Biofuel uses – what are the prospects for aviation and shipping?

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IEA Bioenergy Task 39
(Liquid biofuels)

Task 39 IEA Bioenergy

UBC

Forest Products Biotechnology/Bioenergy (FPB/B)

IEA Bioenergy Task 39 - objectives

- "To facilitate commercialization of conventional and advanced liquid biofuels from biomass"

www.Task39.org

- Collaboration between 15 countries
  - Ensure information dissemination and R&D collaboration
  - Analyze biofuel technology, policy, and markets (e.g. reports)
  - Three Newsletters per year

TECHNICAL ANALYSIS

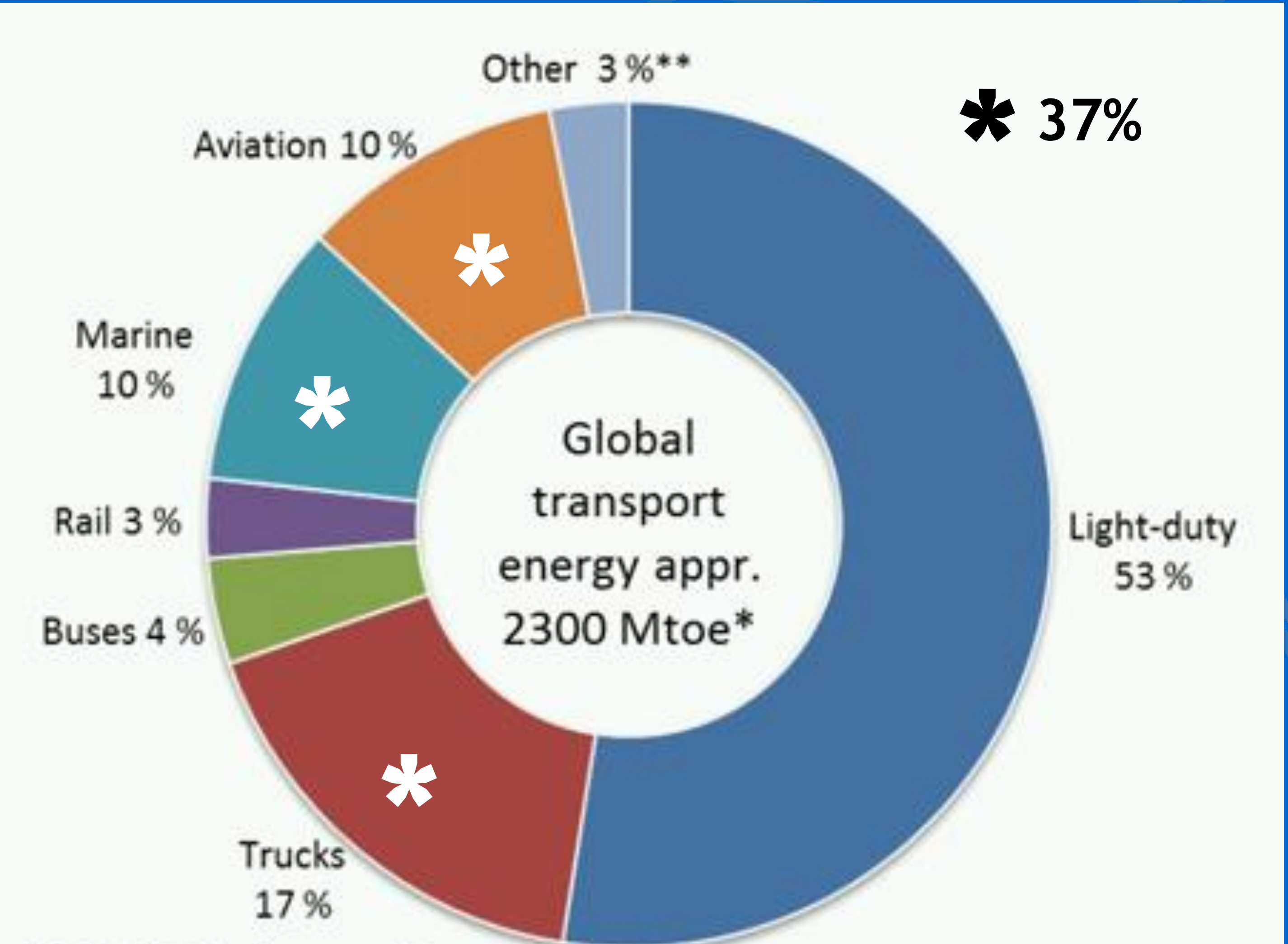
POLICY AND IMPLEMENTATION

Catalyze Cooperative Research → State of Technology & Trends → Policy, Markets → Deployment and Information Sharing

