AVIATION CO_2 REDUCTIONS

ONLINE STOCKTAKING PREVIEW

28 APRIL 2020

OPPORTUNITIES FOR RENEWABLE ENERGY

IRENA
International Renewable Energy Agency

Francisco Boshell

Analyst in Markets and Standards
for renewable energy technologies

Toshimasa Masuyama

Bioenergy Analyst

IRENA

- **Established in 2011**
- **161 Members + 22 States in accession**
- **Mandate:** to promote the **widespread adoption and sustainable use of all forms of renewable energy**

BIOENERGY | GEOTHERMAL ENERGY | HYDROPOWER | OCEAN ENERGY | SOLAR ENERGY | WIND ENERGY

Energy demand in the transport sector must become more efficient and more renewable

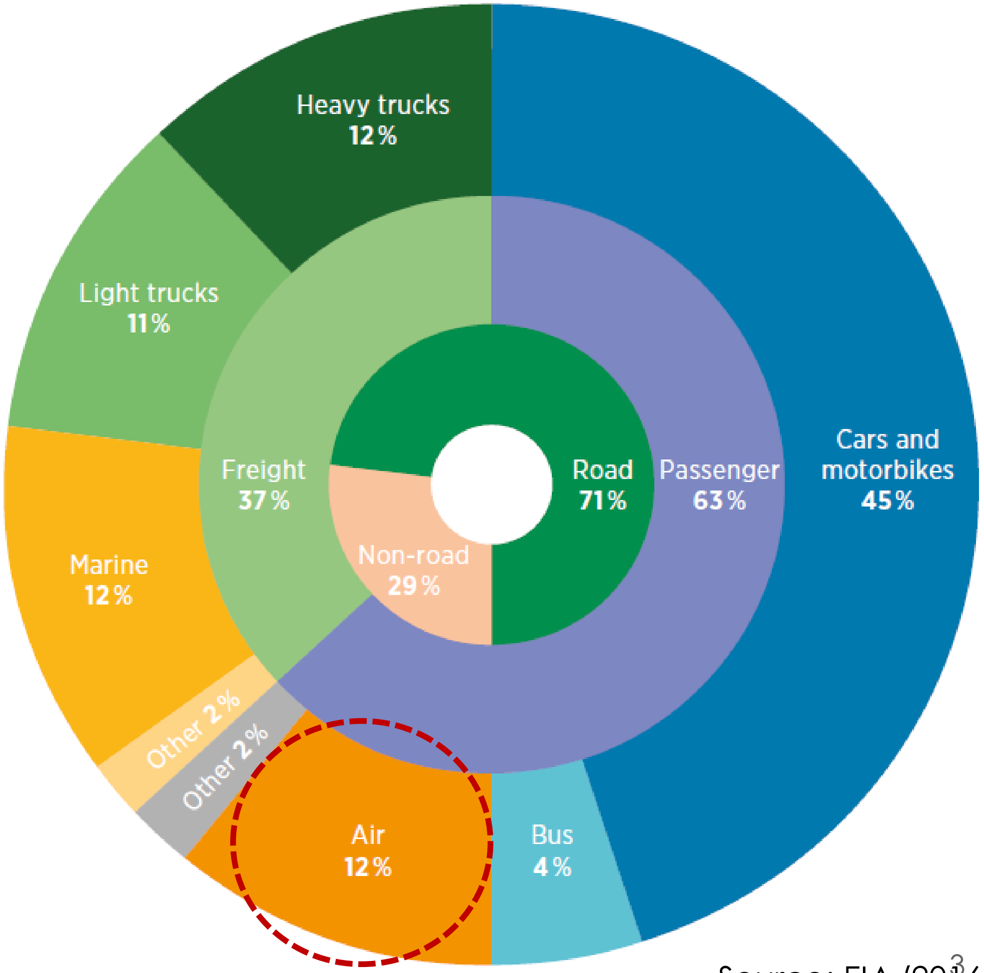
IRENA International Renewable Energy Agency

ICAO | STOCKTAKING 2020

Aviation Sector

- Passenger aviation activity will more than triple even in IRENA's climate friendly scenario
- Aviation as a country would be the eighth largest emitter of greenhouse gases in the world
- Air transport was responsible for 12% of global energy consumption in transport sector in 2016 – 920 Mt CO_2 for all domestic & international flights

Disaggregation of global energy consumption on the transport sector



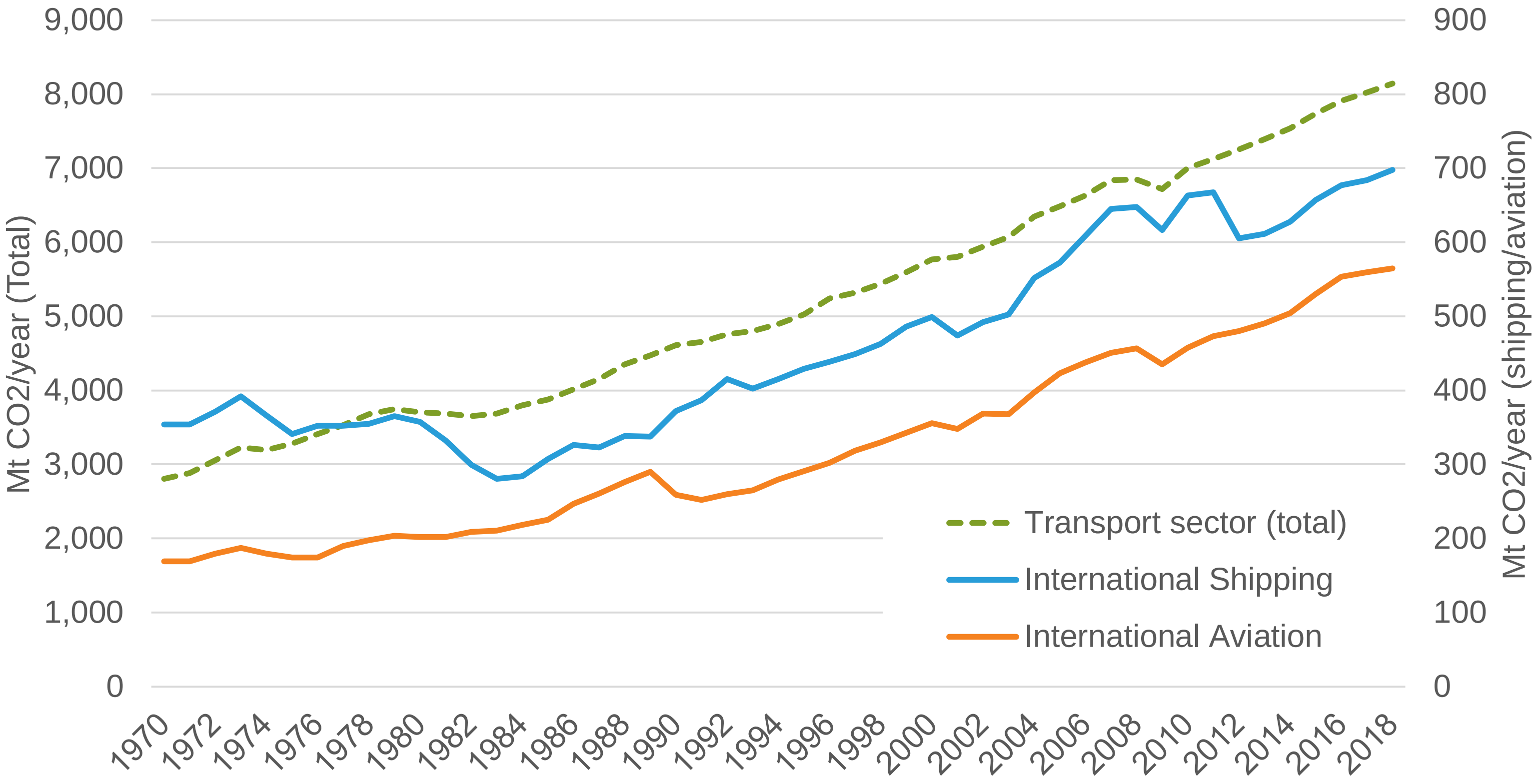
Source: EIA (2016)

