The Contribution of Advanced Renewable Transport Fuels to **Transport Decarbonisation** in 2030 and beyond

IEA Bioenergy

European Commission

Technology Collaboration Programme on Advanced Motor Fuels

Technology Collaboration Programme by iea

Biofuels; state of the art and perspective towards 2030

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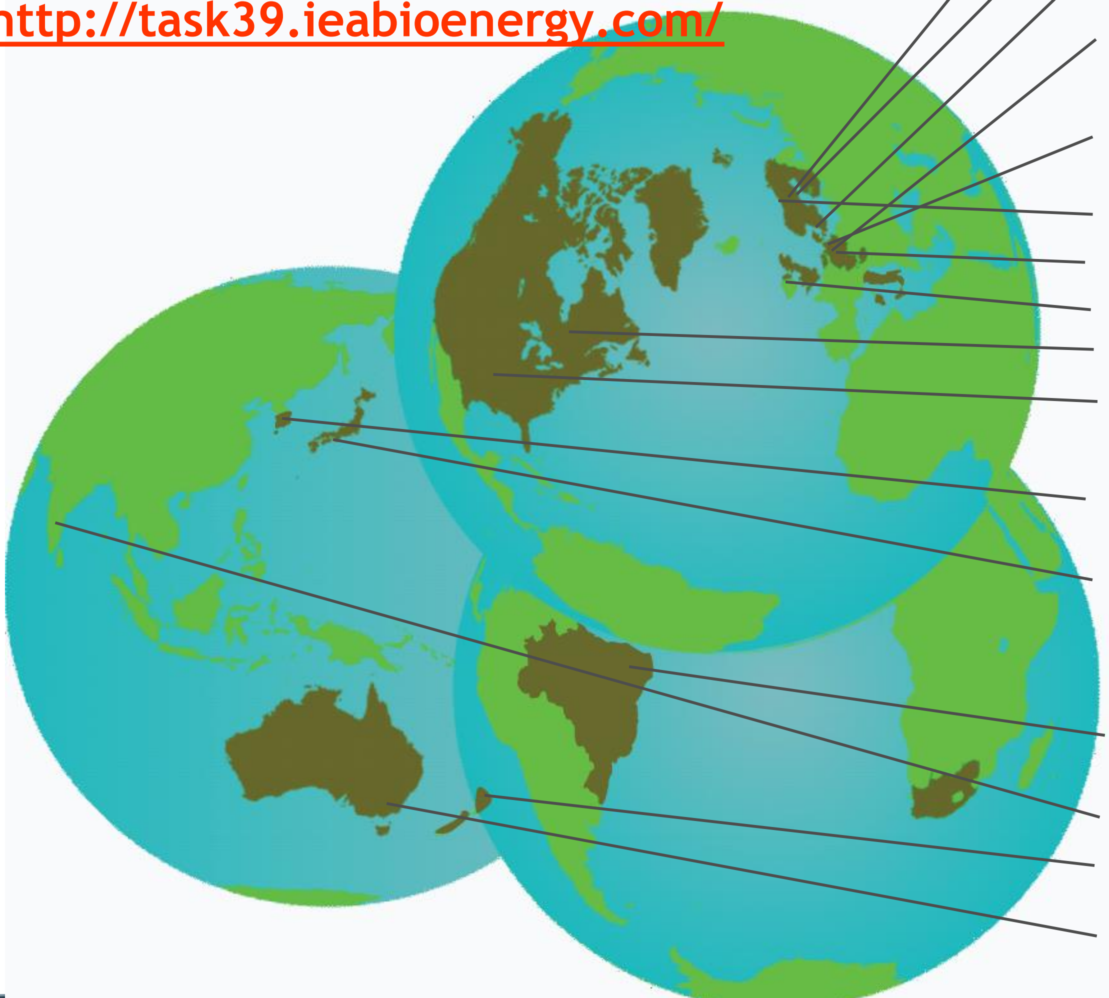
IEA Bioenergy Task 39
The University of British Columbia/NREL

