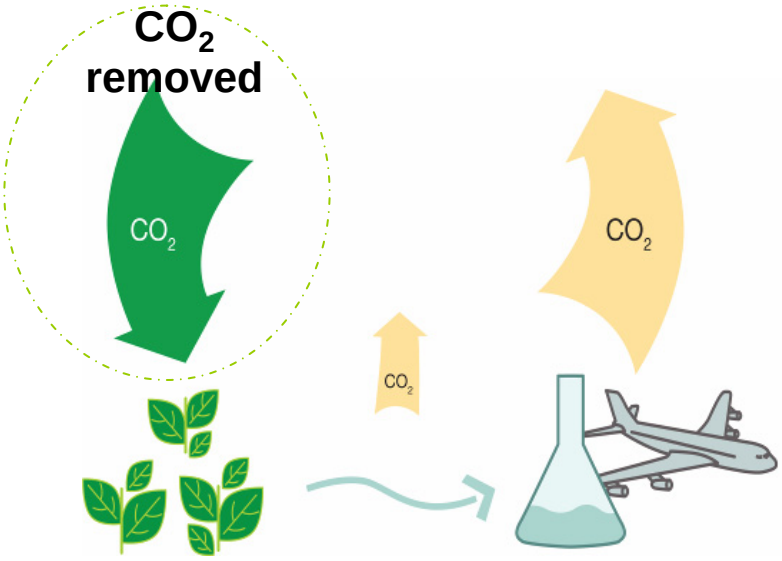
# Plant-based feedstocks naturally remove $CO_2$ from the atmosphere