Annual CO2 emissions from international aviation and shipping on the rise

IRENA International Renewable Energy Agency

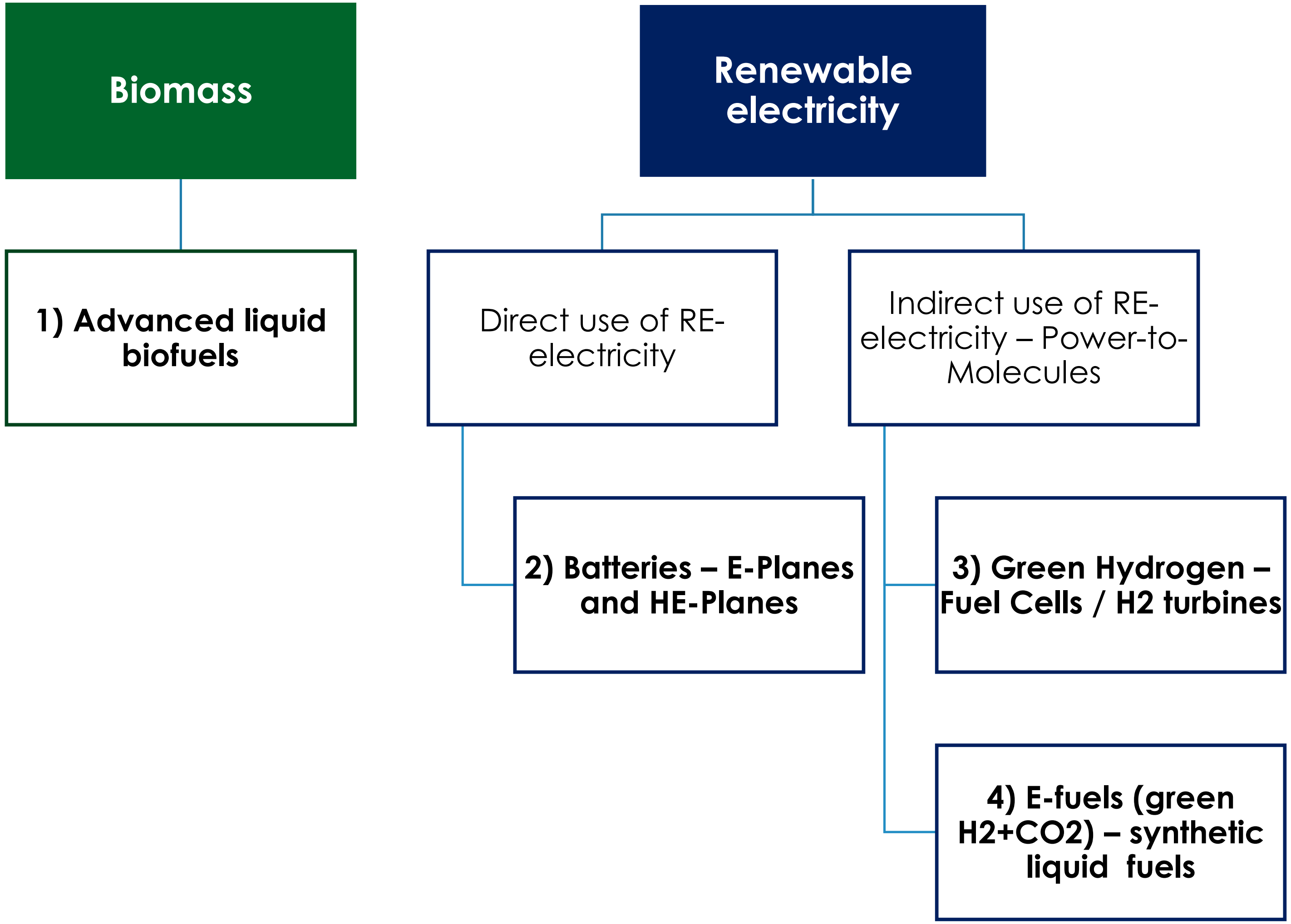
Ways to decarbonize aviation

- **Improved efficiency** through better aircraft design and operation to reduce fuel per person-km or tonne-km
- **Sustainable Aviation Fuel (SAF)** to reduce carbon emissions from fuel still used in more efficient aviation



Source: JRC-EDGAR (2018)

