A PATHWAY TO DECARBONISE THE SHIPPING SECTOR BY 2050

IRENA
International Renewable Energy Agency

Perspectives on biofuels potential on the shipping sector

Gabriel Castellanos V.
International Renewable Energy Agency (IRENA)

Email: *GCastellanos@irena.org*

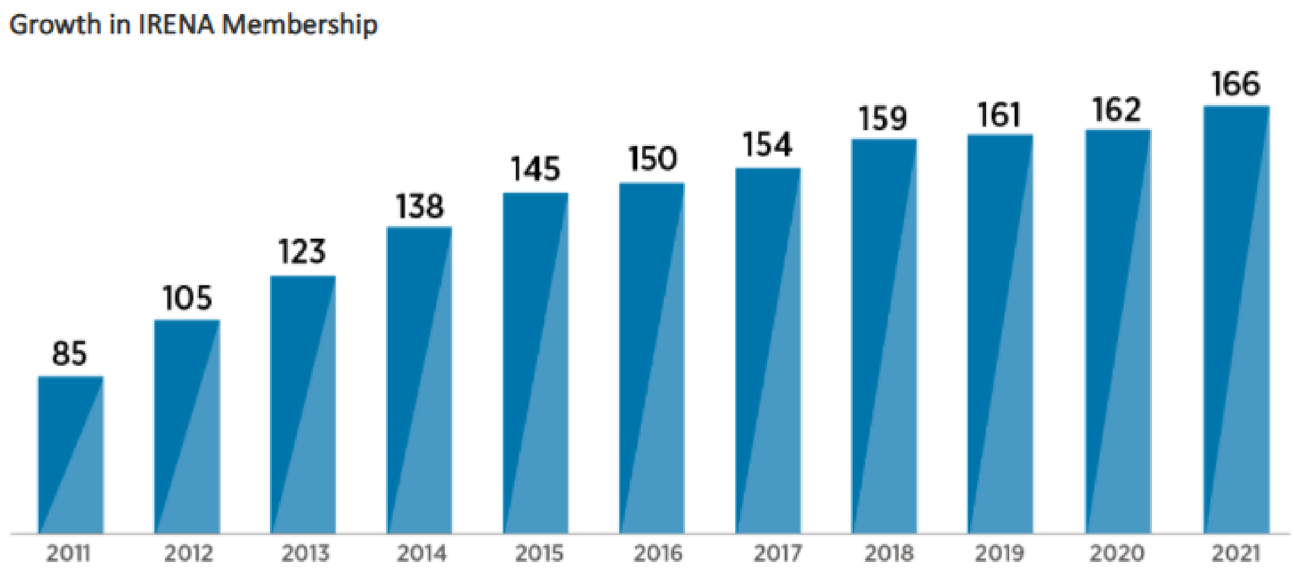
23 Nov 2021

IRENA
International Renewable Energy Agency

Mandate

To promote the widespread adoption and sustainable use of **all forms of renewable energy** worldwide

- Intergovernmental Organization (IGO)
- Established in 2011
- Headquarters in Masdar City, Abu Dhabi, UAE
- IRENA Innovation and Technology Centre – Bonn, Germany
- Permanent Observer to the United Nations – New York, USA
- Director-General – Francesco la Camera

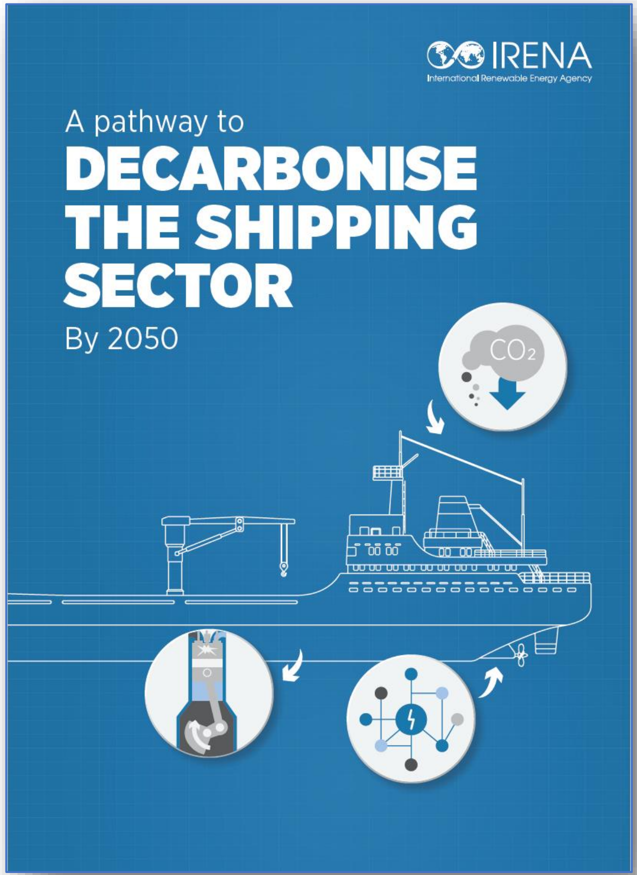


Membership

166 members

Urgent action is necessary to accelerate the pace of the global energy transition and the decarbonisation of the global economy

IRENA
International Renewable Energy Agency



Download link

The report analyses the renewable fuel options and actions needed to decarbonise the international shipping sector by 2050; and seeks to identify a realistic mitigation pathway consistent with a wider societal goal of limiting global temperature rise to 1.5°C:

01 Market dynamics and trends, trade volumes, associated energy demand, and CO_2 emissions

02 Technology readiness and cost of relevant renewable energy fuels

03 The long-term decarbonisation pathway by 2050 and its implications

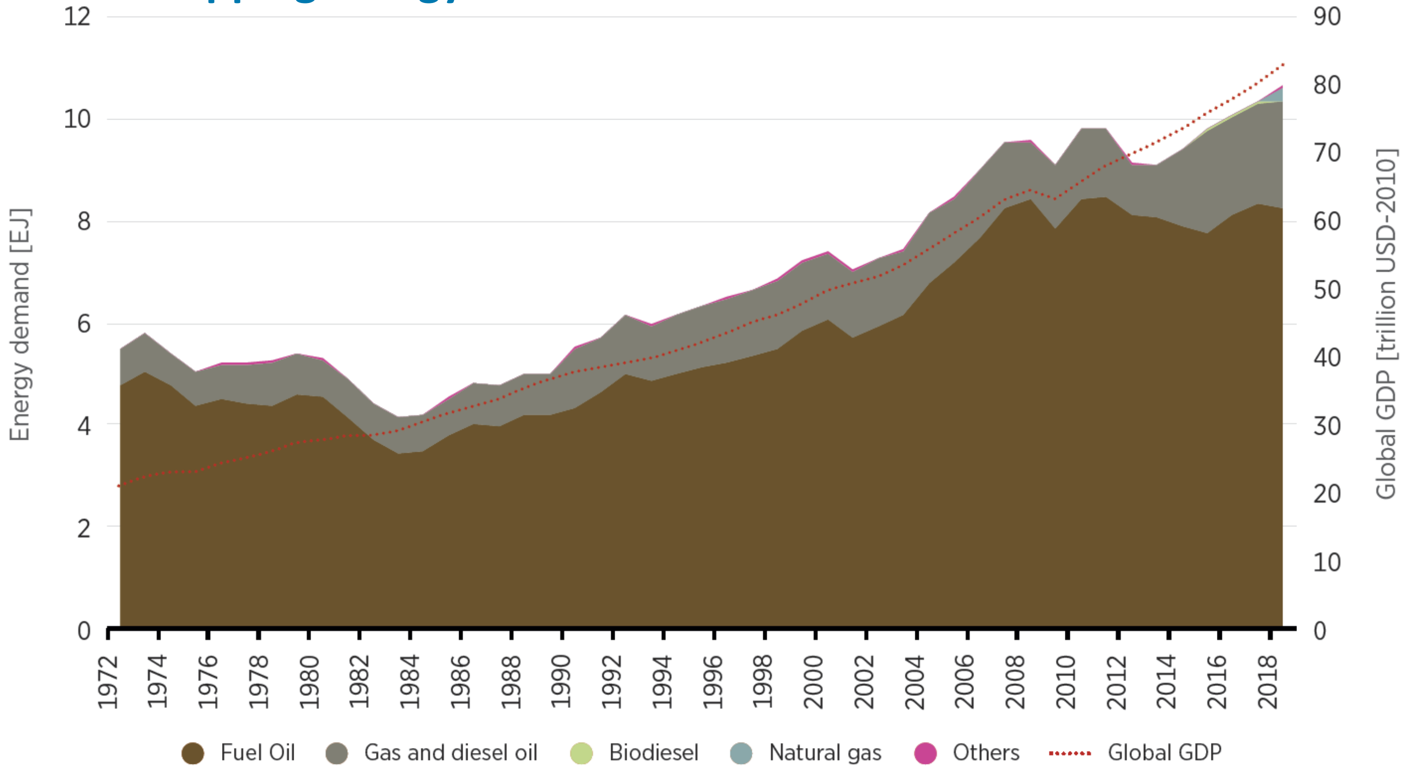
04 Enabling actions to raise the decarbonisation ambition

Key focus:

- **Renewable Fuels**
- **International shipping**
- **Large and very large vessels**
- **Decarbonisation pathways**

International shipping is a key sector of the global economy → Trade and manufacturing sector activity have been the key drivers shaping energy demand

Global shipping energy demand and GDP



Note: Comprises energy demand from domestic navigation plus international shipping.

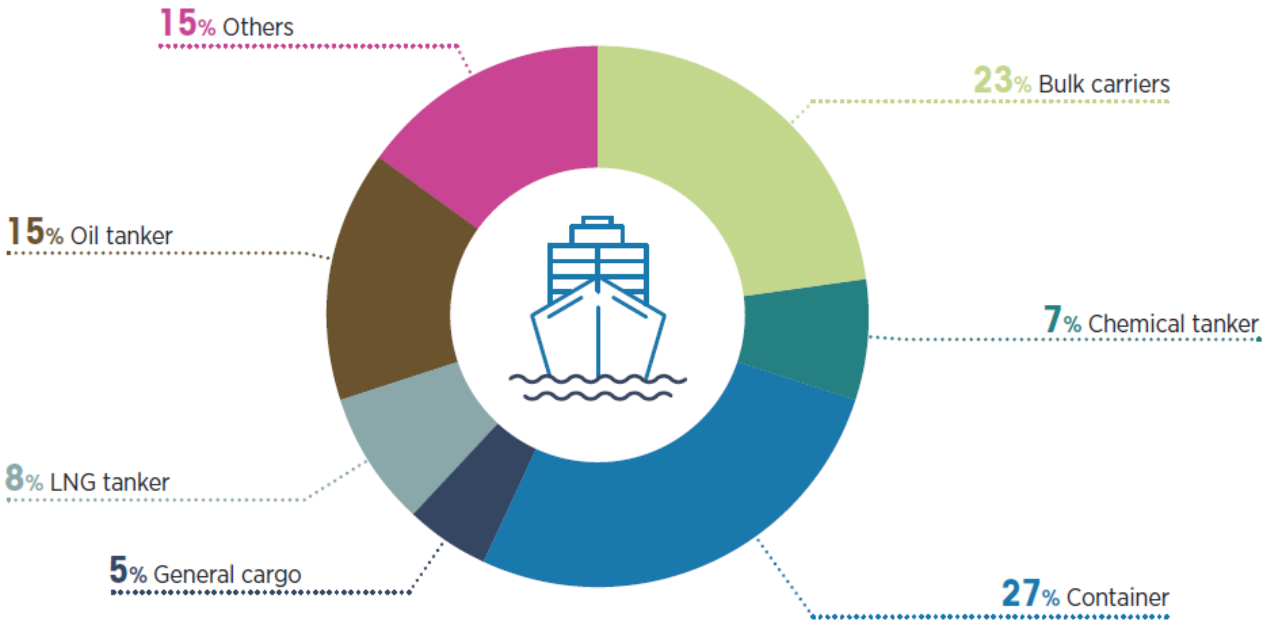
Source: IRENA analysis based on DNV GL (2020a), World Bank (2020)

- As the adoption of energy efficiency (EE) measures in international shipping increases**, the nexus of the nexus of GDP, trade and energy demand may decouple progressively.**
- Given the pivotal role of international shipping in the global economy, **the role of EE has limitations in terms of carbon reduction potential.**

A Pathway to Decarbonise the Shipping Sector by 2050 (IRENA, 2021)

International shipping is a key sector of the global economy → 20% of the global fleet comprises large and very large vessels responsible for around 85% of the net GHG emissions

Voyage-based allocation of energy consumption for international shipping



- **Key sector of the global economy**; around **80-90% of global trade** enabled **by maritime shipping**.
- The **shipping sector** is responsible for around **3% of annual global greenhouse gas (GHG) emissions**.
- If the **international shipping** sector were a country, it **would be the sixth- or seventh-largest CO2 emitter**.

A Pathway to Decarbonise the Shipping Sector by 2050 (IRENA, 2021)

IRENA
International Renewable Energy Agency

A pathway with a 70% share of renewable fuels enables an 80% cut in CO_2 emission by 2050

A 1.5°C Scenario featuring 80% decarbonisation is based on four key measures:

Renewable fuels

- Indirect electrification by employing **e-fuels**
  → 60% decarbonisation

- Direct employment of **advanced biofuels**
  → 3% decarbonisation

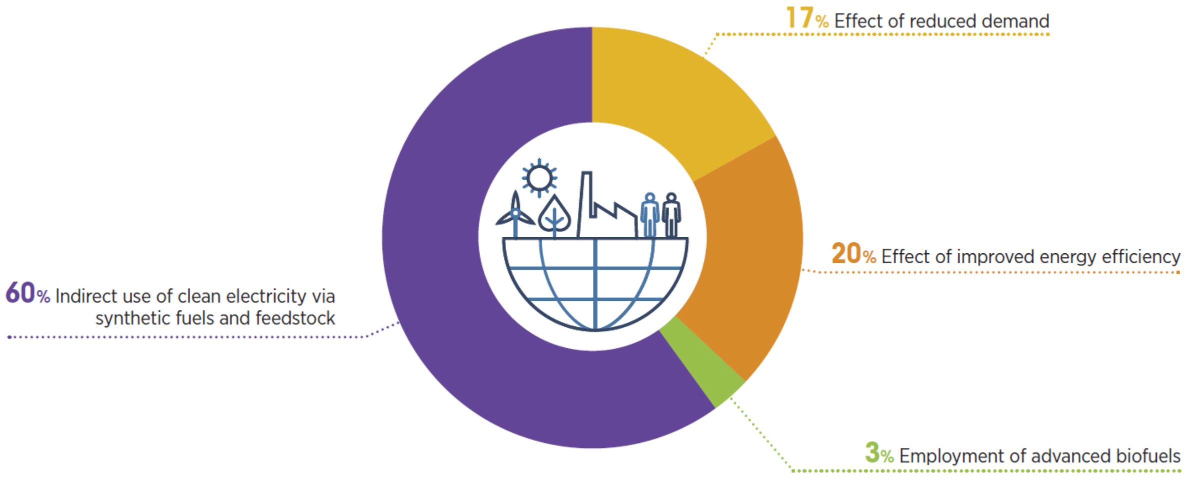
Energy efficiency

- Improvement of vessels' **energy efficiency**
  → 20% decarbonisation

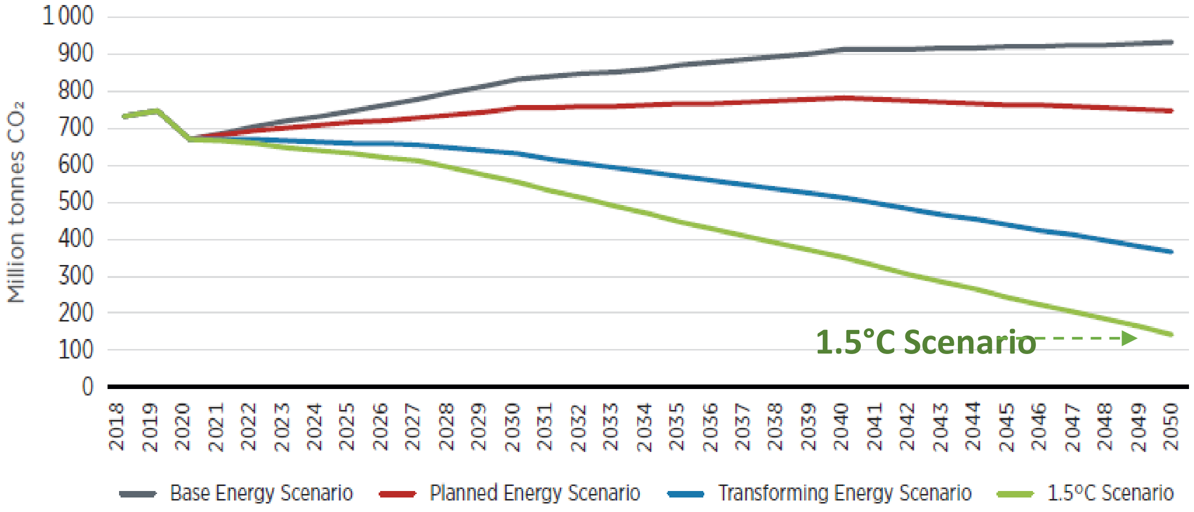
Systemic changes in global trade dynamics

- Reduction final energy due to **sectoral activity changes**
  → 17% decarbonisation

Estimated roles of key CO_2 emission reduction measures associated with IRENA 1.5°C Scenario



Comparison of CO_2 emissions associated with each scenario, 2018-2050

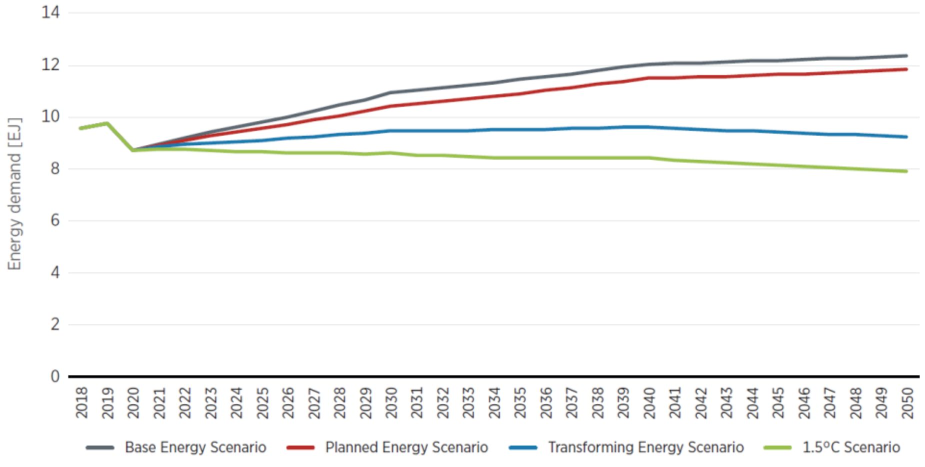


A Pathway to Decarbonise the Shipping Sector by 2050 (IRENA, 2021)

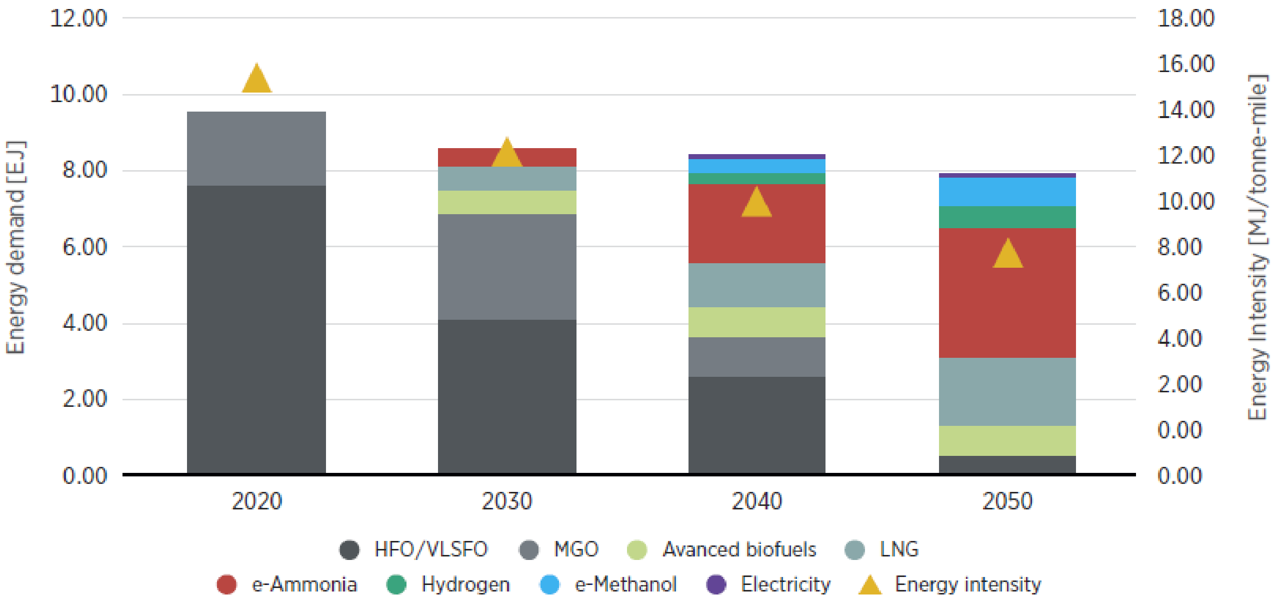
IRENA
International Renewable Energy Agency

In the immediate term energy efficiency is essential. **Short term biofuels play a key role.**
In the medium and longer term, green hydrogen fuels are pivotal to sectoral decarbonization.