“Long Distance Transportation” sectors unique dependence on drop-in biofuels

- Cannot use ethanol or biodiesel
- Cannot be electrified: too long distance, too large batteries
- New environmental regulations: e.g. GHG & sulfur emissions

Aviation and Marine share of global transportation energy



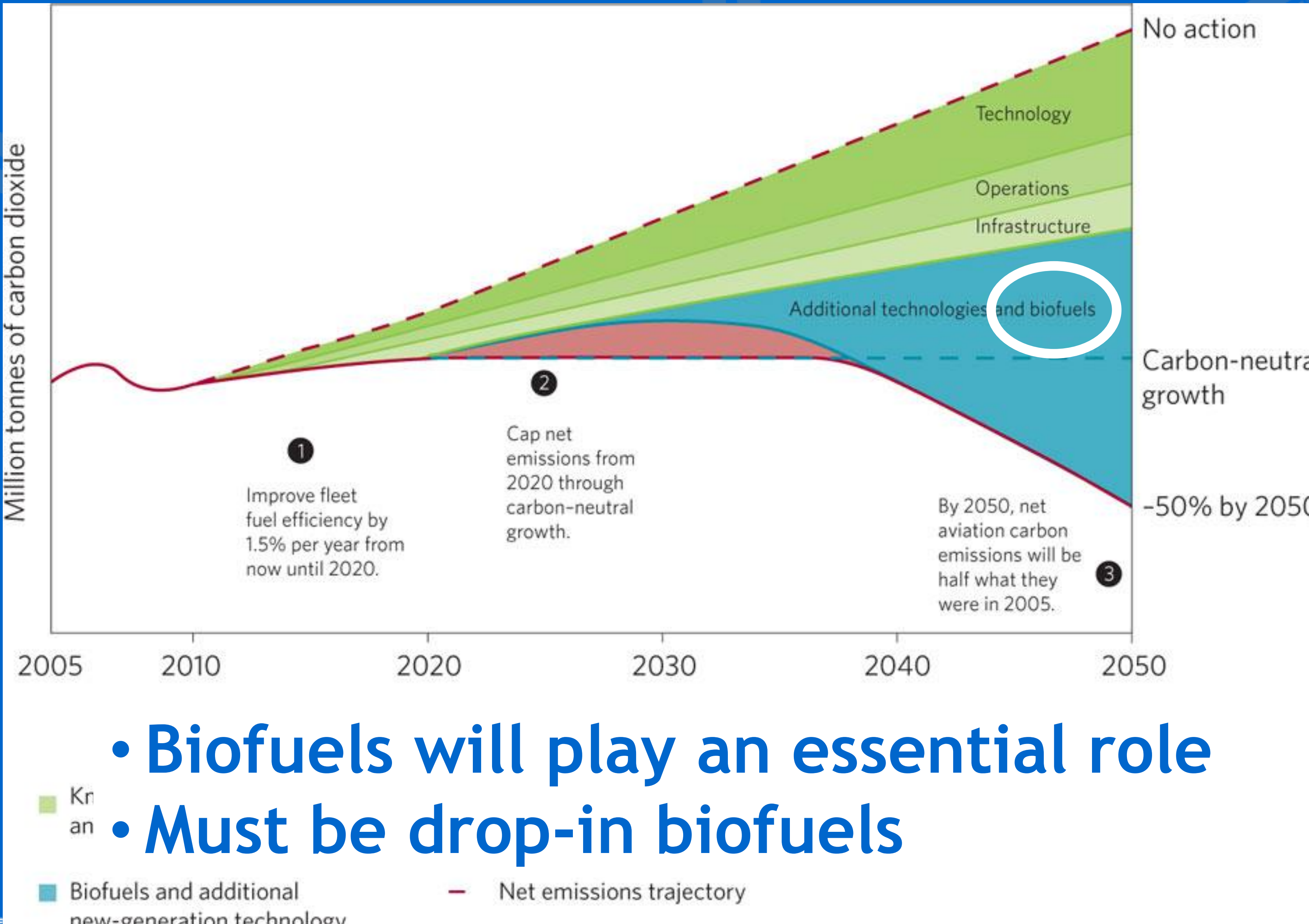
* 2009 ** Includes two and three wheelers.
Data from World Economic Forum 2011 and IEA WEO 2011. Figure by IEA-AMF (A-S 2012).