Transport Decarbonisation Workshop
18 November 2019
Brussels, Belgium

IEA Bioenergy Task 39
Transport biofuels focus
16 member countries 2019-2021

http://task39.ieabioenergy.com/



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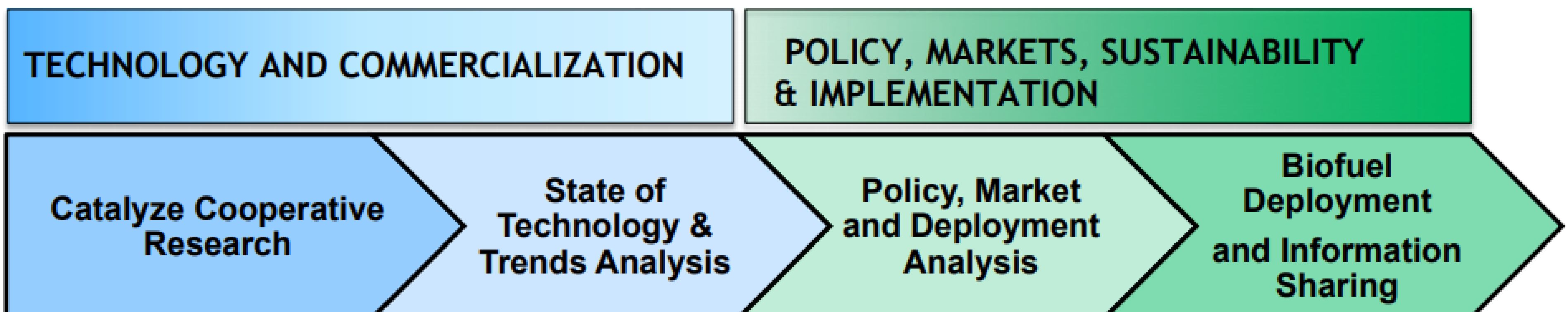
IEA Bioenergy Task 39 - Scope and Objectives

Commercializing Conventional and Advanced Transport Biofuels from Biomass and Other Renewable Feedstocks

(www.Task39.org)

- Collaboration between 16 member countries
- Analyze policy, technology and markets and sustainable biofuel implementation
- Focus on **Technical** and **Policy** issues
- Catalyze cooperative research and development
- Disseminate information & outreach with/to engage stakeholders



Terminology (Confusing!)

- "Conventional" biofuels
  - Ethanol from sugar/starch (e.g. sugarcane, corn, sugar beet and wheat)
  - Biodiesel from Oleochemicals/lipids (Fatty acid methyl ester (FAME))
- "Advanced" biofuels
  - Cellulosic ethanol (1.5G and 2G), Oleochemicals/lipids from Algae Biomethane/RNG, Green Hydrogen, etc.
- "Conventional" drop-in biofuels, via oleochemical/lipid feedstocks
  - Hydrotreated esters and fatty acids (HEFA), Hydrotreated vegetable oil (HVO), Hydrogenation-derived renewable diesel (HDRD), renewable diesel, "green" diesel, etc. (Low CI, UCO/Tallow/Tall Oil; Higher CI, Palm, Rape, etc.)
- "Advanced" drop-in biofuels, via biomass feedstocks
  - Production of biocrude liquid intermediates from lignocellulosic feedstocks (sometimes algal oils) and upgraded via standalone biorefineries or by co-processing in existing oil refineries
  - Alcohol-to-Jet, Sugar-to-Jet, Gasification-followed-by-Fisher-Tropsch, etc.

Highly probable that fossil derived transportation fuels will (always?) be cheaper than "renewable fuels". Therefore, the "right policies" are very important.

On what basis has, and will, biofuels use be assessed?

- Volumetric?
- Energy Content?
- Reduction in Carbon Intensity (CI)?