Petroleum releases $CO_2$ that has been locked underground



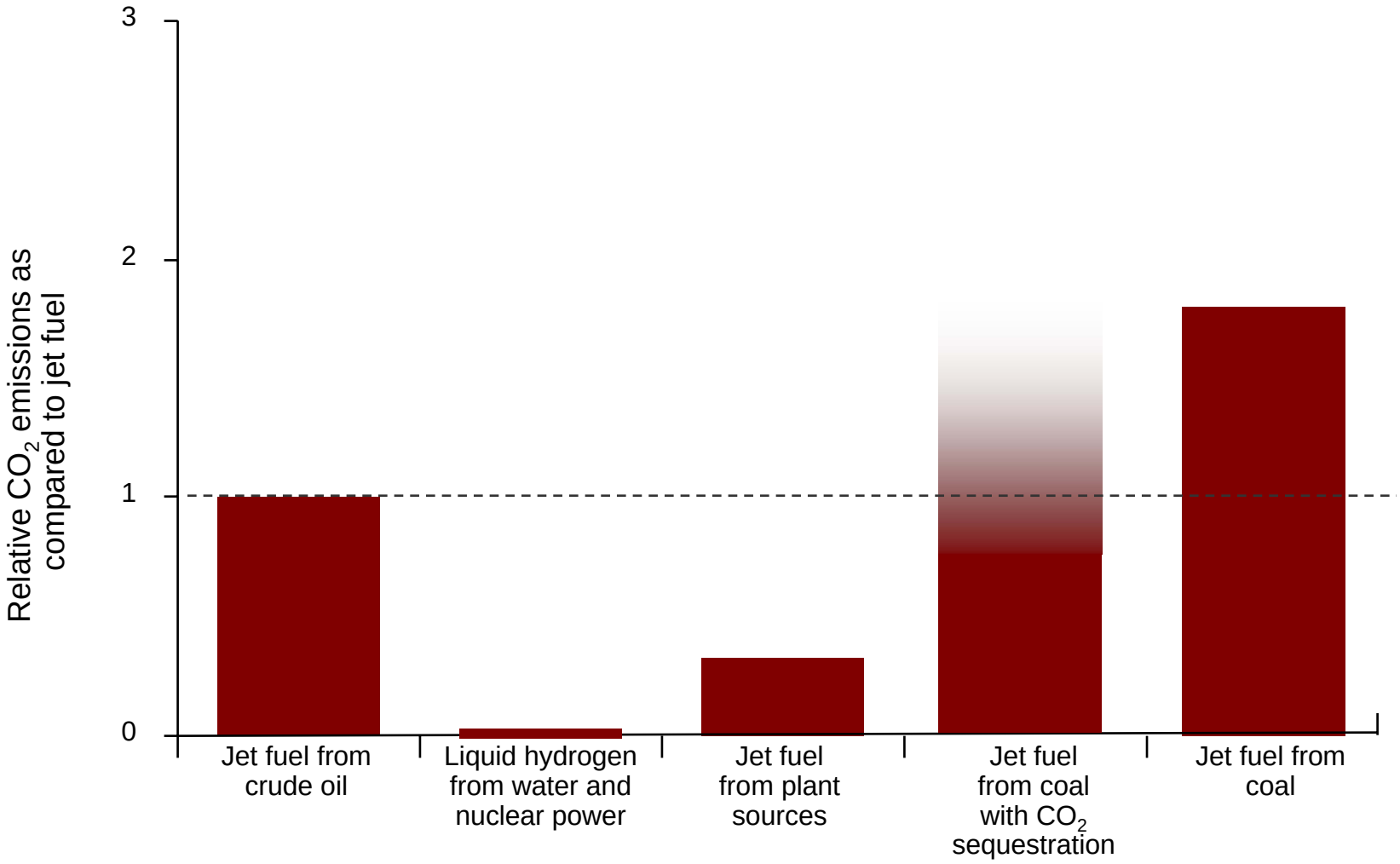

**Petroleum-based fuel**

Plant feedstocks re-absorb $CO_2$ emissions as they grow