Renewables to play a central role in Sustainable Aviation Fuels



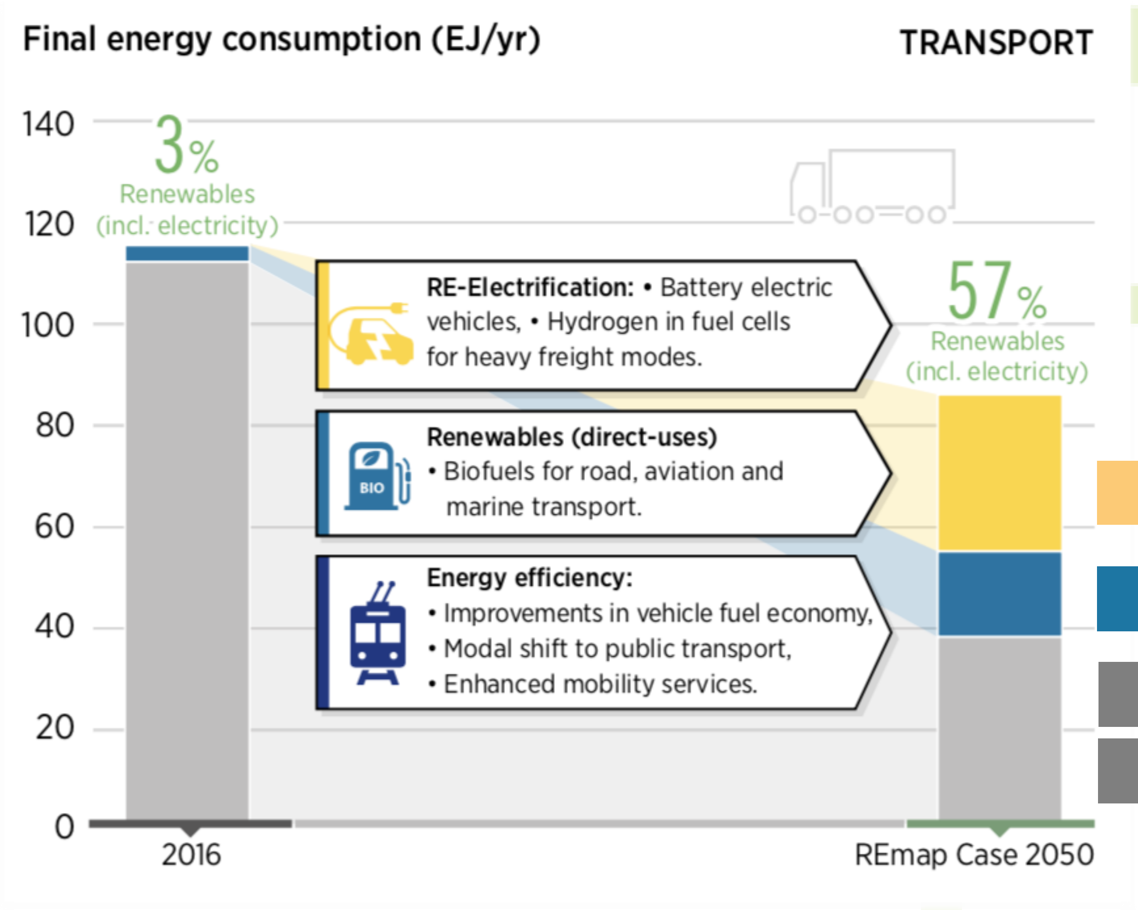
Role of renewables in SAF

- Low-carbon aviation fuels from Biomass and renewable electricity
- Four concrete renewable options for SAF

Biofuels

Biofuels along with electrification and energy efficiency key to decarbonize the transport sector

International Renewable Energy Agency

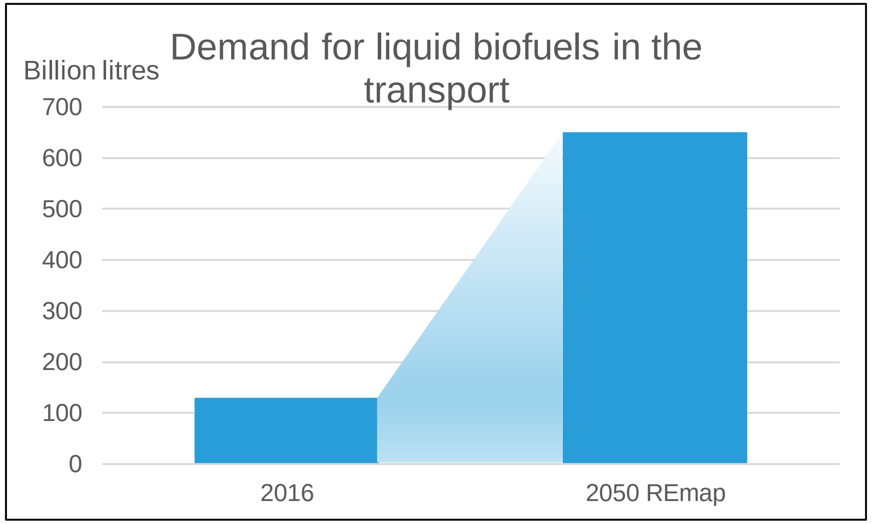


Electricity 37GJ (43%)

Biofuels 17GJ (20%)

Oil 29GJ (34%)