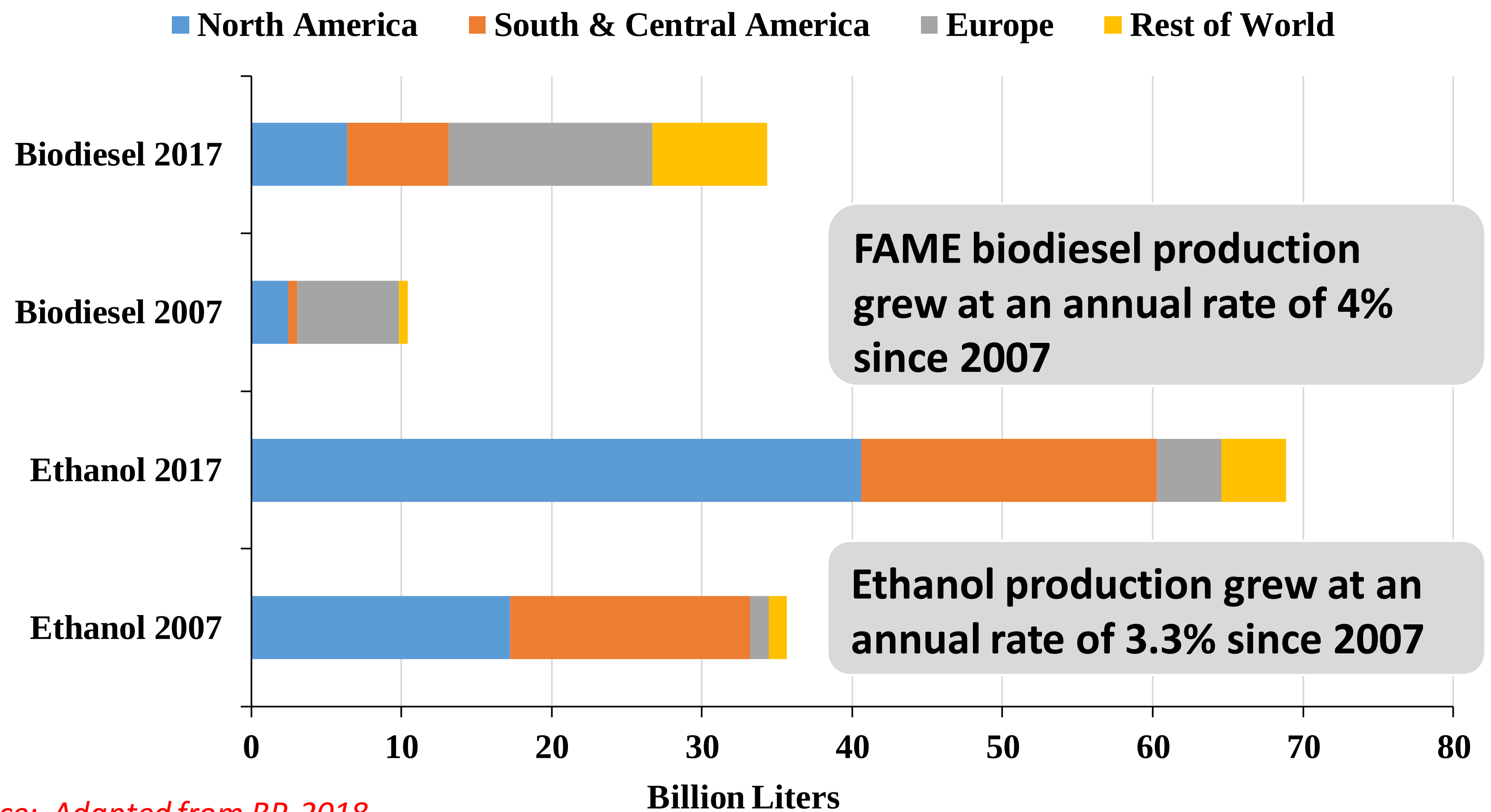
What policies have been used so far to develop biofuels?

- Market pull?
- Technology/R&D push?

What policies will "incentivize" the oil sector and make more use of the fuel distribution network?

- Carbon Intensity (i.e. LCFS)

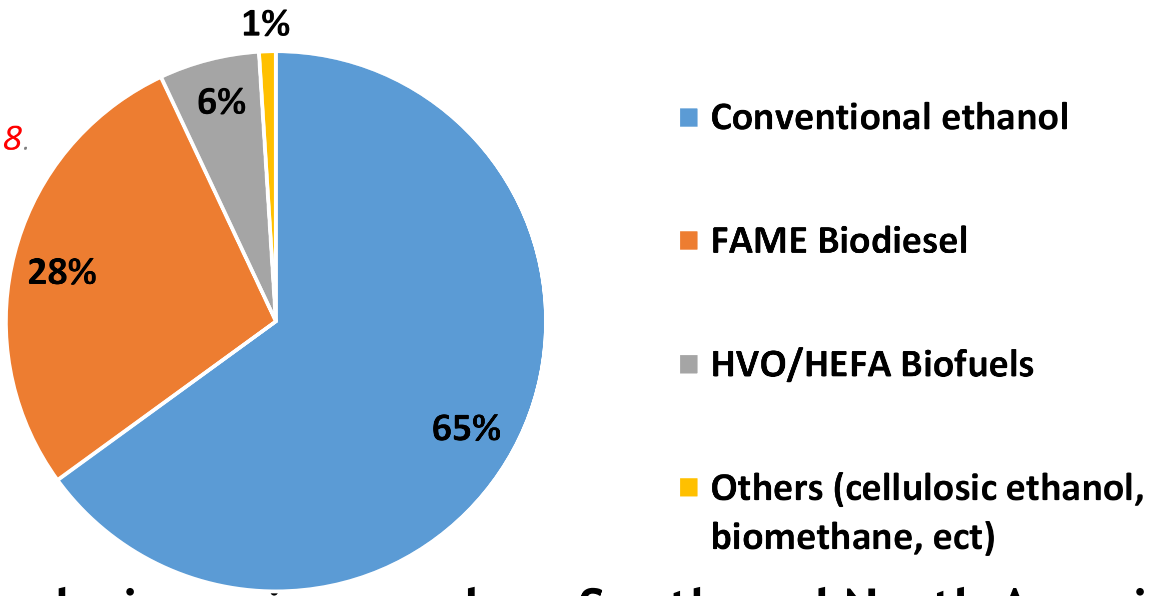
Blending mandates will continue to drive the growth of "conventional" biofuels