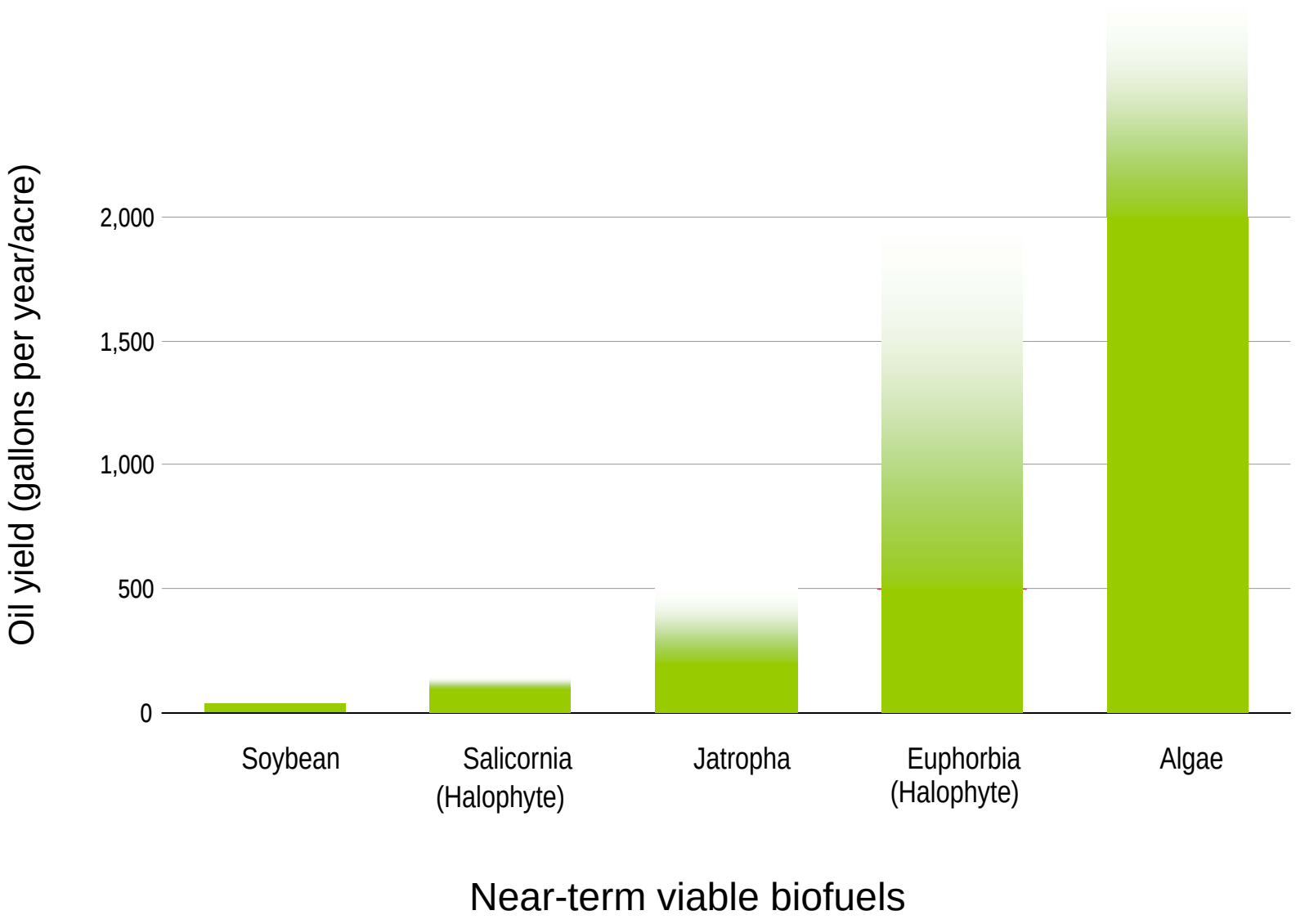



**Plant-based fuel**

# Boeing is focusing on alternate fuels that have low life-cycle $CO_2$ emissions

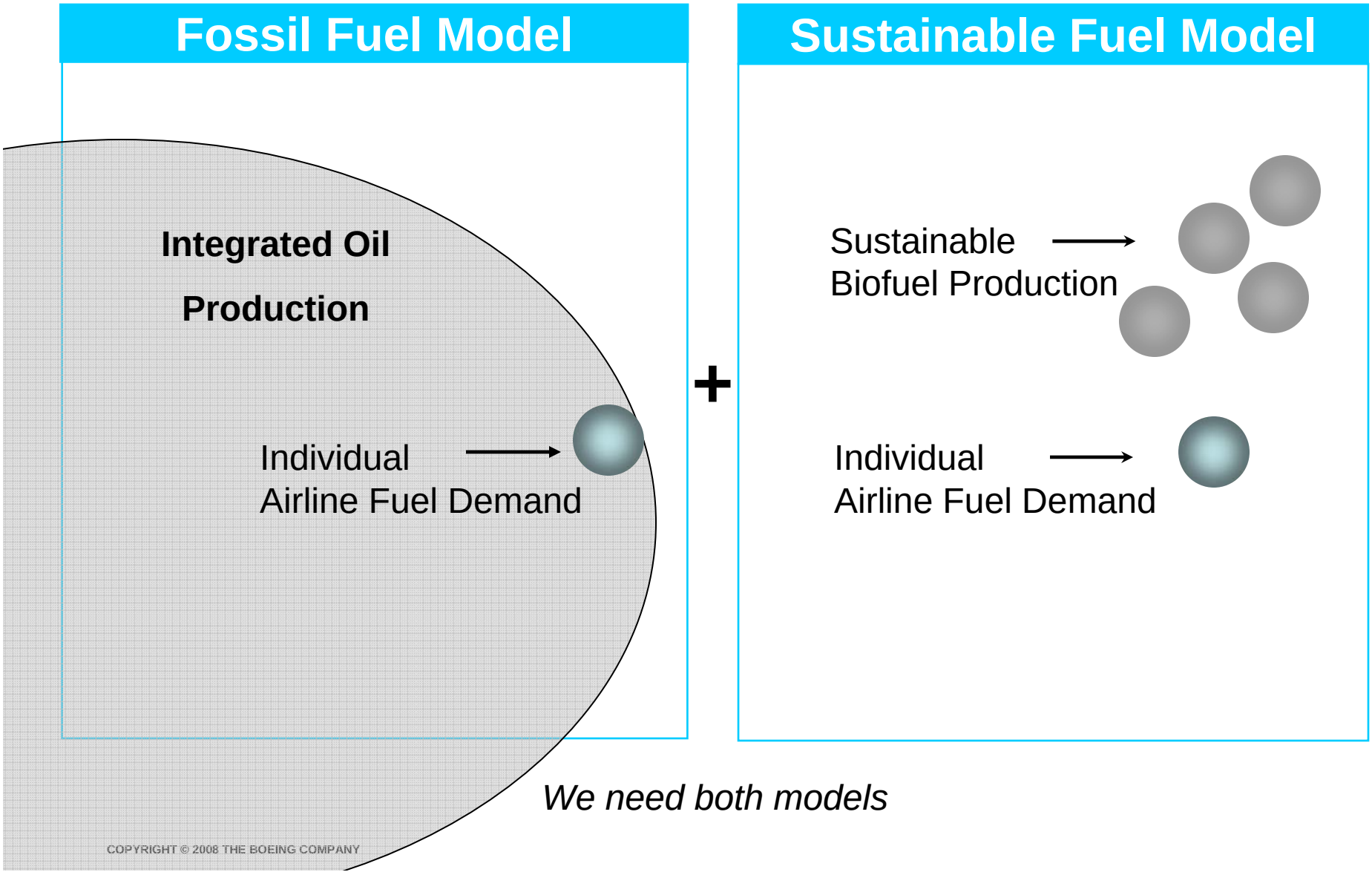


# Boeing is focusing on high-productivity sustainable biofuels




Economically Viable
Economically viable biofuels will deliver sustainable aviation fuel