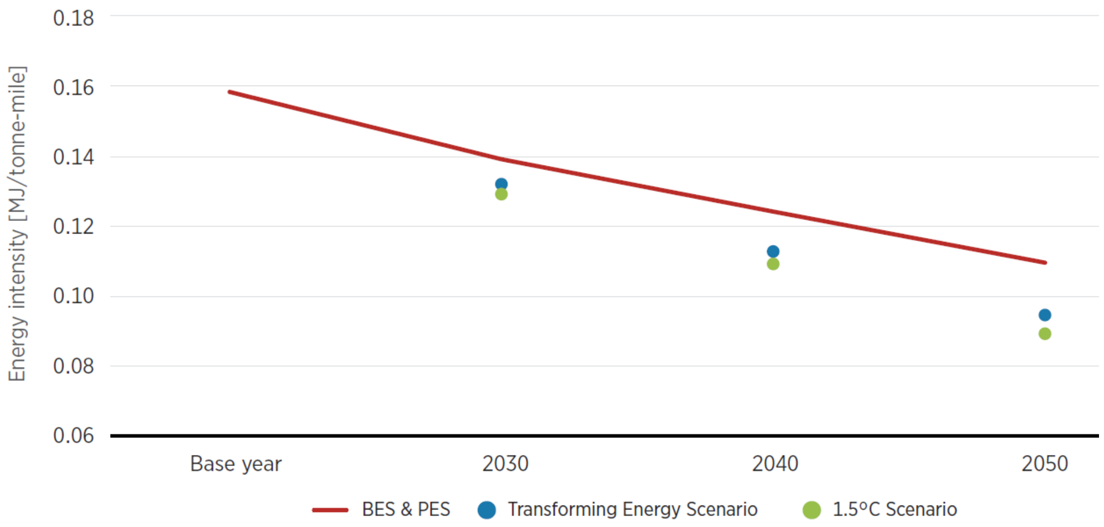
Final energy demand projections, 2018-2050



1.5°C Scenario energy pathway, 2018-2050



Energy intensity global average for the shipping sector, 2018-2050



By 2050, shipping will require a total of **46 million tonnes of green hydrogen for e-fuels production.**

→**73%** will be needed **for** the production of **e-ammonia**
→**17%** for **e-methanol** and;
→**10%** will be used **directly as liquid hydrogen.**

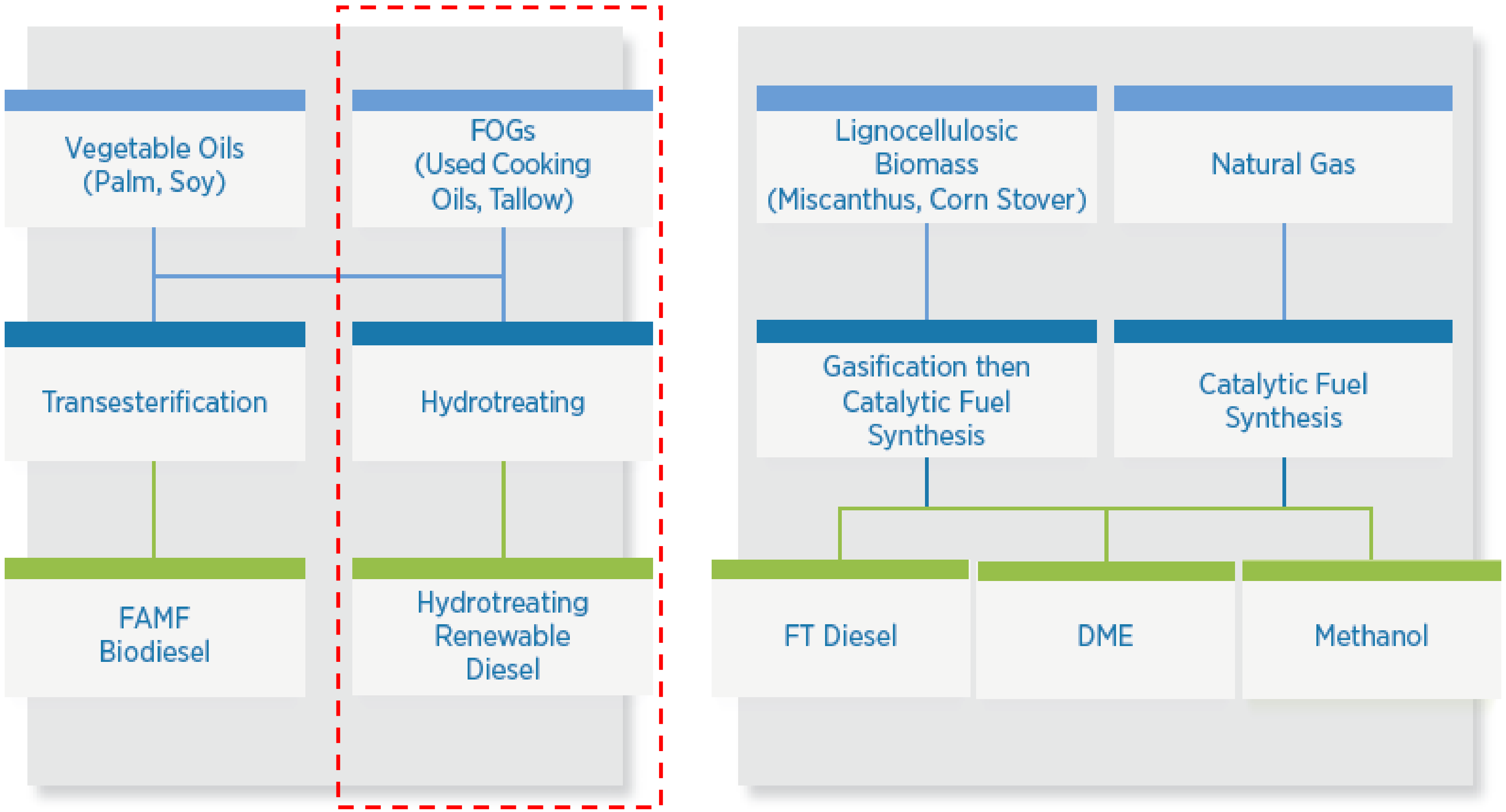
E-ammonia will be **pivotal for decarbonising shipping by 2050.**

→ **183 million tonnes of renewable ammonia** for international shipping alone in 2050 will be needed – a comparable amount to today's ammonia global production.

A Pathway to Decarbonise the Shipping Sector by 2050 (IRENA, 2021)

IRENA
International Renewable Energy Agency

LIQUID BIOFUELS - Differences in feedstock and production methods for alternative liquid fuels



- **There are 2 approaches to harnessing liquid biofuels:**
  - **One requires blending first-generation biofuels with existing fossil fuels to mitigate a percentage of emissions.**
  - The other route involves harnessing second-generation liquid biofuels as a replacement for current conventional shipping fuels.