Source: Adapted from BP, 2018

Global Biofuel production (in energy terms) in 2017

Source: REN21, 2018; BP, 2018.



- Abundant feedstocks in regions such as South and North America means that conventional biofuels are expected to continue dominate the biofuels market in the short-to-mid term.

- However, increased production of HVO/HEFA biofuels (drop-in biofuels) is anticipated: concerns over “sustainability”, biofuel policies increasingly focusing on carbon intensity (CI) and increasing involvement of petrochemical sector

There is still considerable room to increase the "conventional" biofuels market, but by how much?

Opportunities

- Potential increases in ethanol (15% in the US and 27+% in Brazil) and biodiesel blends (10+% in Brazil)
- National policies in Brazil (RenovaBio), Canada (Clean Fuel Standards), etc.
- Growth in other regions: China, India, Thailand, Indonesia, etc.?

Challenges

- EU's REDII, limits on "food derived fuels"
- "Food security" concerns in Japan and China
- Policy confusion/uncertainty
- Food vs Fuel (rather than Food & Fuel)

Biofuel policies, market pull the primary driver of "conventional" biofuel production and use

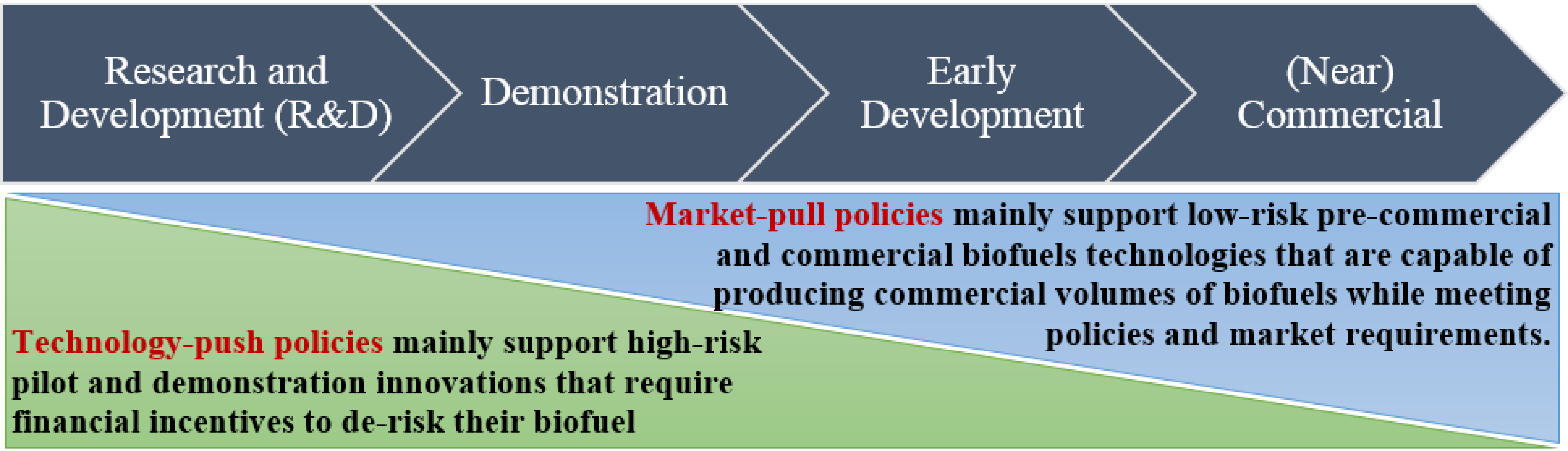
- Biofuel blending mandates (still the primary policy tool)
  - Effective tool to establish biofuels markets but not necessarily successful in expanding markets
  - Not necessarily successful in meeting GHG reduction targets
  - However, will continue to be one of the primary policy tools in the short-to-mid term for the production/use of conventional biofuels.