# New fuel supply models increase aviation fuel supplies




*We need both models*

# Aviation is uniquely structured to maximize benefits of sustainable biofuels


◇ Tens of thousands fueling stations

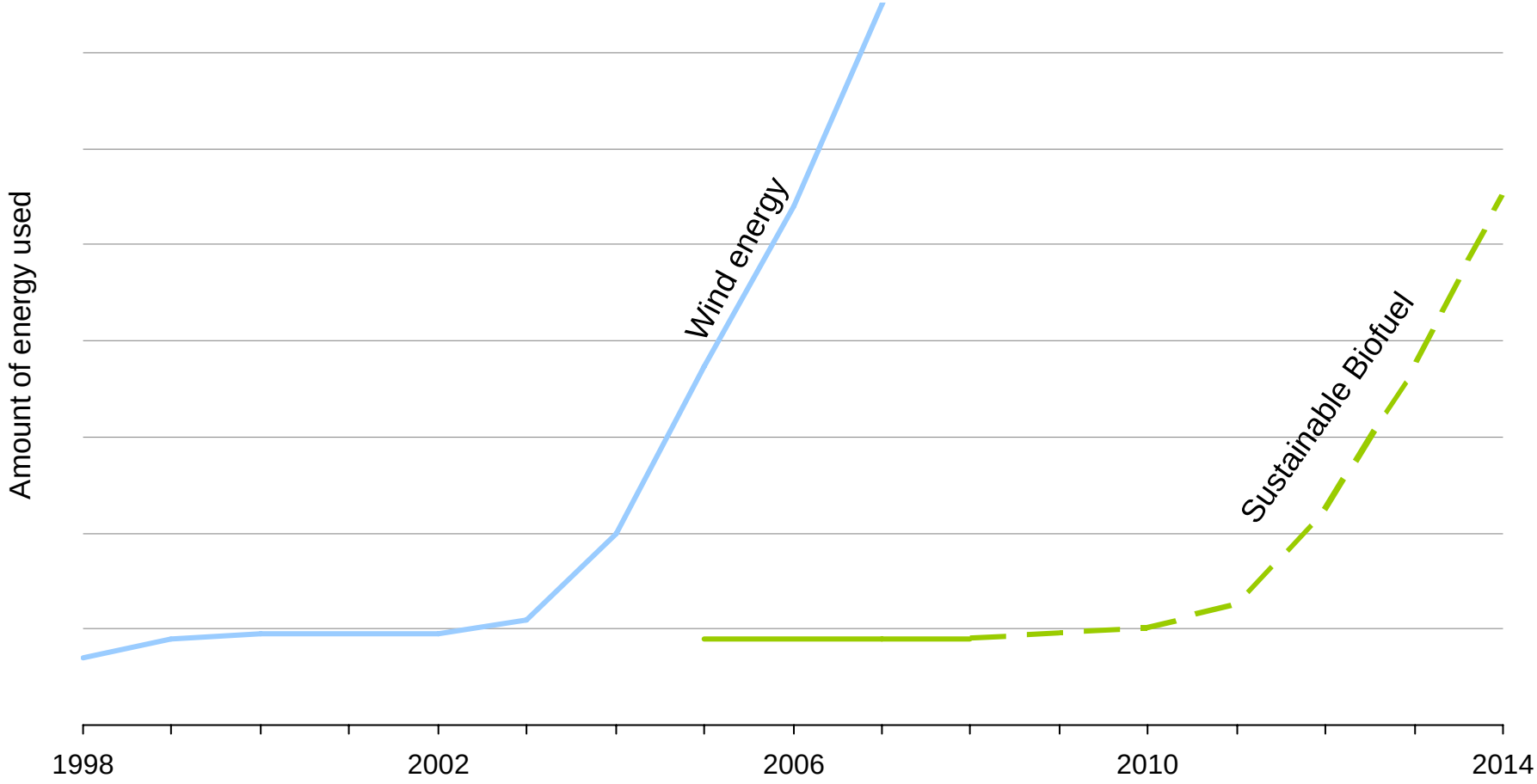
● Hundreds of millions of vehicles


◇ Several hundred fueling stations (airports)