A Pathway to Decarbonise the Shipping Sector by 2050 (IRENA, 2021)

IRENA
International Renewable Energy Agency

LIQUID BIOFUELS - Potential biofuels for the shipping industry and their viability

- **FAME** - popular biodiesel due to its shared similar properties with fossil fuel diesel. This form of biofuel is produced from fats, oils and greases (FOGs). (fatty acid methyl ester)
- **HVO** - from virgin vegetables oils, such as rapeseed. The most viable feedstock option for this type of biofuel is waste FOGs. (hydrotreated vegetable oils)
- **DME** – Produced either by gasifying solid biomass feedstock to syngas or by reforming biomethane to syngas followed by gas cleaning and catalytic DME synthesis. (Dimethyl ether)
- **Bio-methanol** - produced using biomass gasification and reformation. Feedstock usually forestry and agricultural waste and by-products, biogas from landfill, sewage, municipal solid waste, and black liquor from the pulp and paper industry.

Fuel	Pathway	Feedstock	Compatibility	Feedstock availability	Cost	Tech. readiness	Industry interest
FAME biodiesel	Transesterification	FOGs	1	1	2	2	2
		Vegetable oils		2	2	2	0
Hydrotreated renewable diesel	Hydrotreating	Waste FOGs	2	1	1	1	2
		Vegetable oils		2			0
FT diesel	Gasification then FT synthesis	Lignocellulosic biomass	2	2	1	1	2
		Natural gas			2	2	0
DME	Gasification then fuel synthesis	Lignocellulosic biomass	1	2	1	1	2
		Natural gas		2	2	2	1
	Electrolysis then fuel synthesis	Renewable electricity and CO_2		1	0	1	2
	Gasification, fuel synthesis, methanol reduction	Natural gas		2	1	1	1
Methanol	Gasification then fuel synthesis	Natural gas Biomethane	1	2	2	2	1
		Lignocellulosic biomass		2	1	1	2
	Electrolysis then fuel synthesis	Renewable electricity and CO_2		1	0	1	2

Key: 2 = Good, 1 = Average, 0 = Poor.

Source: ICCT (2020)

A Pathway to Decarbonise the Shipping Sector by 2050 (IRENA, 2021)

LIQUID BIOFUELS - Comparison of life cycle GHG emissions associated with different biofuels

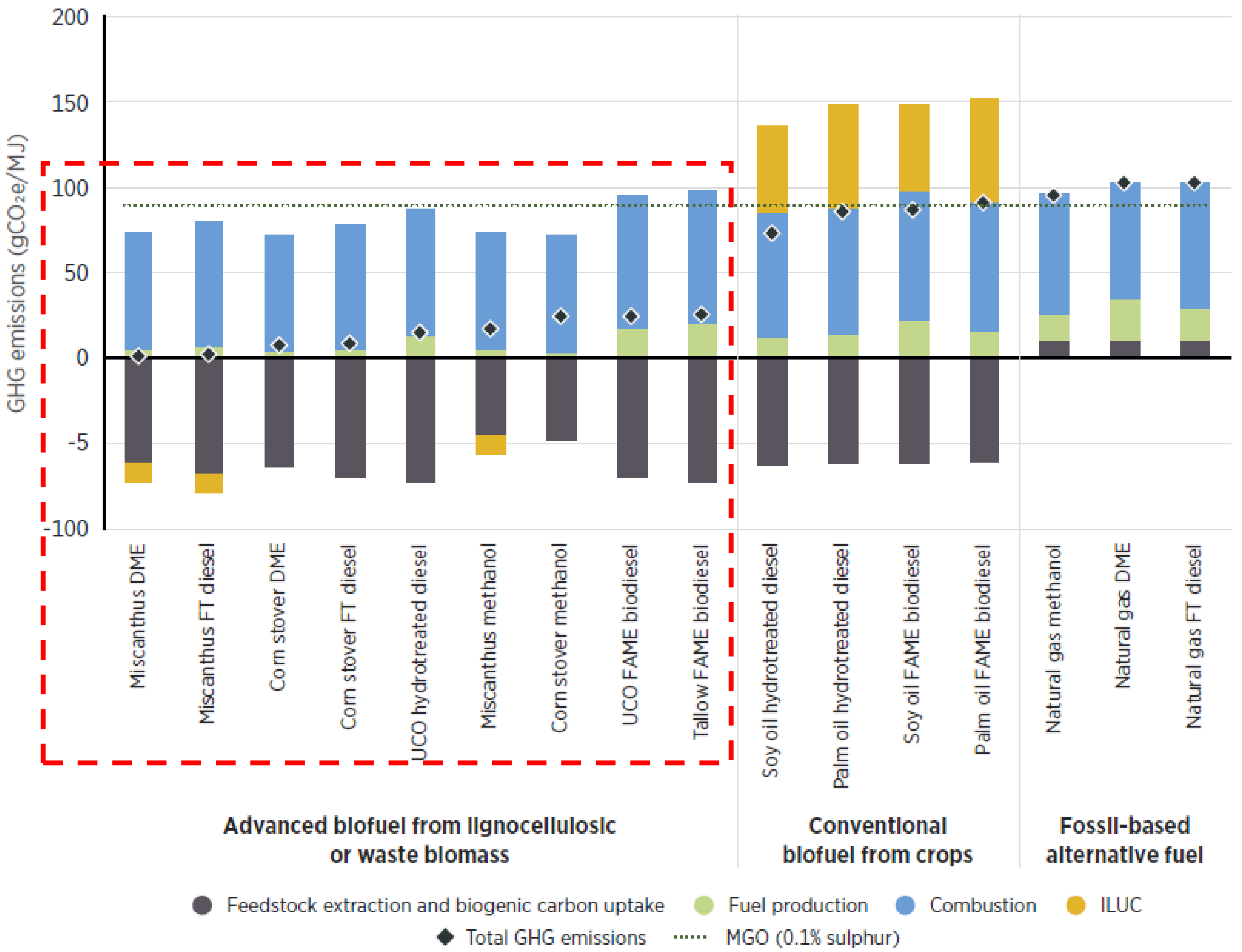
GHG Emissions

- Advanced biofuels; those that use 2nd generation produce overall lower life cycle emissions than first-generation feedstock biofuels.

Fuel technical characteristics

- FAME diesel has an estimated energy density ratio of 90% compared with fossil diesel, making it a viable choice as a fuel alternative.

- FAME diesel from FOGs the more viable choice.