- Fuel/CO_2 excise reductions/exemptions or zero tariff
  - Mainly used to make the production of biofuels economically competitive with fossil fuels in the short-to-mid term
  - However, as biofuel production is becoming more cost efficient and if the price of oil gradually rises, the fuel excise reduction/exemption incentive is either modified or lifted.

"Conventional" biofuels: GHG emission reduction potential

- Transitioning to using heat and/or electricity from renewable sources such as hydroelectricity, co-gen, biogas/renewable natural gas in biofuel plants
- Development of "bolt-on" technologies converting corn kernel fibre coproducts into cellulosic ethanol, reusing or selling CO_2, etc. (driven by policies such as the LCFS)
- Many existing biodiesel facilities already using "waste lipids" (UCO, tallow, etc.). However, limited supply will likely result in need to use higher CI lipid/oleochemical feedstocks, resulting in higher CI biodiesel
- Feedstock is the challenge (cost, availability, CI, etc.) not the conversion technology.

Advanced Biofuels:
We need both technology-push & market-pull policies to increase their production and use



Balanced mixture of policy efforts: Market-pull and Technology-push.

Results in the Development, Deployment and Growth of advanced biofuels.

Production of "advanced" biofuels: not progressing as initially hoped

- Global production capacity of advanced biofuels at the end of 2015 was estimated to be 850 million liters per year
- Planned capacity expansions might add about 1.5 million liters of new capacity per year, with initiatives underway in Brazil, China, Canada, France, the Netherlands, Sweden, the United Kingdom and the US.
- The majority of existing capacity is for cellulosic ethanol (1.5G and 2G), produced in the US, Brazil and EU.
- However, biomethane has been mainly produced in the US (17.4 PJ) and the EU (Sweden and Germany) (6.1 PJ). The largest market for biomethane is the US, when (in 2015) biomethane was included in the "cellulosic biofuels" category of the RFS2 program.

Pioneering 2G cellulosic ethanol plants- Shutdown/Sold/Slow/Ongoing progress

BiofuelDigest, 2016, UPM, 2016; Clariant, 2019.