● 20,000 vehicles


Commercialization
The business case for sustainable aviation biofuel

# Sustainable biofuels can follow a similar adoption curve to wind energy



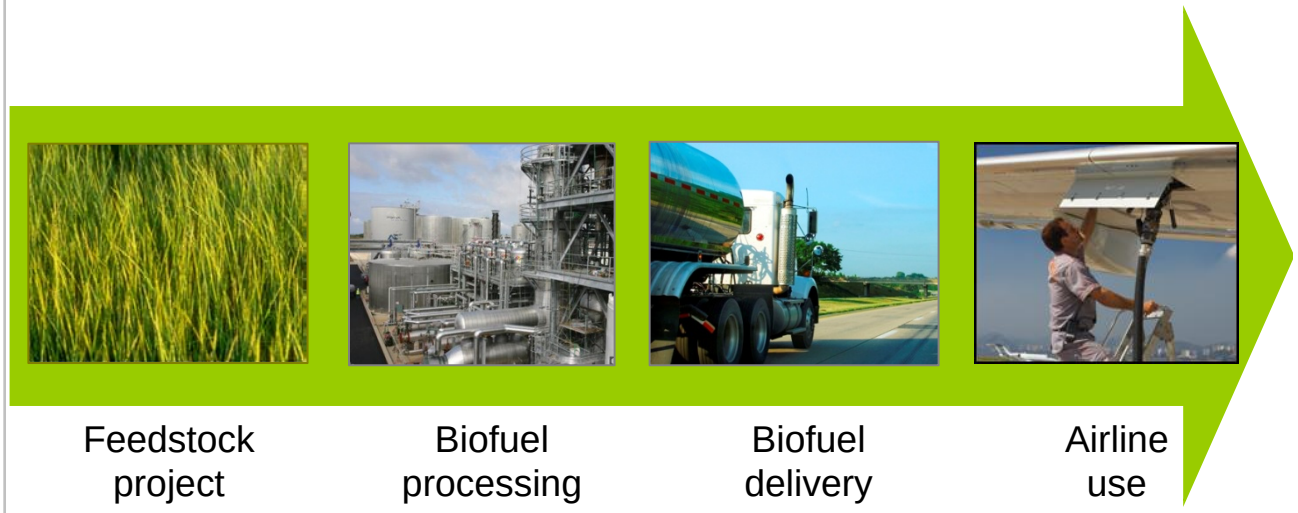

** Notional data*

*Technology matured; financial markets became comfortable with investing*

# Sustainable biofuel supply chain overview

**Commercial viability threshold requirements:**

- ☑ Sustainability principles established
- ☑ Sustainability practices and auditing
- ☑ Technology/agronomy in place
- ☑ Fuel processing technology in place
- ☑ Viable feedstock and processing developers in place