Background on aviation industry

- Fuel represents ~33% of operational costs
- Aviation responsible for 2-3% of global CO2 emissions (but growing rapidly with growth in Asia and South America)
- Jet fuel has to meet high technical specifications

- Aviation industry interest in biofuels
- Environmental
    - Target for 2020 – carbon neutral growth
    - Target for 2050 – 50% reduction in net CO2 emissions (over 2005 levels)
  - Supply security
  - Price stability

Environmental goals of industry



- **Biofuels will play an essential role**
- **Must be drop-in biofuels**

Air Transport Action Group (ATAG) 2010

Test and commercial flights with biojet

Year	2008	2009	2010	2011	2012	2013	2014
Single (commercia[l]) test flights							a commercial ween Montréal- Airport and eathrow Airport
Series of commercial flights							ercial flight y Bishop Toronto and Ottawa l Airport ches the first intercontinental biojetfuel
Supply chai[n] initiatives							GOL UNITED KLM
							ent (SkyNRG)

1600 flights; 21 airlines
>90% based on oils and fats feedstock (HEFA-SPK) (oleochemical platform)

But currently still a "boutique" supply – small volumes

Source: SkyNRG

ASTM certification of biojet pathways

APPROVED

- Fischer-Tropsch liquids (2009)
- HEFA (2011)
- Synthesized Iso-paraffins (SIP) (previously DSHC) (2014)

Near-term approval

- Alcohol to jet (isobutanol)
- Hydrotreated depolymerized cellulosic jet (HDCJ)

- Commercial volumes of HEFA drop-in fuels (~3 BLY diesel) currently produced and expanding (various feedstocks)