Abengoa
Hugoton, KS

POET-DSM
Emmetsburg, IA

Raizen
Costa Pinto, Brazil

Enerkem
Edmonton, Alberta

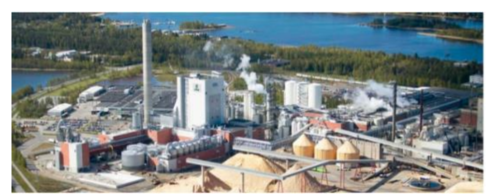
Clariant
Straubing, Germany

DuPont
Nevada, IA

IneosBio
Vero Beach, FL

GranBio
Alagoas, Brazil

Beta Renewables
Crescentino, Italy



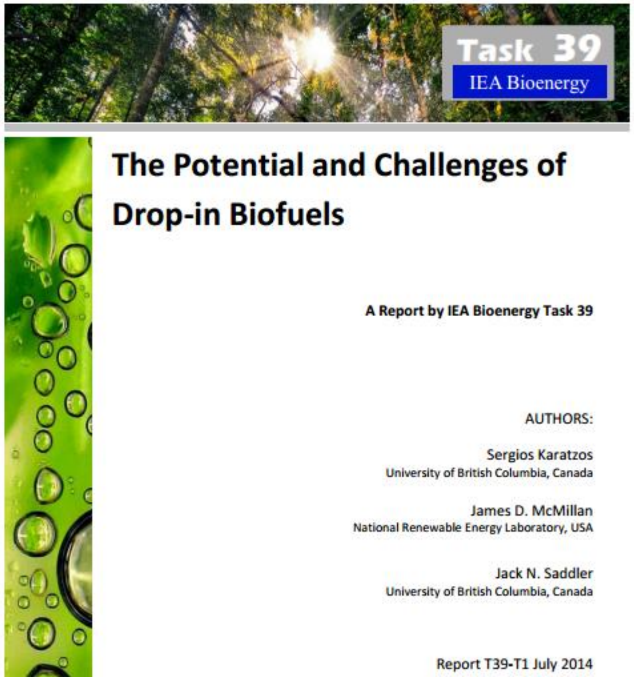
St1
Pietarsaari, Finland

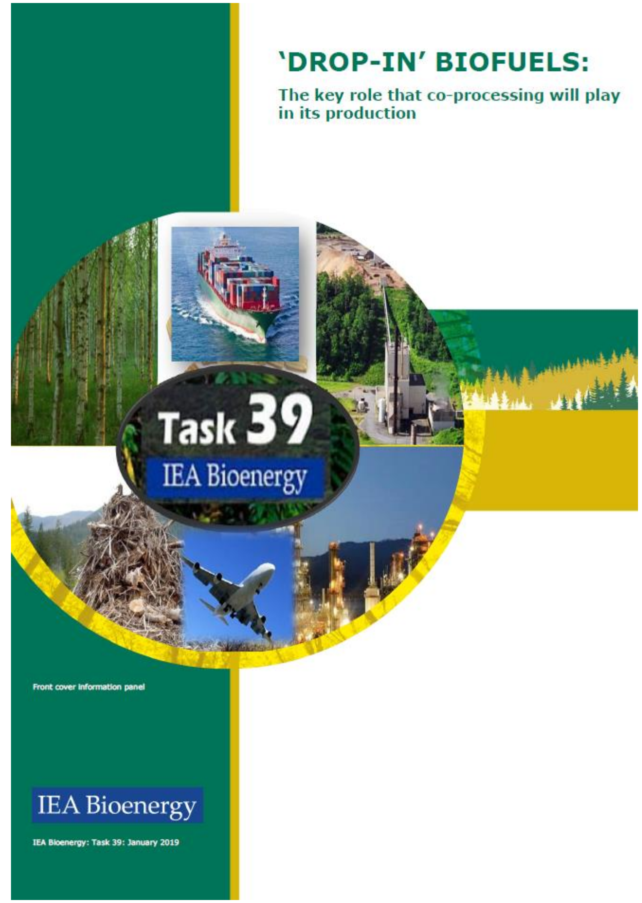
Some producers of advanced/cellulosic ethanol

- Ethanol production from corn fiber (Generation 1.5) has become an area of active R&D and commercialization in the US since 2014, when the EPA classified corn kernel fiber as a crop residue (Seven corn ethanol plants approved to produce cellulosic ethanol from corn kernel fiber).
- POET-DSM, US: using corn stover
- Granbio & Raízen, Brazil: using bagasse and sugarcane residues
- Clariant, Demo plant (Germany), commercial plant (Romania): using wheat straw
- Praj Biofuels, Demo plant (India): using bagasse and sugarcane residues
- ST1, Demo/Commercial plant (Finland): using sawdust
- However, need to add value from co-products, lignin/hemicellulose, etc.

Drop-in biofuels reports (2014 & 2019)

www.Task39.org





Definition of "drop-in" biofuels

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

Most commercial volumes of drop-in biofuel produced via the "conventional"/oleochemical platform, in dedicated facilities