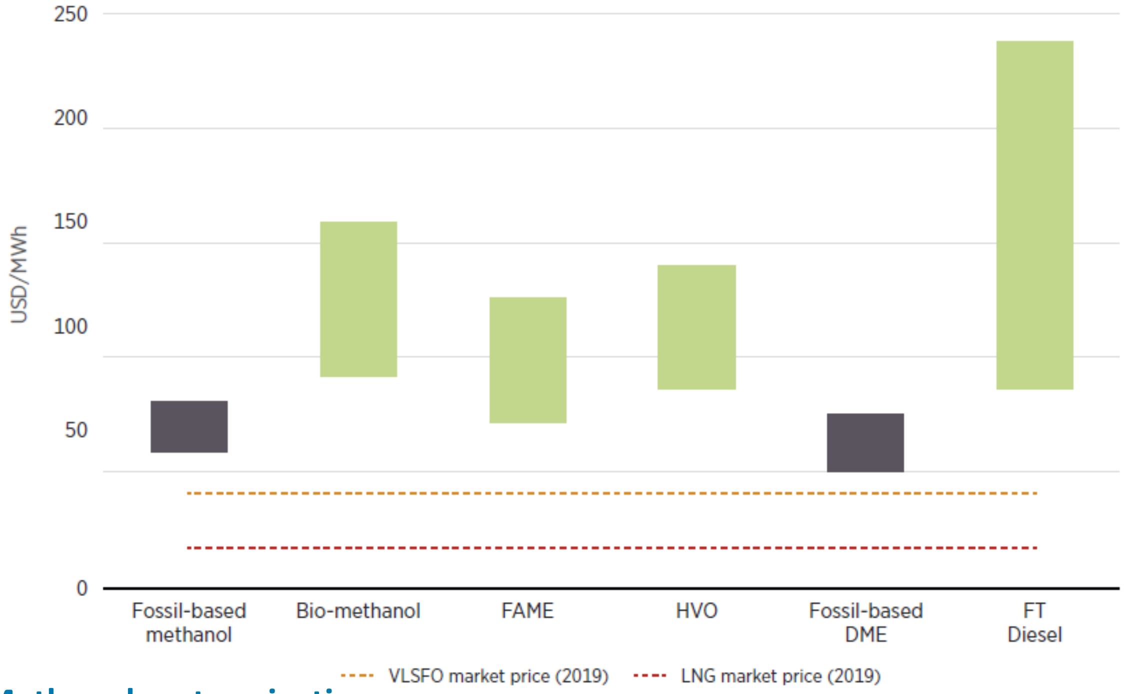


Note: gCO_2: grams of CO_2 equivalent

Source: ICCT (2020)

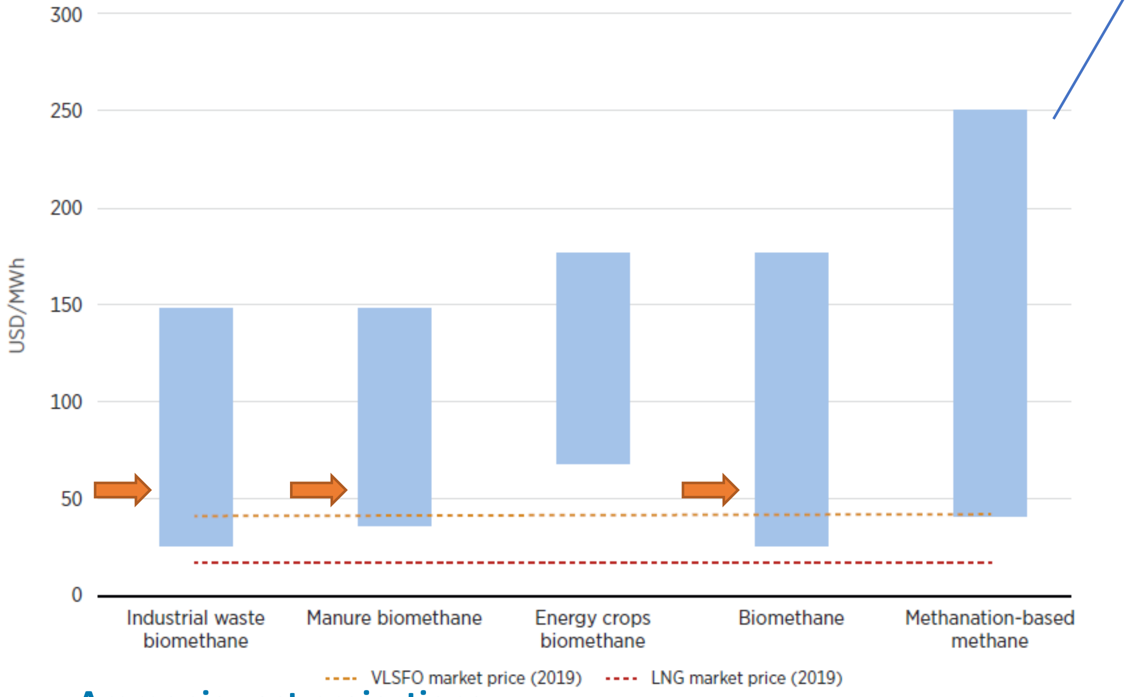
BIOFUELS - Cost comparison; liquid and gaseous