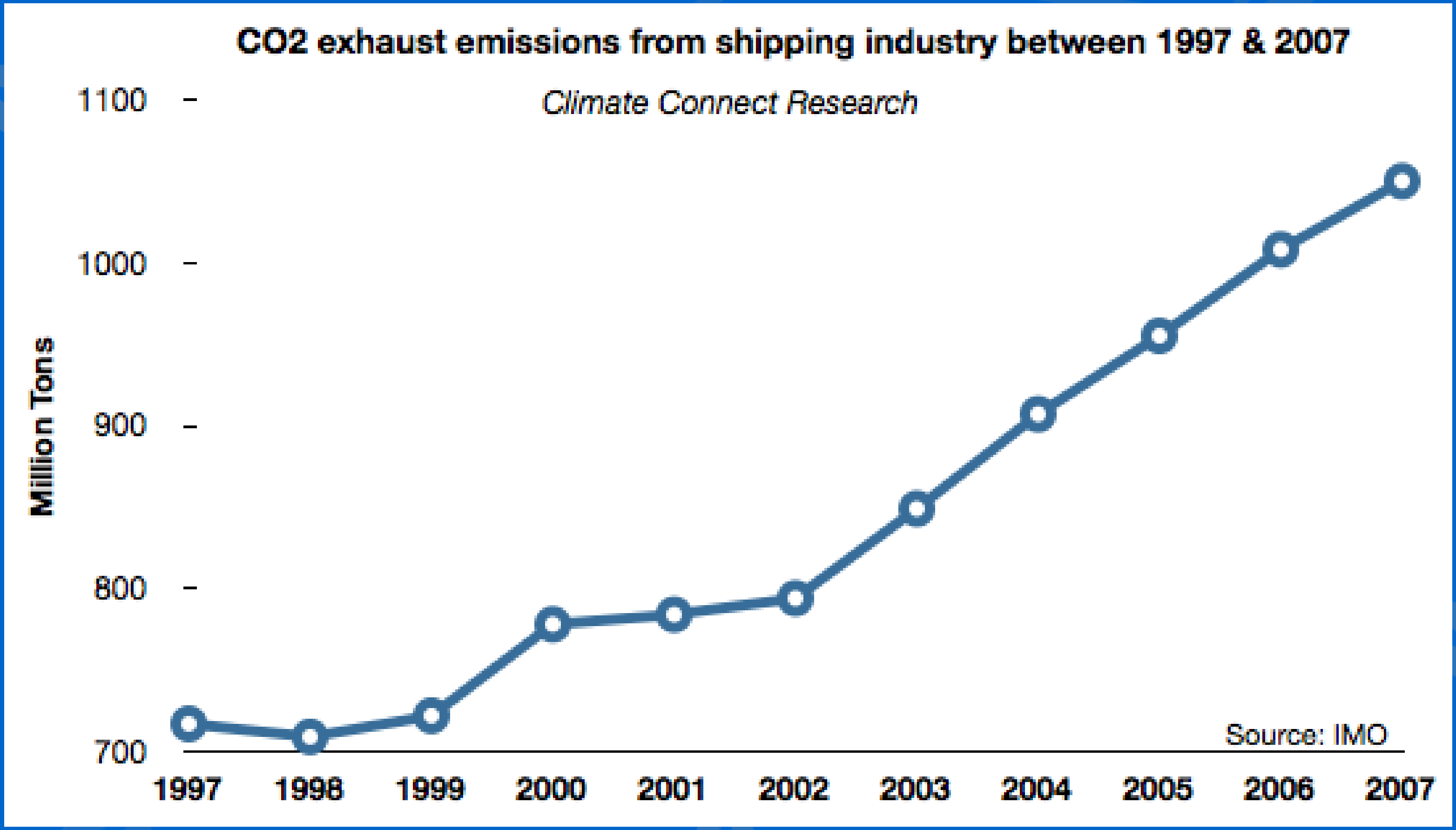
Comparison – aviation vs shipping

- Strict certification process
- Narrow specifications – carbon number (C8-C16), freezepoint, viscosity, aromatic content, energy density
- Extensive processing requirements for biojet
- E.g. synthetic paraffinic kerosene, (FT-SPK, HEFA-SPK)

- Wide range of specifications (very forgiving)
- Limited processing required to make a biofuel
- Many options, e.g. pure vegetable oil, pyrolysis oil, biodiesel, renewable diesel

Shipping industry

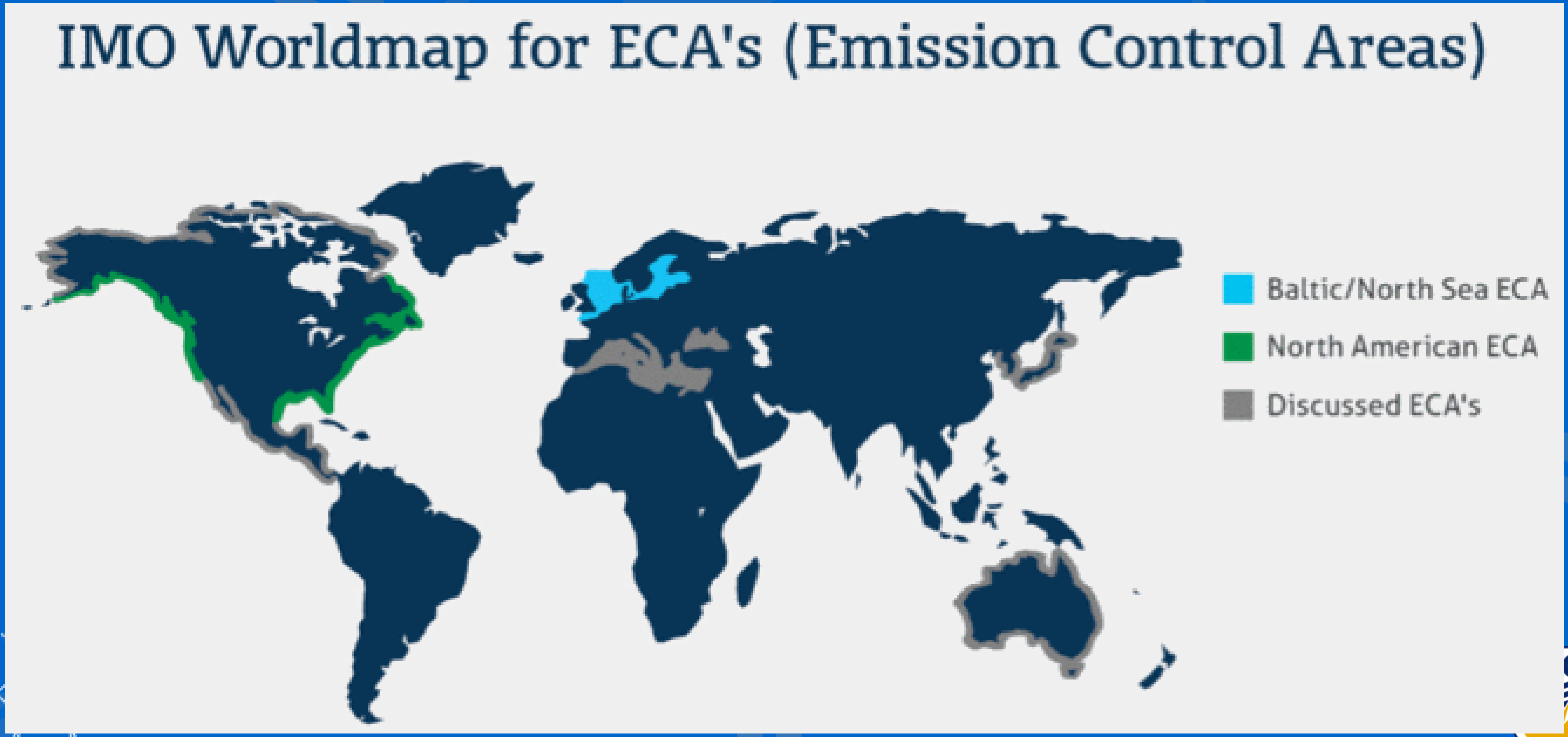
- Cheap, low grade bunker fuel with high emissions