Neste Oil facility, Rotterdam

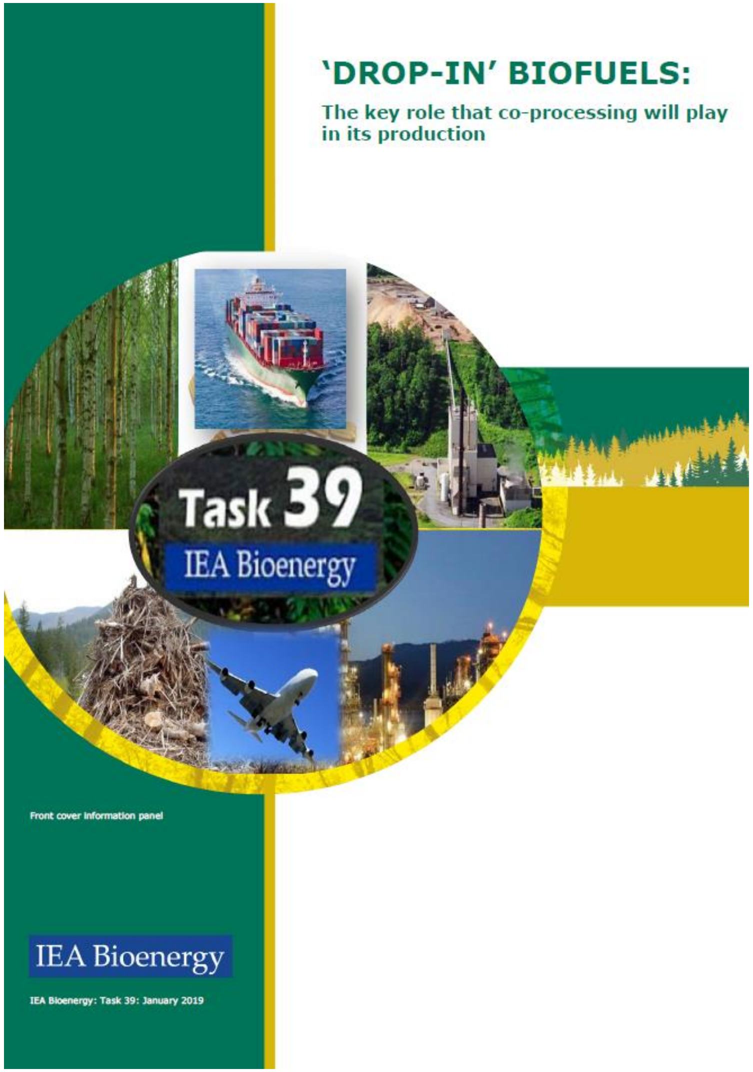
world energy

Company	Location	Feedstock	Capacity
Neste	Rotterdam	Vegetable oil, UCO and animal fat	1.3 bn L/y
Neste	Singapore	Vegetable oil, UCO and animal fat	1.3 bn L/y
Neste	Porvoo, Finland	Vegetable oil, UCO and animal fat	385 m L/y
Neste	Porvoo 2, Finland	Vegetable oil, UCO and animal fat	385 m L/y
ENI	Venice and Gela, Italy	Vegetable oils, UCO and animal fat	1 bn L/y
Diamond Green Diesel	Norco, Louisiana	Vegetable oils, animal fats and UCO	1 bn L /y
UPM	Lappeenranta, Finland	Crude tall oil	120 m L/y
World Energy (AltAir)	Paramount, California	Non-edible oils and waste	150 m L/y
Renewable Energy Group	Geismar, Louisiana	High and low free fatty acid feedstocks	284 m L/y
Total	LA MÈDE	UCO and vegetable oils	641 mL/y

Growth in drop-in biofuels being driven by polices e.g. LCFS & markets, such as aviation & marine

Low Carbon Fuels Standard

- Fuel-agnostic, with credits or deficits generated based on the carbon intensity (CI) of the particular fuel
- Proven to be a successful tool to decarbonize the transportation sector by encouraging the reduction of carbon intensity of all renewable fuels, especially biofuels
- Proven to be successful in encouraging the production and use of low-carbon intensive drop-in biofuels and advanced biofuels by increasing their market values
- California and British Columbia are at the forefront of the implementation of this policy



'DROP-IN' BIOFUELS: The key role that co-processing will play in its production

Executive Summary and full report available from the Task 39 website www.Task39.org

Review

Biofpr Biofuels Bioproducts & Biorefining

Potential synergies of drop-in biofuel production with further co-processing at oil refineries

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View online at Wiley Online Library (wileyonlinelibrary.com);
DOI: 10.1002/bbb.1974; *Biofuels. Bioprod. Bioref.* (2019)

Abstract: Drop-in biofuels have been defined as functionally equivalent to petroleum-based transportation fuels and are fully compatible with the existing petroleum infrastructure. They will be essential in sectors such as aviation if we are to achieve emission reduction and climate mitigation goals. Currently,

Production of "conventional" and "advanced" drop-in biofuels through co-processing

- Possible to leverage existing petrochemical/refining infrastructure to produce low-carbon intensive, drop-in biofuels.
- Approximately 40 refineries around the world have implemented or are assessing the possible co-processing of biogenic feedstocks at levels ranging from 2-30 vol%.
- A variety of insertion points are possible
  - Fluid Catalytic Cracker (FCC), Hydrotreater, Hydrocracker.
- However, co-processing "biocrude" feedstocks likely more challenging
- Refinery co-processing can:
  - reduce investment cost of freestanding biorefineries
  - Produce lower carbon intensity fuels
  - Improve properties of final fuels e.g. lower sulfur

Technology Challenges in producing Advanced Biofuels and Advanced drop-in Biofuels

- The major challenge in producing advanced and advanced drop-in biofuels is the recalcitrance and heterogeneity of the biomass substrate

- Relative ease of conversion of sugar, starch, oleochemical/lipids means these sources will continue to predominate, increasing CI emphasis

- Production of conventional drop-in biofuels from oleochemicals will predominate in producing low-carbon intensive drop-in biofuels (used by the long distance transport sector).