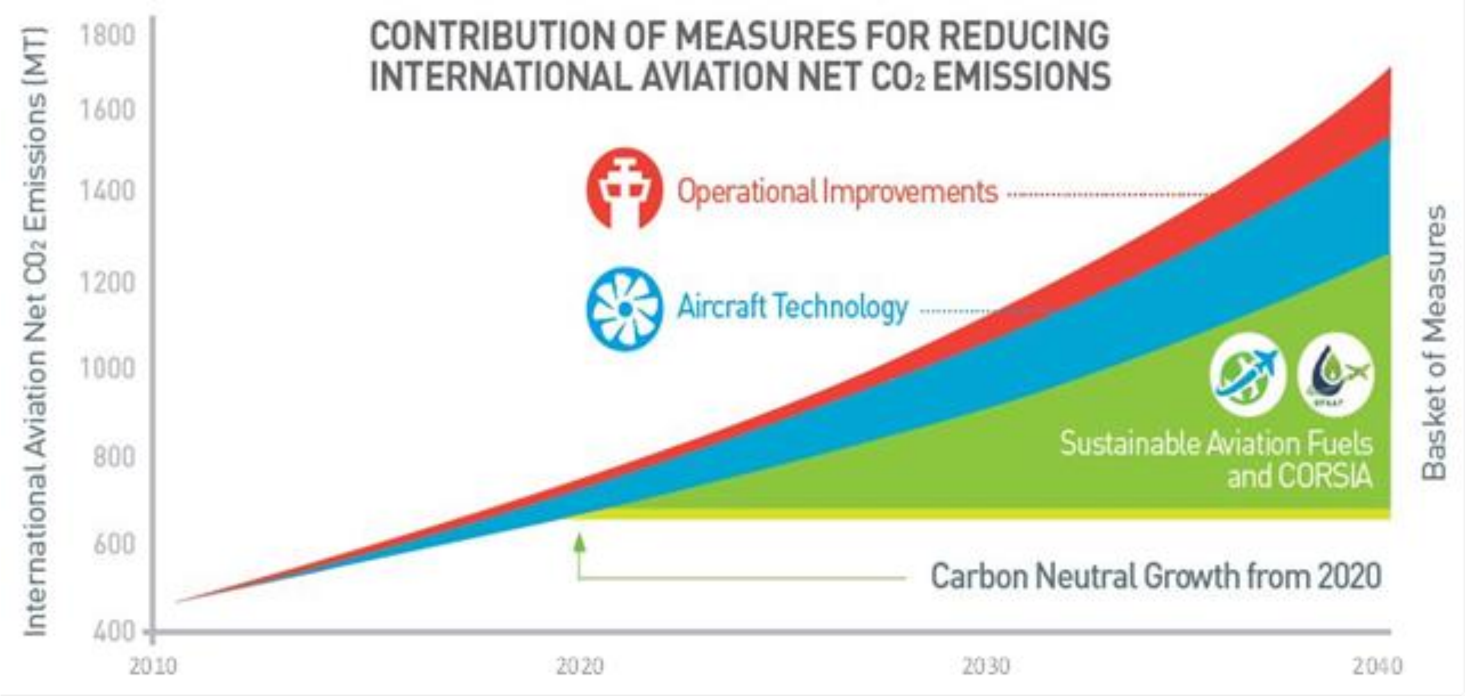
Gas 3GJ (4%)



ICAO STOCKTAKING 2020

International aviation climate target

- An average **improvement in fuel efficiency** of 2% per year from 2021 to 2050
- A cap on net aviation CO2 emissions from 2020 (**carbon-neutral growth**)
- SAF should play a major role in the decarbonization of the aviation sector



Biofuels are the best available alternative

Oilseed crops on restored land (upgrade biodiesel)

- Europe (rapeseed), China, Americas
- FORBIO project – set aside land in EU

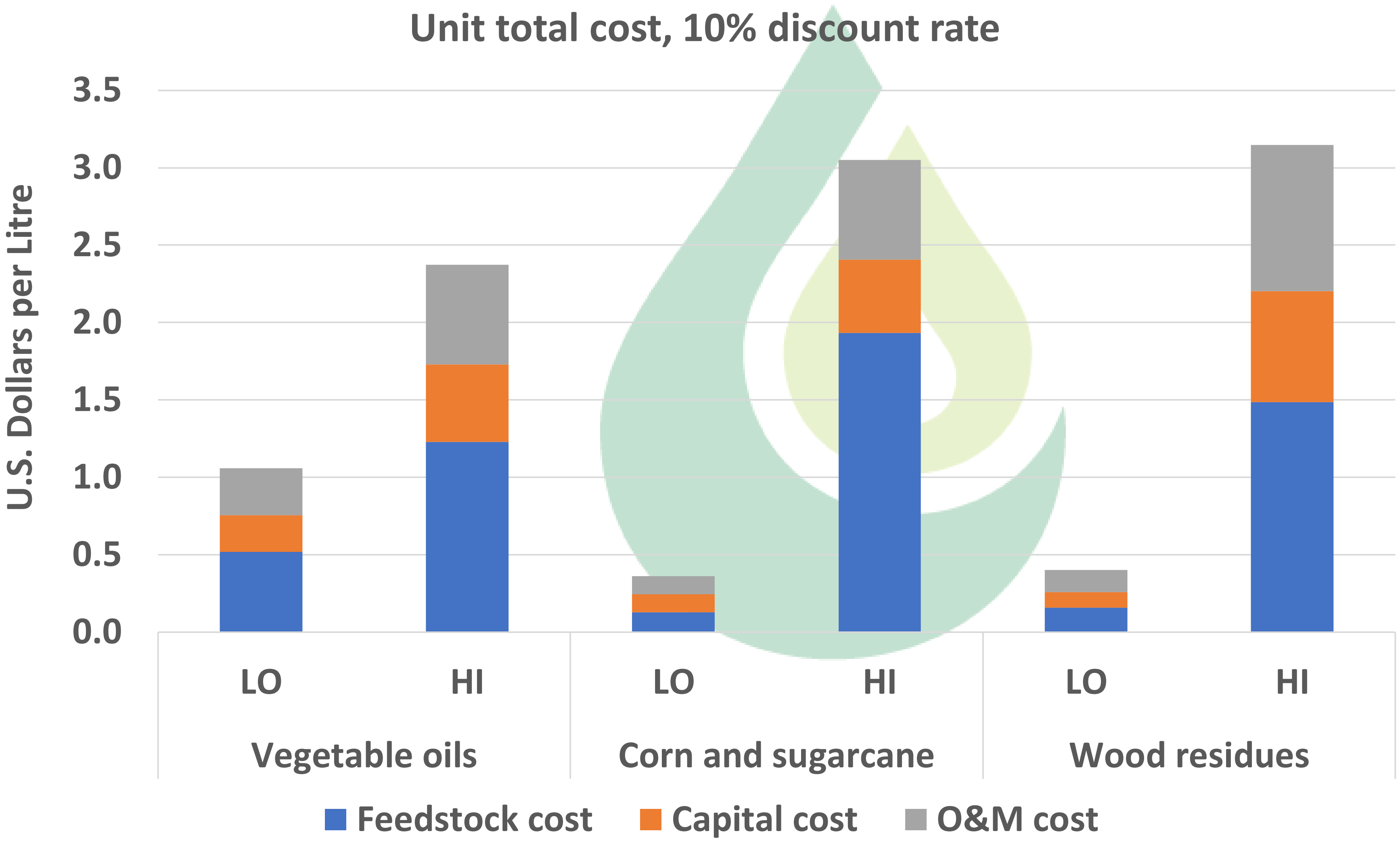
Wood residues (thermochemical routes)

- Uncollected logging residue in Scandinavia
- Unrealised forestry potential in SE Europe

Sugar/Energy cane (1G+2G ethanol plus conversion)

- Brazil, Southern Africa, Caribbean
- Economies from shared 1G/2G process steps
- Future potential enhanced by high-yield energy cane

How total costs for biojet compare?