# Boeing helped form the Algal Biomass Organization

*Promotes the development and commercial application of algae biomass*

- Global organization
- Founded in May 2008


WSGR
Wilson Sonsini Goodrich & Rosati
PROFESSIONAL CORPORATION

Virgin atlantic

Continental Airlines

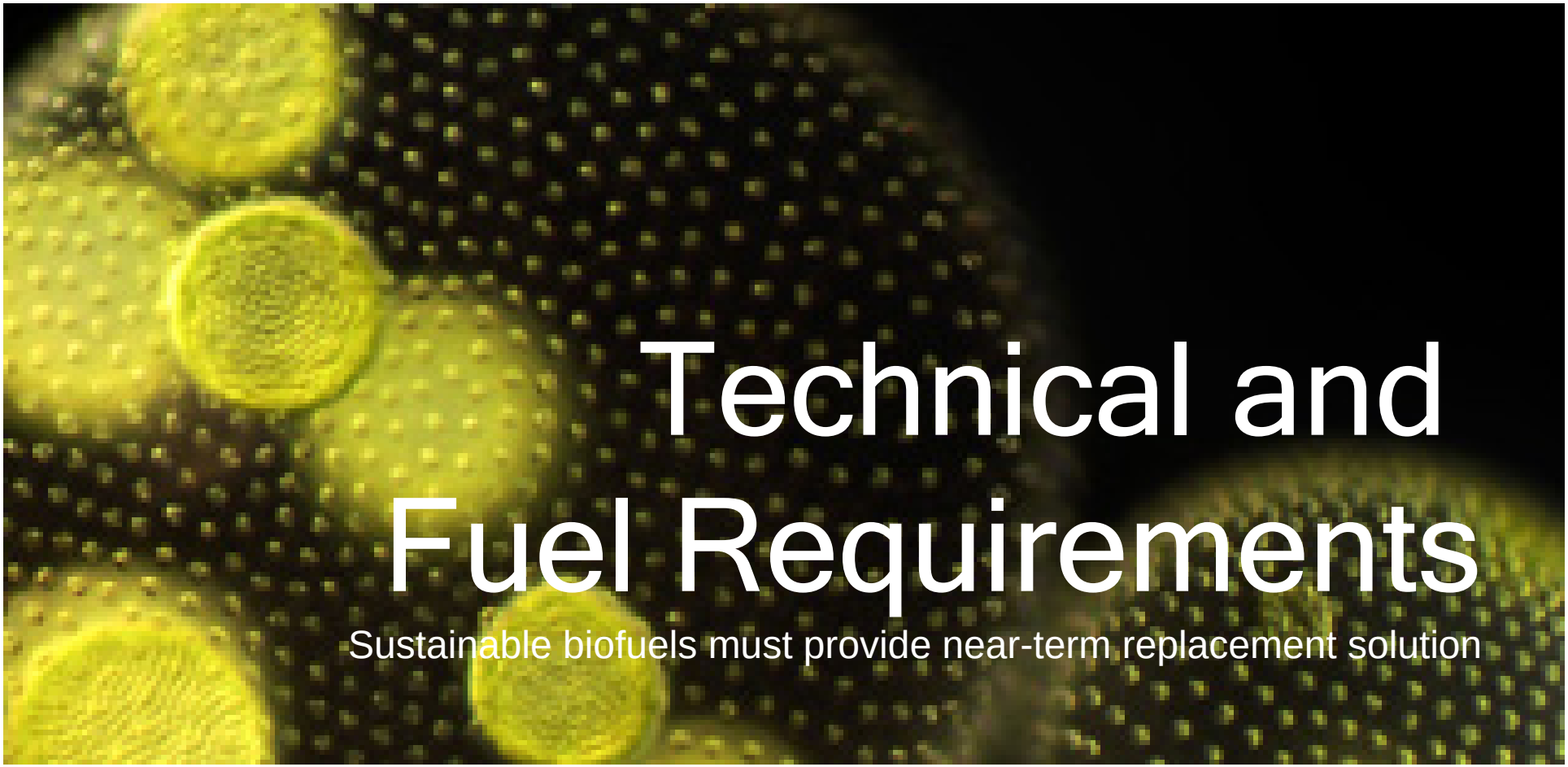
BOEING

BYRNE
& Company Limited

FedEx

UOP
A Honeywell Company

AIR NEW ZEALAND



# Technical and Fuel Requirements

Sustainable biofuels must provide near-term replacement solution

# Sustainable biofuels are a drop-in solution

- Sustainable biofuels have equal energy content
- Sustainable biofuels perform as well or better than today's Jet-A fuel
- Sustainable biofuels work in existing aviation structure
- Sustainable, scaleable and affordable processing methods exist

*There are no apparent showstoppers*

# Sustainable biofuels performing better than Jet-A fuel

Key fuel requirements:

- ☑ Freezing point
- ☑ High temperature thermal stability
- ☑ Energy density
- ☑ Storage stability
- ☑ Elastomeric compatibility
- ☑ Must be a replacement solution
- ☑ Meet ASTM fuel specs
- ☑ Have a low $CO_2$ footprint

| ***Detailed Requirements of Aviation Turbine Fuels*** | | | | | |
|---|---|---|---|---|---|
| ***Property*** | | ***Jet fuel specification*** | ***Comparison of bio and petroleum jet performance*** | | ***ASTM Test Method*** |
| | | | ***Jatropha*** | ***Petroleum JP-8 (same as Jet A1)*** | |
| ***Fluidity*** | | | | | |
| **Freezing point, degrees Celsius** | **max** | **-40 Jet A** | **-69** | **-51** | **D 5972, D 7153, D 7154, or D 2386** |
| | | **-47 Jet A-1** | | | |
| ***Combustion*** | | | | | |
| **Net heat of combustion, MJ/kg** | **min** | **42.8** | **43.5** | **43.2** | **D 4529, D 3338, or D 4809** |