- Ongoing pressure to "decarbonise" will encourage the oil and gas sectors increasing involvement. Co-processing will also contribute to the production of drop-in biofuels but challenges in qualifying the biogenic content of the final fuels and securing enough biogenic feedstock for even 5-10 vol% blends.

Policies will continue to be essential

- **Market pull: Biofuel blending mandates**
  - They are expected to stay as one of the primary policy tools in short-mid terms to encourage the production and use of conventional biofuels.

- **Technology push: R, D & D investments**
  - Needed to diminish the risk of building "pioneering" and demonstration plants, establishing markets for co-products, etc.

- **Increasing use of policies such as LCFS (reducing CI)**
  - Relative success of LCFS policies in California and British Columbia, encouraging related policies in other jurisdictions (e.g. Canada Clean Fuel Standard and Brazil RenovaBio).
  - Likely that, in the mid-to-longer term, many biofuel policies will be modified to accommodate LCFS type policies in their compliance programs.

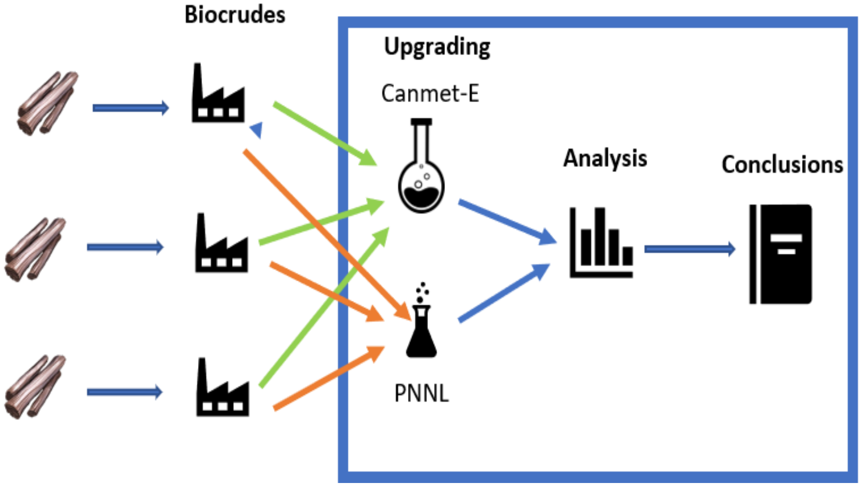
Conclusions

- Conventional biofuels (ethanol/biodiesel) will dominate in the short-to-mid term, driven mainly by blending mandates.
- Future biofuels growth will predominantly occur in Latin America and non-OECD Asian countries, with other “motivators”, such as increasing rural development and energy security, playing a significant role.
- Despite the ongoing predominance of conventional biofuels, policies that encourage the production of low carbon intensity biofuels will grow
- Other factors, such as the increasing engagement of the oil-and-gas sector, will encourage the production of HVO/HEFA biofuels (drop-in biofuels) with sustainability, technology readiness and policies such as the LCFS enhancing low CI biofuels production from wastes and residues.
- The production of both advanced biofuels and advanced drop-in biofuels will require considerable policy support. On-going technical challenges

ATM Project- Assessment of likely Technology Maturation pathways to produce biojet from forest residues

(posted on www.Task39.org, NORAM Engineering Press Release)

- Source biocrudes from three different technology providers: BTG (the Netherlands), VTT (Finland), Aarhus University (Denmark)
- Upgrading of bio-oil; characterization of biojet & other fractions (CANMET and PNNL)
- Feedstock supply chain logistics and feasib
- Life cycle assessment
- Biocrude production, performance and techno-economics;
- Demonstration plant concept and design



Thank you! Questions?

IEA Bioenergy Task 39 (www.Task39.org)

- "To facilitate commercialization of conventional and advanced transportation biofuels"
  - Analyze policy, markets and sustainable biofuel implementation
  - Focus on Technical and Policy issues
  - Catalyze cooperative research and development
  - Ensure information dissemination & outreach with stakeholders

TECHNOLOGY AND COMMERCIALIZATION

POLICY, MARKETS, SUSTAINABILITY & IMPLEMENTATION

- Catalyze Cooperative Research
- State of Technology & Trends Analysis
- Policy, Market and Deployment Analysis
- Biofuel Deployment and Information Sharing

The Contribution of Advanced Renewable Transport Fuels to **Transport Decarbonisation** in 2030 and beyond

More information: https://iea-amf.org/content/news/TD-WS

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