Kerosene Price at Crude Oil Price of $50-100 per barrel

ICAO STOCKTAKING 2020

Renewable Electricity

Direct electrification: Electric- and hybrid-planes

Prospect

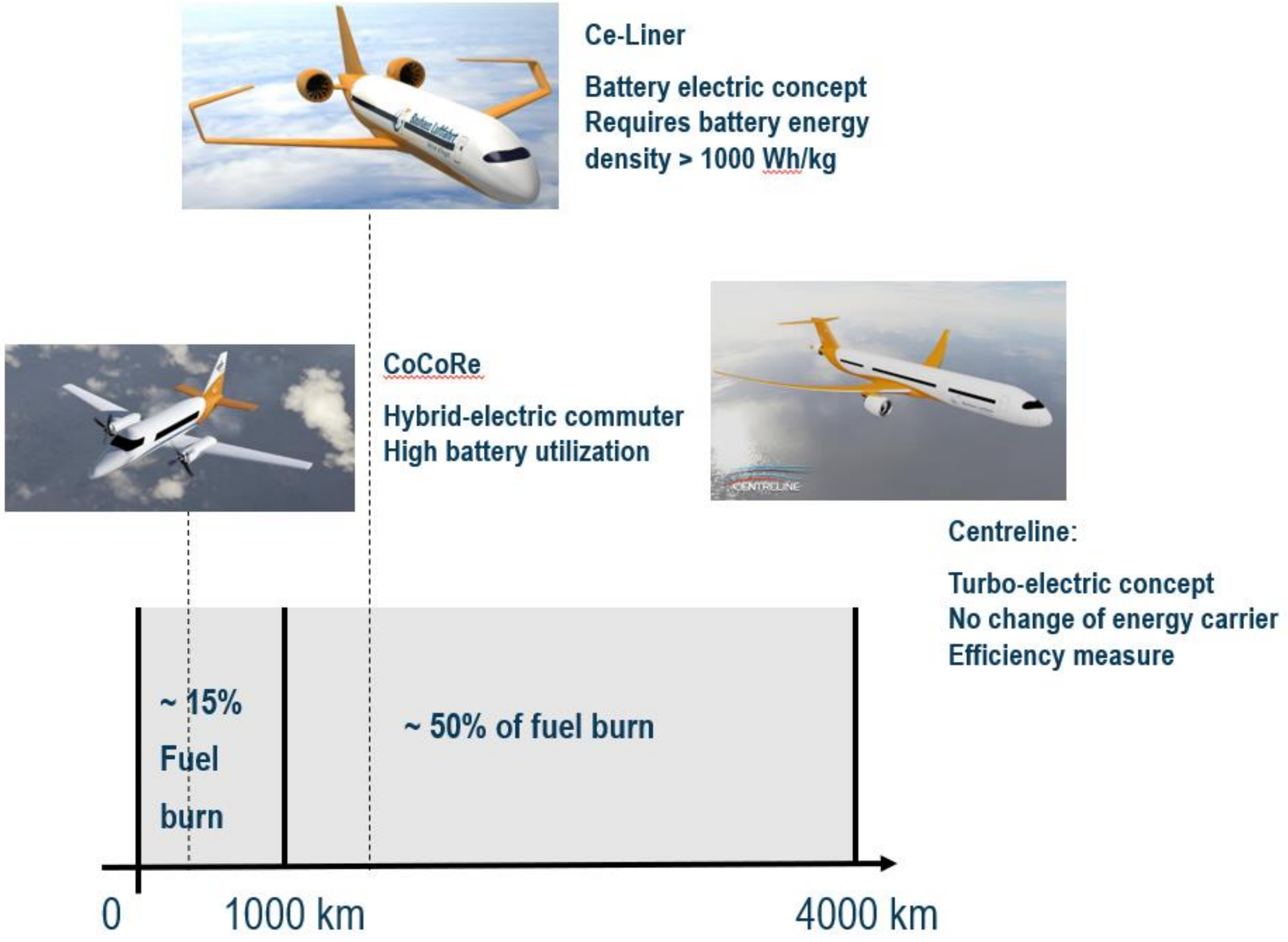
- Advantages - lower complexity, fewer moving parts, lower maintenance and operating costs
- Targeted at short-haul routes

Progress

- ICAO lists 27 electric planes currently in development (e.g. Boeing, Airbus) and five hybrid-electric models

Key challenges

- Battery energy density – from 300 Wh/kg to + 1 000 Wh/kg
- Needs an entirely different propulsion system



Sources: Bauhaus Luftfahrt
M. Hornung, *Ce-Liner*
EU Project Centreline: www.centreline.eu ;

Indirect electrification: Hydrogen fueled planes

IRENA
International Renewable Energy Agency

EnableH2

HyLiner

Liquid hydrogen powered long-haul aircraft

Prospect

- H2 directly combusted or use in Fuel Cells for electric propulsion
- Targeted at short and mid-haul routes

Progress

- HyLiner
- ENABLEH2 - Enabling cryogenic Hydrogen

Key challenges

- Hydrogen storage takes substantial space – looking into cryogenic H2
- Increase efficiency of fuel cells
- Not certified by ASTM