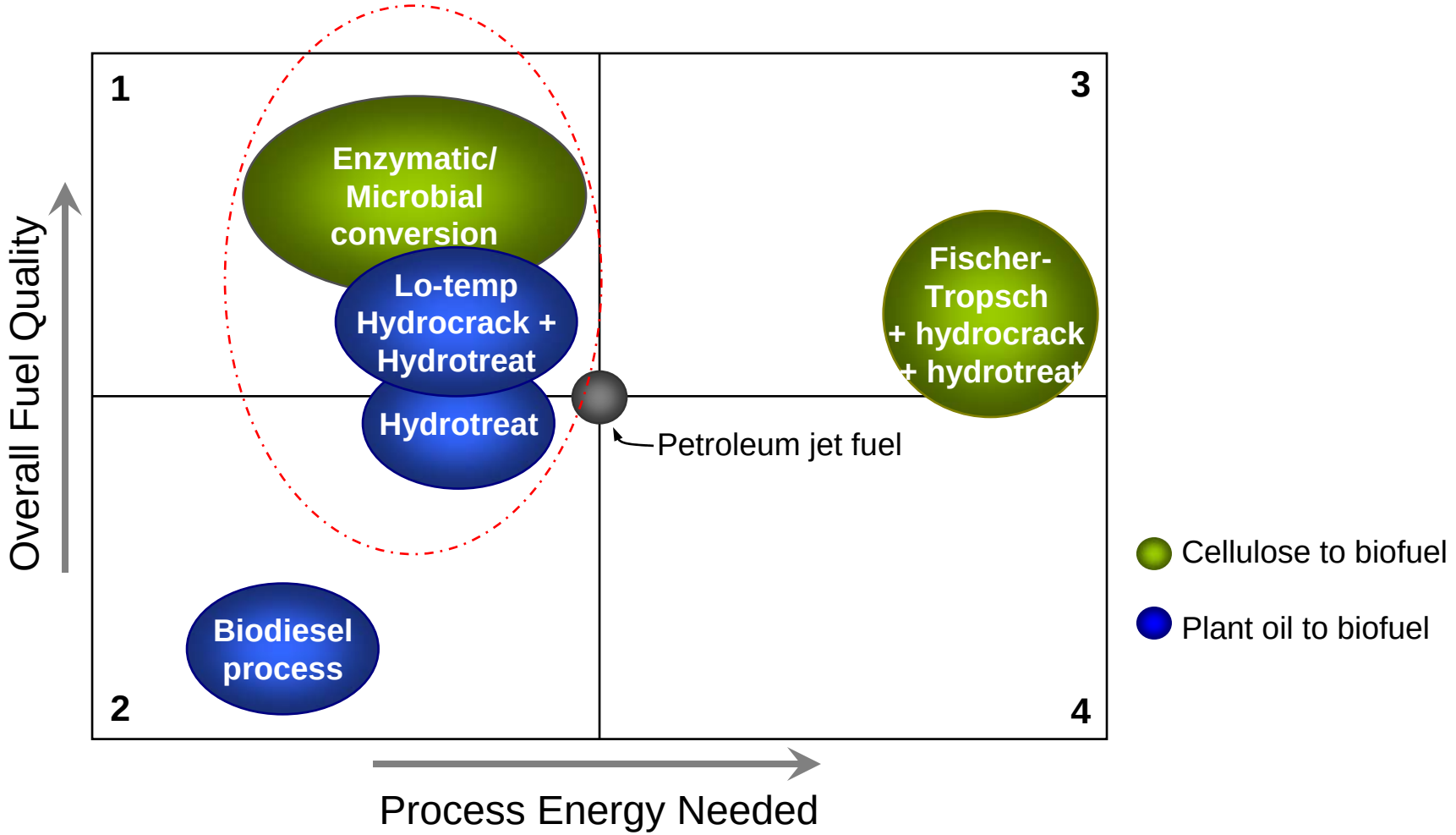
30 degrees F colder flow

Nearly 2% more energy dense than petroleum

# Sustainable biofuels work in existing aviation infrastructure

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

# Sustainable, scaleable and affordable processing methods exist




*Boeing is focused on accelerating the viability of options in Quadrant 1*

# So What Should We Do Now?

**Continue collaborations focused on accelerating commercial markets for sustainable aviation fuels**

- **Specific collaborative groups (e.g. Aviation Fuels Alliance)**
- **Accelerate methodology & definition of LCA & Sustainability Assessments**
- **Accelerate real public & private investments in real projects**

# Boeing Commercial Airplanes is committed to the environment

***www.newairplane.com/environment***