Liquid biofuels

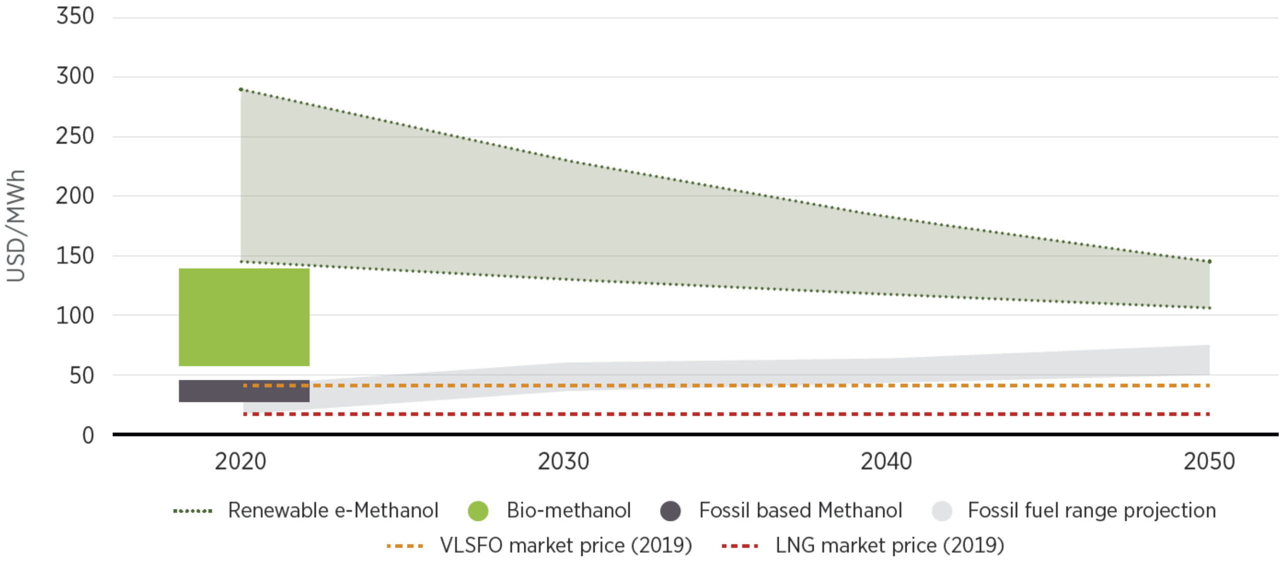


Renewable gaseous fuels

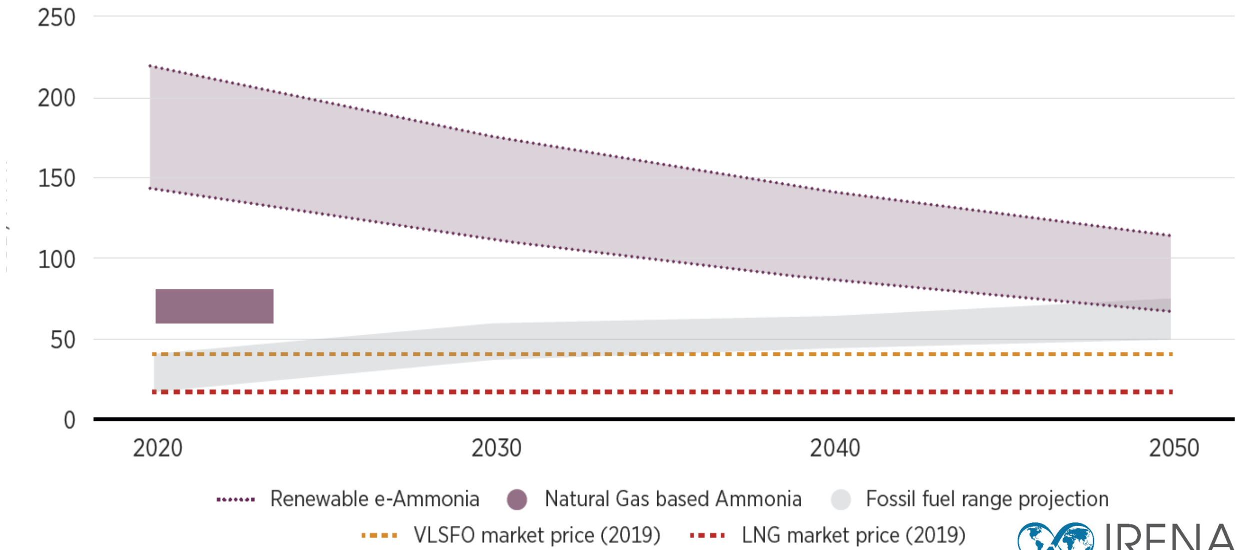
Hydrogenation of carbon dioxide and carbon monoxide, resulting in methane.



Methanol cost projections



Ammonia cost projections

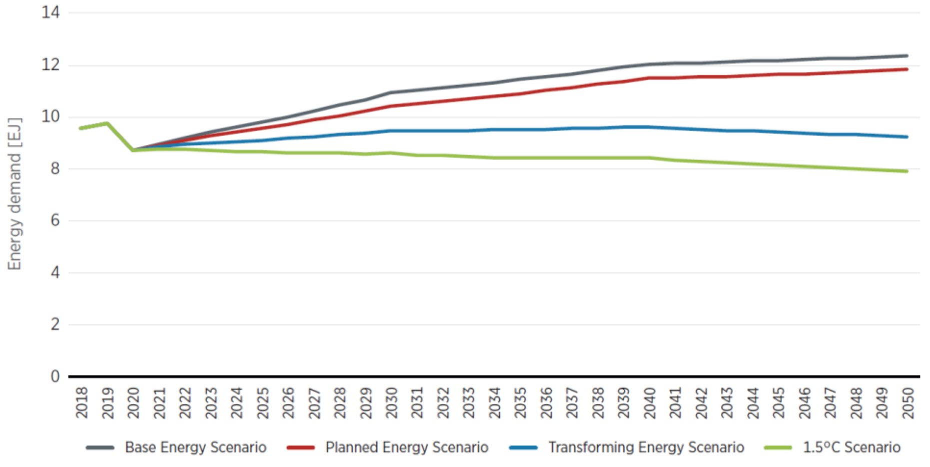


A Pathway to Decarbonise the Shipping Sector by 2050 (IRENA, 2021)

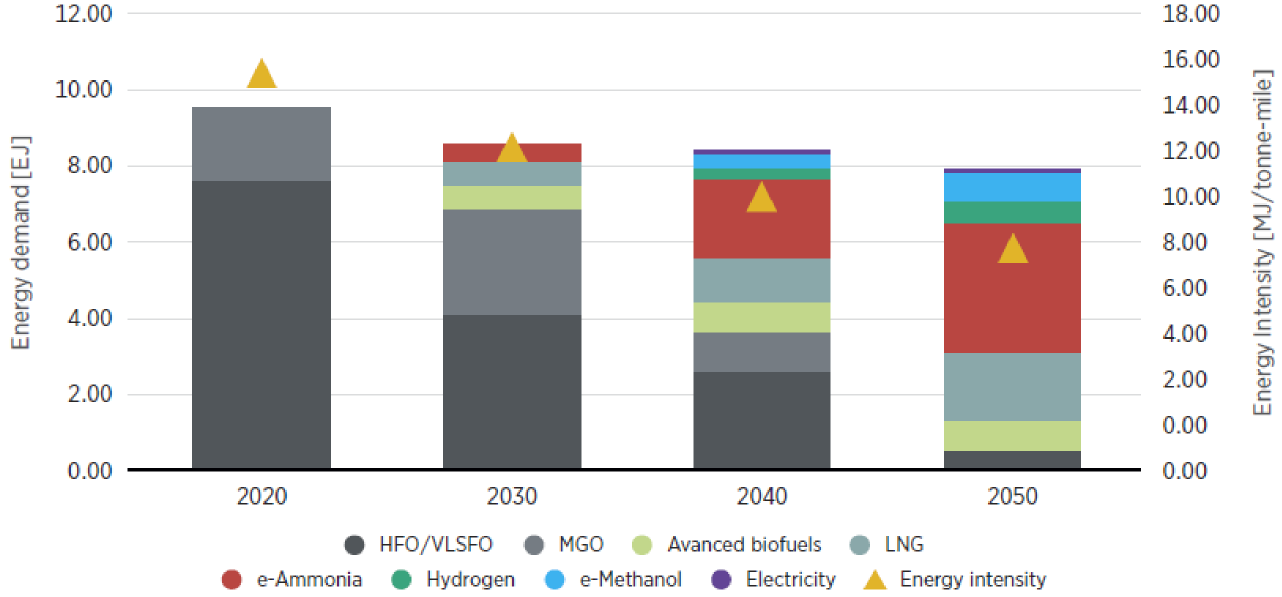
IRENA
International Renewable Energy Agency

In the immediate term energy efficiency is essential. **Short term biofuels play a key role.**
In the medium and longer term, green hydrogen fuels are pivotal to sectoral decarbonization.