Indirect electrification: Synthetic jet fuels

IRENA
International Renewable Energy Agency

Prospect

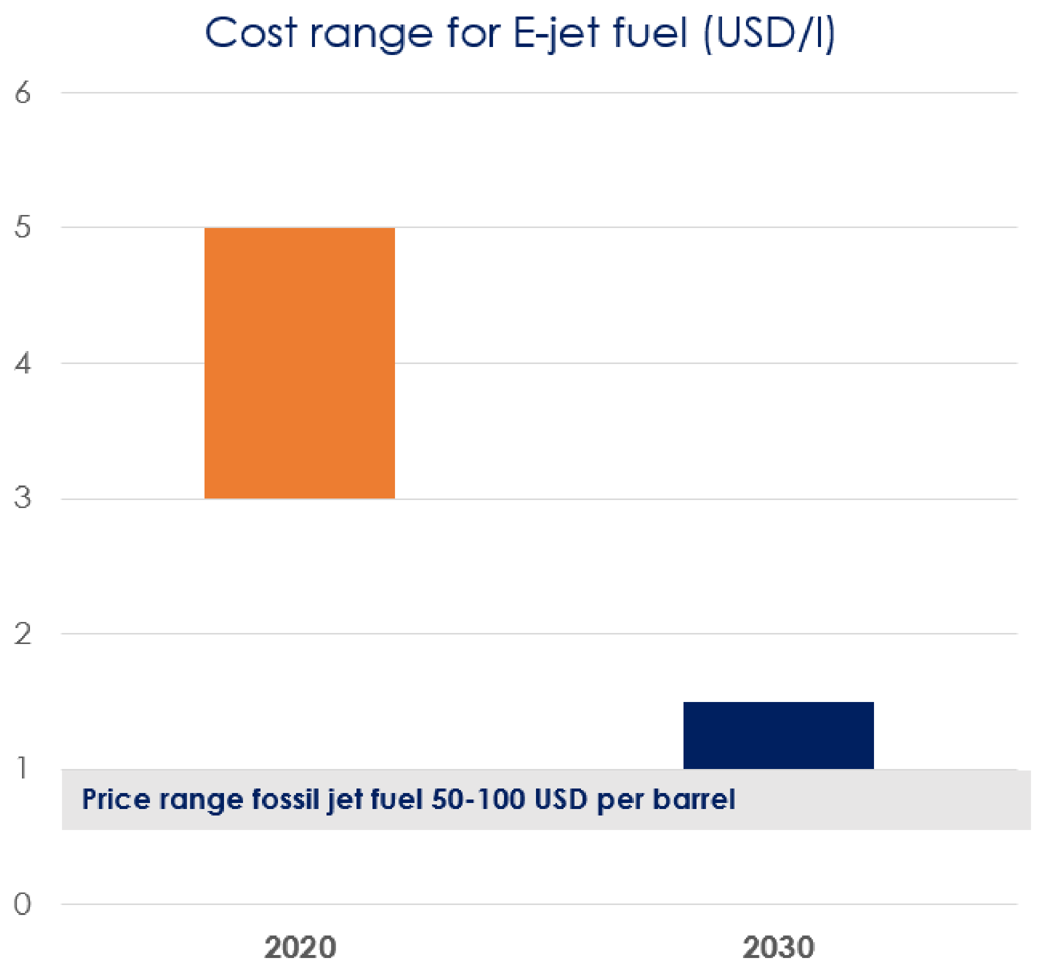
- ❑ Similar to the existing kerosene
- ❑ Fischer-Tropsch route is certified by ASTM and allowed to blend up to 50%
- ❑ Use in existing aircrafts, no major changes in design

Progress

- ❑ Norsk E-Fuel syncrude plant in Norway -100 ML per year 2025
- ❑ German Westküste 100 project 700MW green-hydrogen coupled with CO2 from cement production
- ❑ IRESEN 100 MW green hydrogen plant in Morocco by 2023
- ❑ SAF+ Consortium in Canada 4 ML/yr of SAF plant 2025.

Key challenges

- ❑ Economics: low cost RE electricity + low cost electrolysis + low cost CO2 capture
- ❑ Sustainability certifications/schemes such as Guarantees of Origin (GO)



ICAO | STOCKTAKING 2020

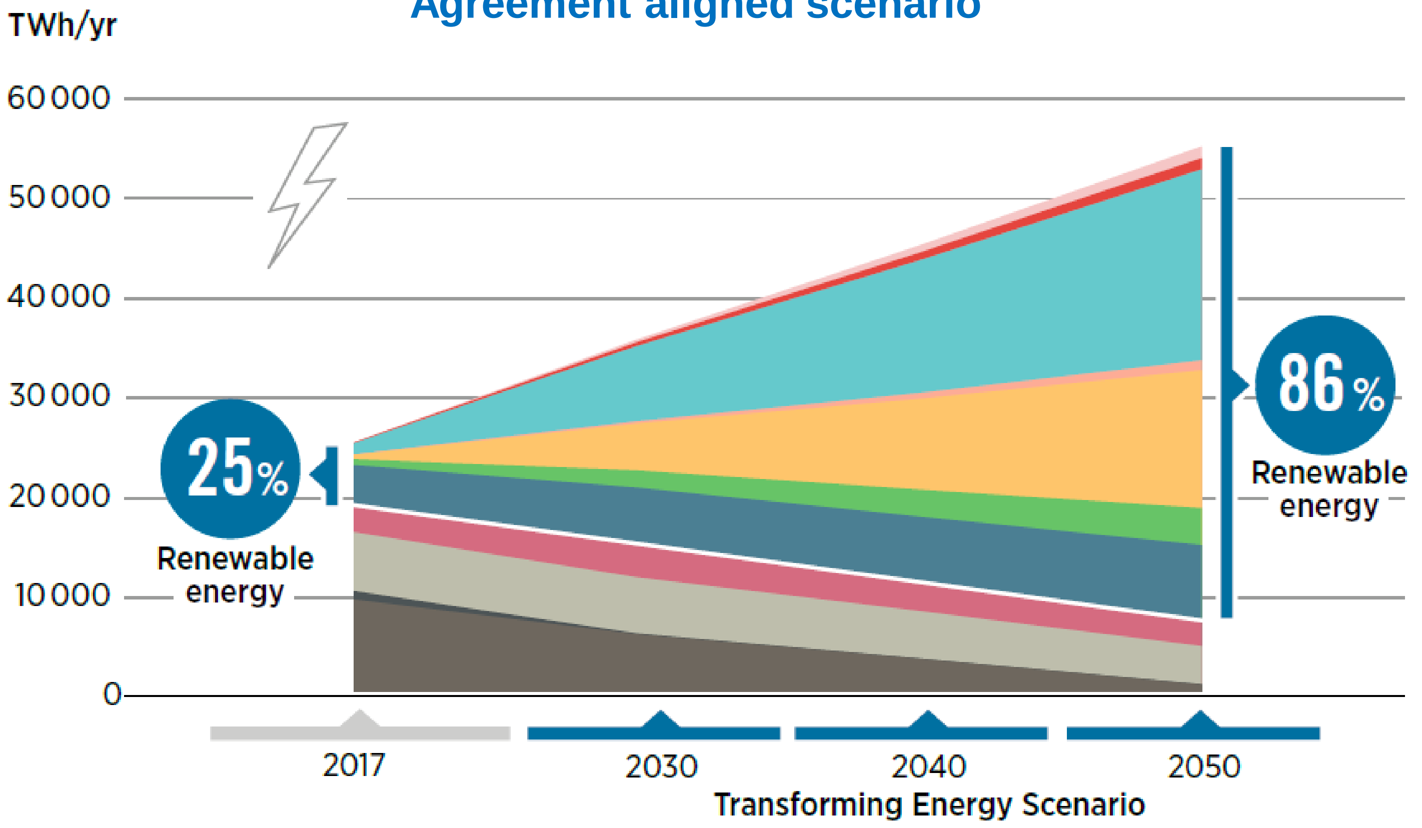
Synthetic jet fuels need abundant and affordable renewable electricity