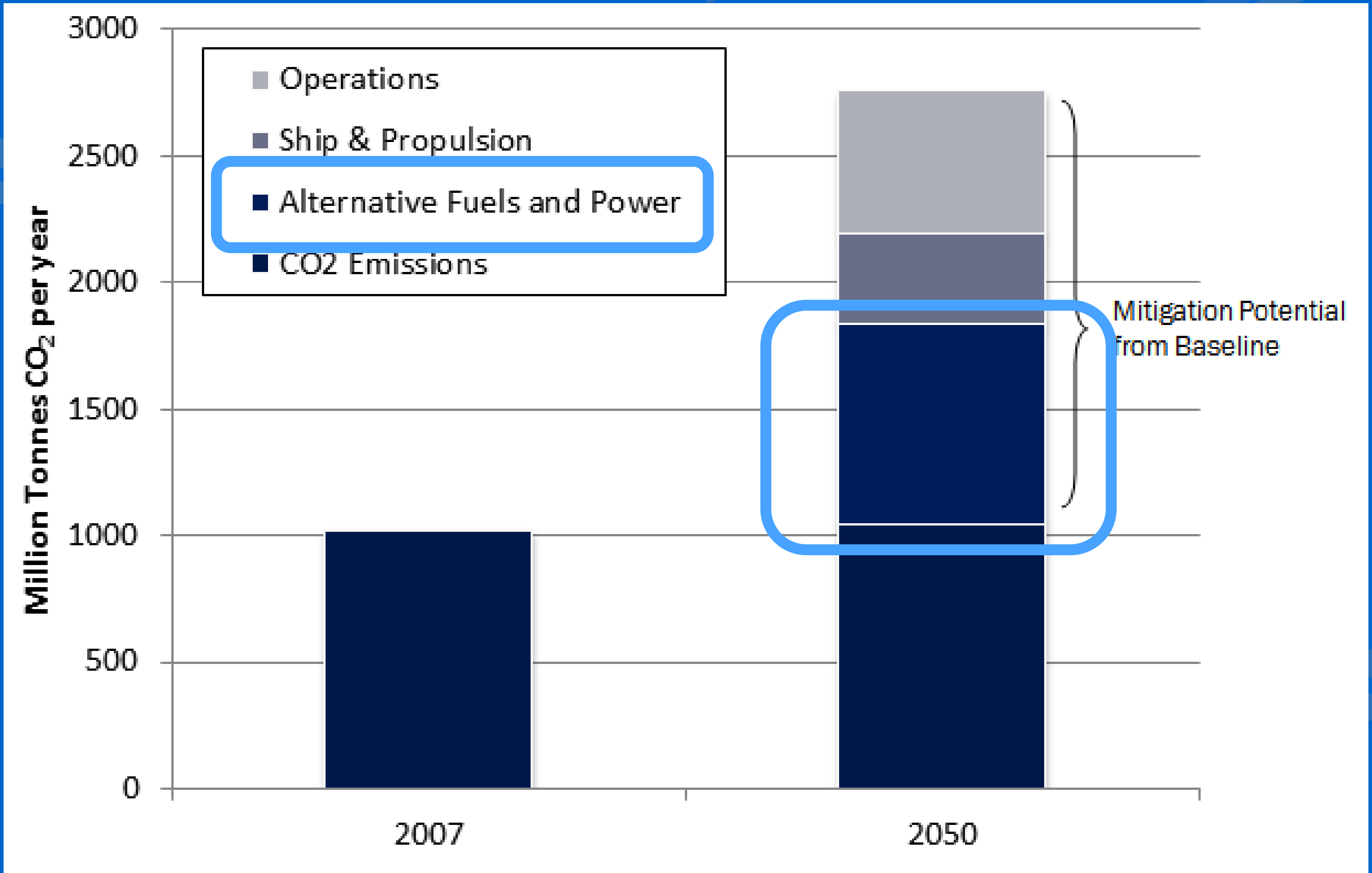
http://www.marineinsight.com/marine/environment/how-the-carbon-credit-trading-system-works-in-the-maritime-industry/

Shipping emission control areas (ECA)

- Introduced through MARPOL Convention (Annex VI Prevention of Air Pollution from Ships - entered into force 19 May 2005)
- Sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts in designated emission control areas



Mitigation potential of biofuels in shipping



http://www.c2es.org/technology/factsheet/MarineShipping

Sustainable marine fuel (further info.)