IRENA
International Renewable Energy Agency

Electricity must come from renewables

- ❑ Electricity share in TFEC from 20% today to 50% in 2050
- ❑ For e-fuels - Look for locations with availability of large amounts of low-cost renewable electricity
- ❑ Between 1,000 and 6,000 GW of additional solar or wind power for 500 billion litres/year

Global electricity generation in a Paris Agreement aligned scenario

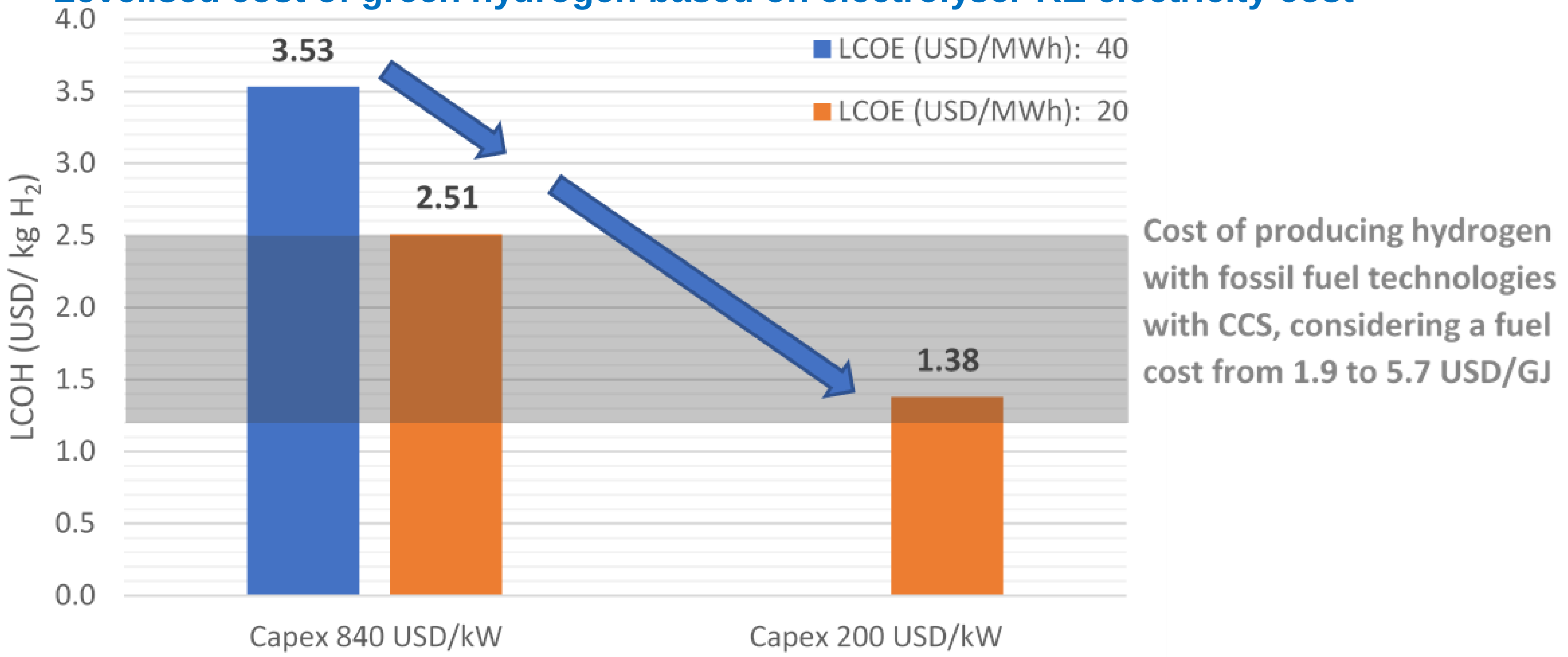


ICAO | STOCKTAKING 2020

Synthetic jet fuels need abundant and affordable GREEN hydrogen

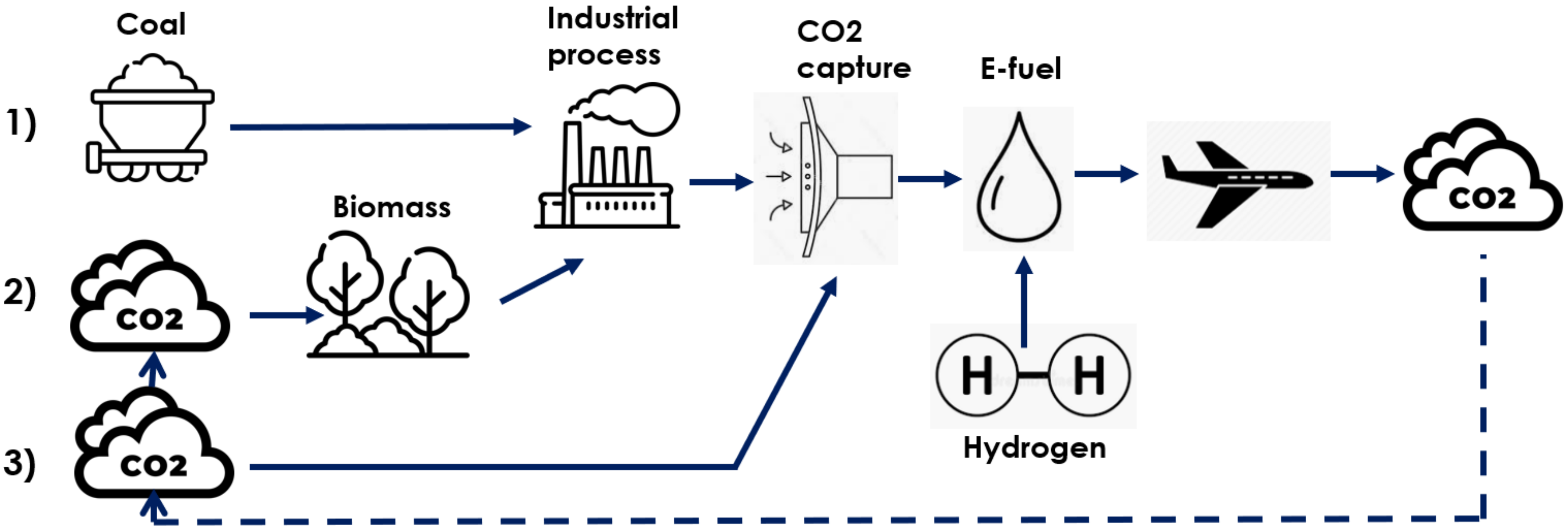
IRENA International Renewable Energy Agency