- Recent reports:
- IRENA (2015) Renewable energy options for shipping
- IEA-AMF. (2013) Annex 41 Report: Alternative Fuels for Marine Applications

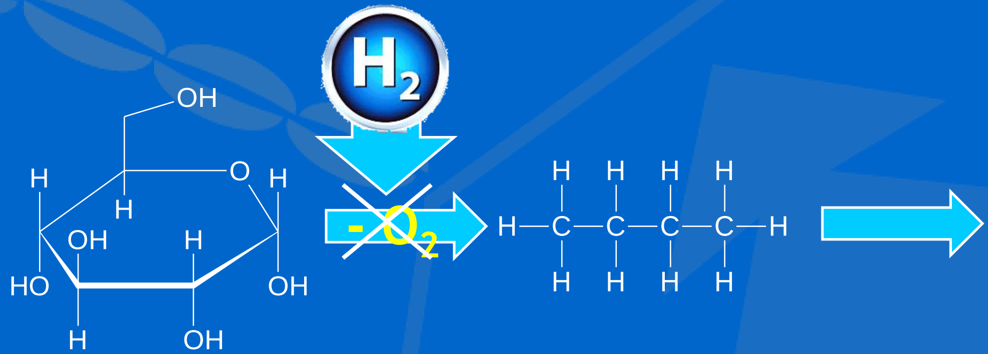
http://goodfuels.com/

Table 2: Current viability of selected biofuels for the shipping sector

	Engine Applications	
	Drop-in fuel	Comment
Diesel cycle	Biodiesel (FAME)	• High availability and variety of feedstock • Land use and food nexus issues for conventional biodiesel production • Standard well-understood specifications • Bio-fouling potential • Requires anti-corrosion seals and components in engine • Suitable for low to medium speed propulsion (e.g. small carriers and cargo ships)
	Straight vegetable oil (SVO)	• Up to 100% replacement possible • Cheap and readily available • High viscosity requires pre-heating • Can be used in dual engines • Suitable for low-speed propulsion of all vessel sizes
	Hydro-treated vegetable oil (HVO)	• Very high quality for shipping • High energy content • Land use and food nexus issues depending on feedstock used • Suitable for medium-speed propulsion of all vessel sizes
	Dimethyl ether (DME)	• High potential • Challenges with stability and storage • Limited availability, but can be produced from ethanol using on-board alcohol to ether (OBAT technology • Requires fuelling infrastructure and anti-corrosion seals and components in engine • Takes up cargo space • Suitable for low-speed propulsion of all types of vessels
	Biomass-based Fischer-Tropsch diesel	• Can use residues for feedstock • Limited availability, depends largely on gasification • Not yet commercially viable • Can be used for medium-speed propulsion of all vessel sizes
	Pyrolysis oil	• Low cost and high availability potential • Corrosive • Low heating value and high viscosity • Difficult to store • Suitable for low-speed propulsion of all types of vessels

Irena shipping report, 2015

The potential and challenges of "drop in" biofuels



Carbohydrate

Hydrocarbon

Sergios Karatzos, Susan van Dyk, Jim McMillan and Jack Saddler

International Energy Agency Bioenergy Task 39 (liquid biofuels)

Forest Products Biotechnology/Bioenergy (FPB/B)

UBC NREL NATIONAL RENEWABLE ENERGY LABORATORY Task 39 IEA Bioenergy

Current biofuels focused on road transportation (www.Task39.org)

- Bioethanol and biodiesel
- Typically used as a blend as it is not the same as gasoline and diesel
- Not readily compatible with infrastructure (except possibly Brazil)

- Drop-in biofuels – only alternative for aviation and shipping

- Drop-in biofuels: are "liquid bio-hydrocarbons that are:
  - functionally equivalent to petroleum fuels and
  - fully compatible with existing petroleum infrastructure"

IEA BioenergyTask 39
'drop in' biofuel report

- OVERVIEW
  - Definition
  - Source of the Hydrogen for drop in biofuels?
  - Supply Chain challenges?
- TECHNOLOGIES
  - Oleochemical (Palm, UCO, Canola, HVO, etc.)
  - Biochemical (Amyris, Gevo, etc.)
  - Thermochemical (Pyrolysis, Gasification)
  - Hybrid

Commissioned reports published by IEA Bioenergy Task 39 (2014)

www.Task39.org

Commercializing Liquid Biofuels from Biomass — Task 39 IEA Bioenergy

Task 39
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The Potential and Challenges of Drop-in Biofuels

A Report by IEA Bioenergy Task 39

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Report T39-T1 July 2014

BiofuelsDigest
The world's most widely read biofuels daily

The Hydrogen Wall: Looking at the prospects for drop-in biofuels

August 11, 2014 | Jim Lane

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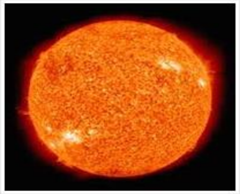
Think affordable, available, sustainable carbon is the biggest barrier to the growth of biofuels?



Envergent Technologies – A Honeywell Company
UOP – A Honeywell Company
ENSYN
NREL – National Renewable Energy Laboratory
NESTE
Pacific Northwest National Laboratory – Proudly Operated by Battelle Since 1965
Enerkem
Borregaard
sundropfuels
Project BioTfueL
CTBE – Brazilian Bioethanol Science and Technology Laboratory
KIT – Karlsruhe Institute of Technology
CHEMREC – Energy to succeed
bioenergy2020+
AMYRIS
SINTEF
gevo
Swedish Energy Agency
solazyme

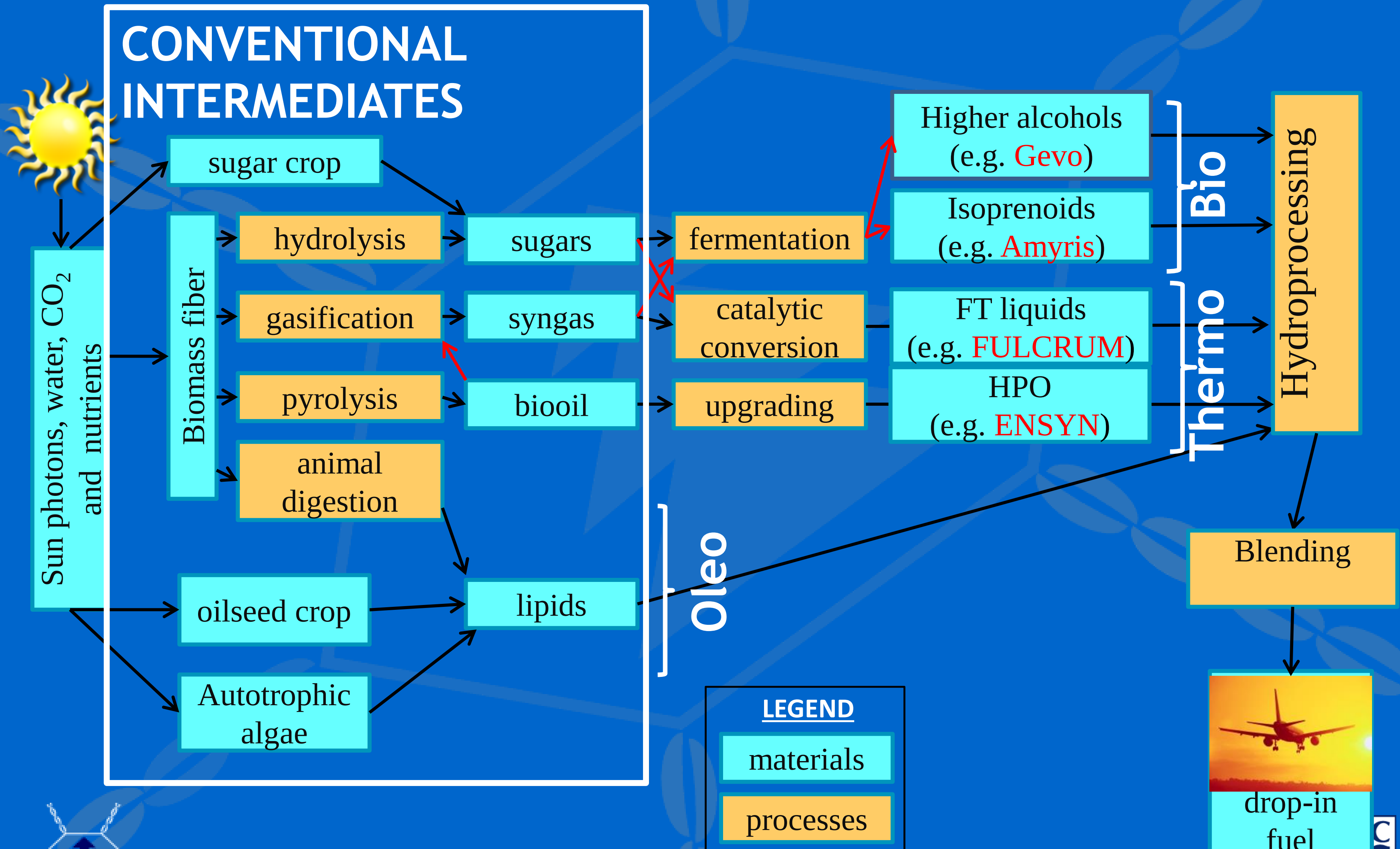
The Hydrogen-Oxygen dilemma of making drop-in biofuels from biomass