Levelised cost of green hydrogen based on electrolyser RE electricity cost



- Supplying half aviation and shipping fuel demand today would need nearly twice the current global hydrogen production
- Cost of green hydrogen to be competitive with NG hydrogen ~ USD 1 – 1.6 per Kg H2 in 2020 and USD 2.5 – 3.2 per Kg H2 in 2030
- Location matters. Renewable electricity in countries such as Chile, Morocco and New Zealand are competitive with NG-based hydrogen
- Capacity factor of electrolysers >50%

Synthetic jet fuels need a sustainable carbon source



- Availability of clean and low-cost carbon is important
- Climate benefits of synfuels depend critically on the carbon source
- Biomass, and biomass combustion constitutes a climate neutral CO supply option, but tend to be smaller in scale
- Capture cost from biomass are typically still moderate at USD 40-80 per tonne CO

Policy messages

Policy messages

International Renewable Energy Agency

BIOFUELS-FOCUSED

- Share lessons learnt from examples of policies to bridge the price gap between bio-jet and conventional jet fuel
- Supply chain policies covering entirely from feedstock to bio-jet distribution: supply chains must be established globally as aircrafts need to be refilled

E-FUELS-FOCUSED

- Crucial to take into consideration the required volume on e-fuels that would be required by 2030 - 2050 and the implications in terms of renewable energy capacity
- Need for cost reduction of electrolysers and carbon sources
- Sustainability Guarantees of Origin (GO) allow fuel to be sold as renewable
- Engage with biomass and heavy industries for carbon sources; e.g. cement or steel and iron

Policy messages – cont.

IRENA International Renewable Energy Agency

CROSS-CUTTING

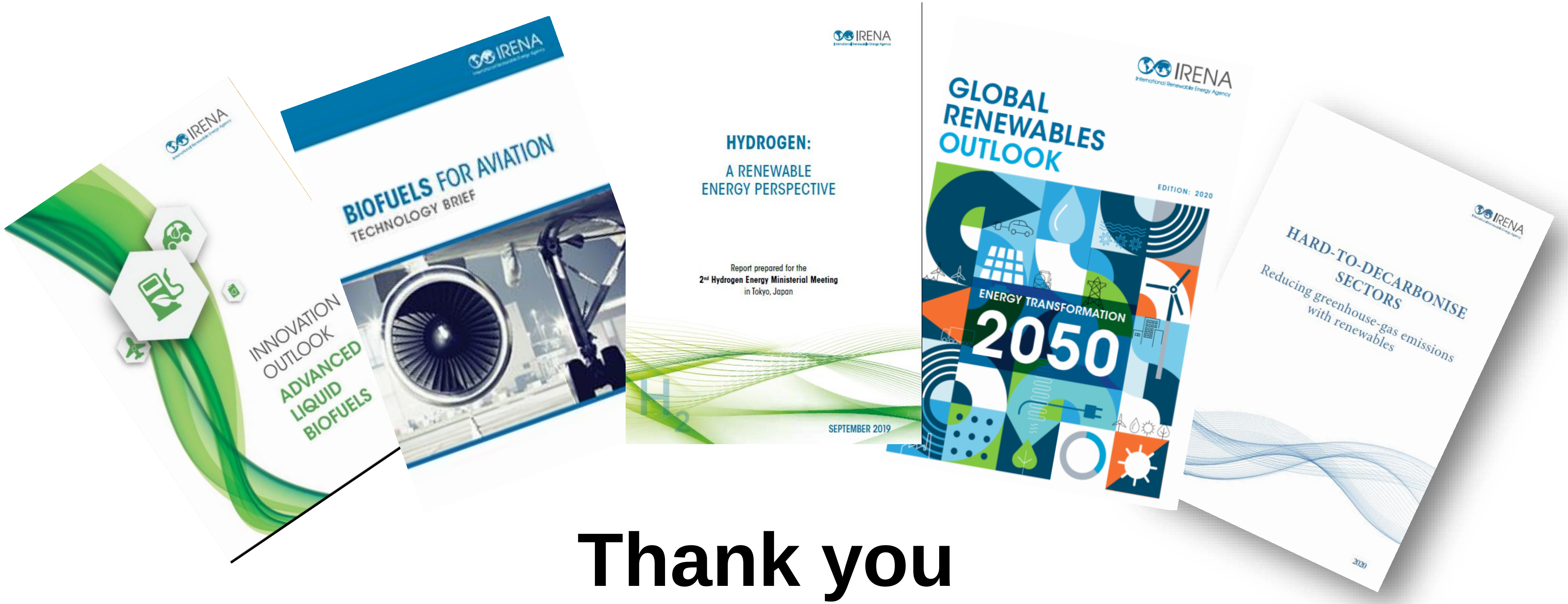
- The international nature of aviation requires approaches to consider international and national context - ICAO plays a major role in the global development of the aviation sector

- Advanced biofuels are an available option today, to be complemented in the next one or two decades by e-planes for short-haul and use of e-fuels for long-haul flights

- RD&D support is important – support investment in pioneering projects

- Cost and price will also depend of the policy and regulation framework and innovative business models - consider mechanisms such as minimum blending mandates, the availability of public funding, certification and carbon prices

- Engage with the shipping sector to benefit from sharing of experiences and create economies of scale



Thank you

www.irena.org

www.instagram.com/irenaimages

www.twitter.com/irena

www.flickr.com/photos/irenaimages

www.facebook.com/irena.org

www.youtube.com/user/irenaorg