- "Drop-in biofuels" contain low or no oxygen content

- Deoxygenation requires hydrogen inputs or "oxidizing/burning" of feedstock carbon

- Lipids have low oxygen and are well suited for drop-in biofuel production

Technology pathways to “drop-in”

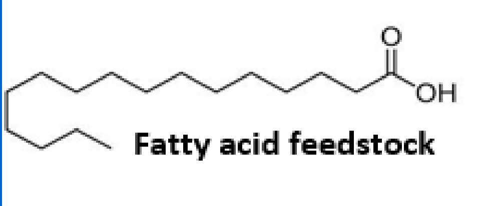


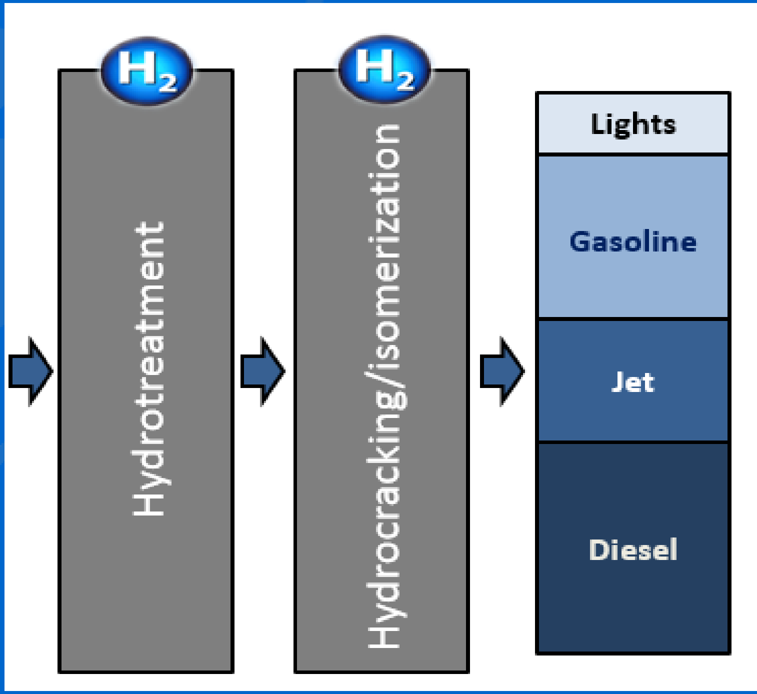
Oleochemical Platform

Hydrotreated Vegetable Oils or HEFAs

Major advantages

- "Simple" technology, low risk (processes already commercial)
  - Bio SPK ASTM certification
- High Hydrogen to carbon ratio (low Oxygen) of Feedstock
  - Palm oil
  - Tallow (rendered animal fat)





Challenges

- Costly feedstock (approx. $500-1000/t)
- Sustainability?

Commercial volumes of drop-in biofuel through oleochemical platform

Neste Oil facility, Rotterdam

- Neste Oil: 2.4 billion L diesel from mixed feedstocks
- Dynamic Fuels: 280 million L diesel from animal fat
- Preem and UPM: 200 million L diesel from tall oil

Summary

- Biofuels in aviation and shipping **have to be "drop-in" fuels**
  Aviation (high spec fuel) versus Shipping (low spec fuel)
- Several technology pathways to make drop-in biofuels (and each with its own challenges)
- Initial supply chains for aviation and shipping likely to be established using oleochemical based production pathway (commercial now and less H_2-dependent with considerable potential for growth; but, feedstock challenges?)
- Accessing cheap/renewable Hydrogen to remove O_2 in feedstocks will be a key challenge in the production of both aviation and shipping biofuels
- The thermochemical pathway will likely supply biofuels in the longer-term, but technology and feedstock challenges remain
  (see Task 39 report for more extensive analysis)

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