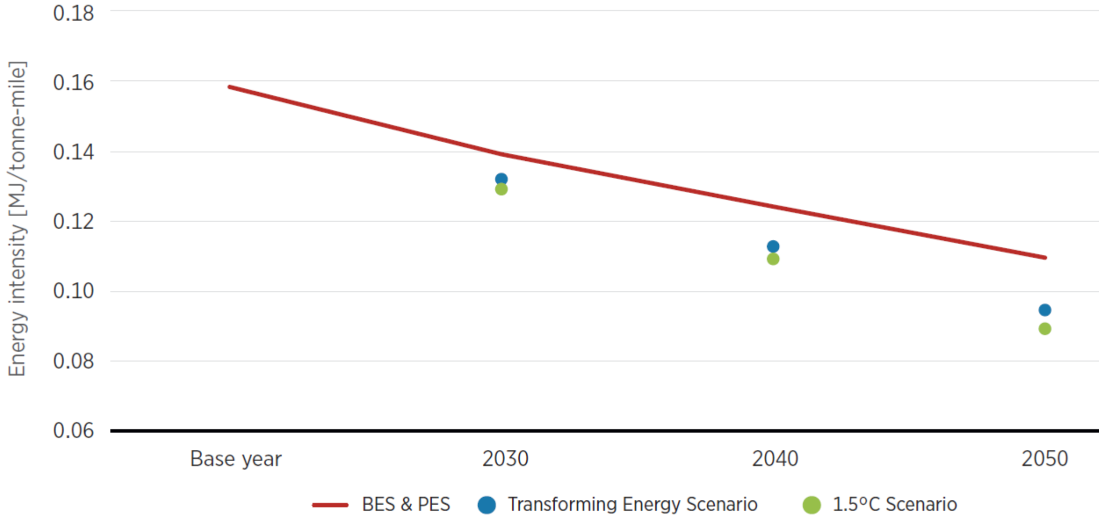
Final energy demand projections, 2018-2050



1.5°C Scenario energy pathway, 2018-2050



Energy intensity global average for the shipping sector, 2018-2050



By 2050, shipping will require a total of **46 million tonnes of green hydrogen for e-fuels production.**

→**73%** will be needed **for** the production of **e-ammonia**

→**17%** for **e-methanol** and;

→**10%** will be used **directly as liquid hydrogen.**

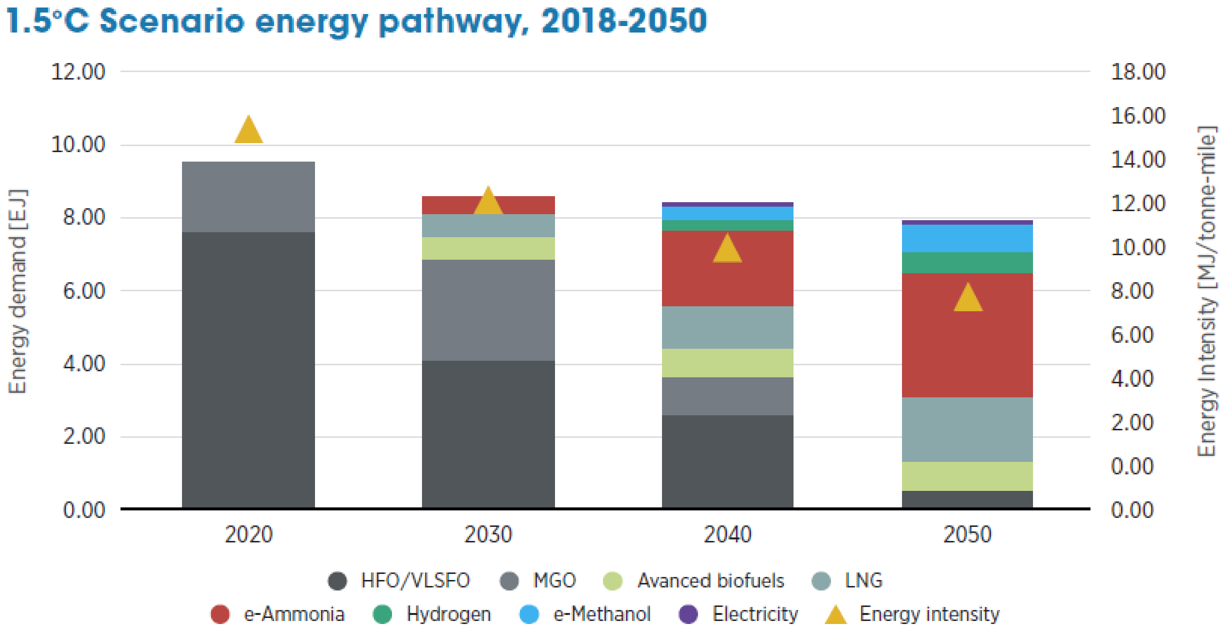
E-ammonia will be **pivotal for decarbonising shipping by 2050.**

→ **183 million tonnes of renewable ammonia** for international shipping alone in 2050 will be needed – a comparable amount to today's ammonia global production.

A Pathway to Decarbonise the Shipping Sector by 2050 (IRENA, 2021)

IRENA
International Renewable Energy Agency

In the immediate term energy efficiency is essential. **Short term biofuels play a key role.**
In the medium and longer term, green hydrogen fuels are pivotal to sectoral decarbonization.



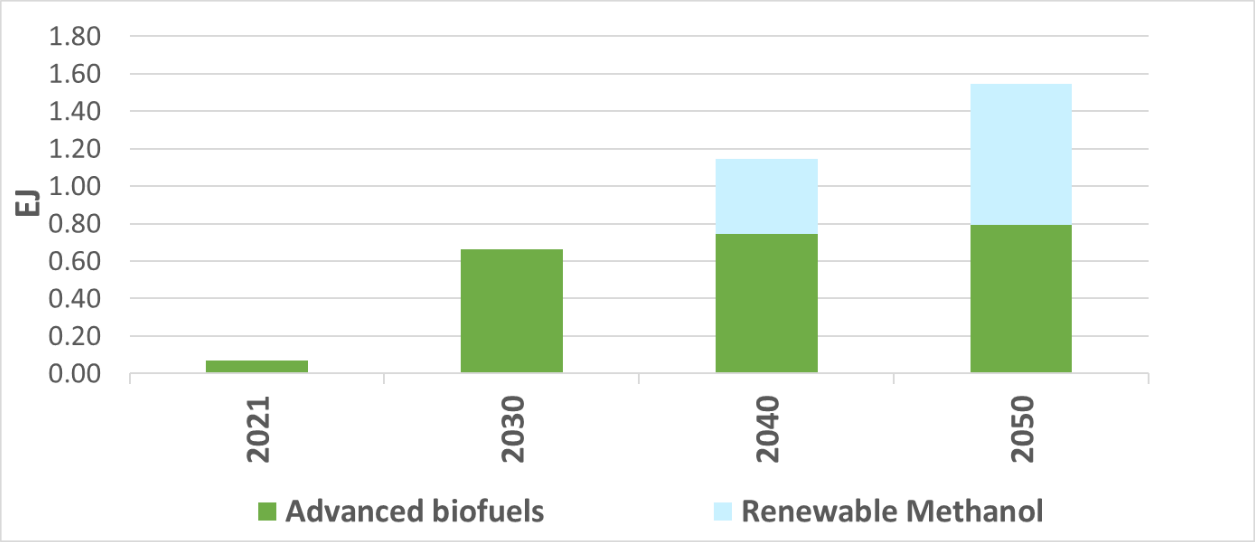
Opportunities

- Expected growth of fossil LNG - Global decarbonisation goals require enormous reductions in CO2 emissions, & integrating LBG (e.g. bioLNG) & other renewable gaseous fuels.
- **Demand 2050 for advanced biofuels + RE methanol comparable to the final demand of Colombia and 1.6 times the final demand of Peru.**

Challenges

- Costs competitiveness; incentives can help. Global pressure to set a carbon levy.
- Limitations on scaling LBG technology into the shipping industry are attributed to the lack of infrastructure required for LBG refueling.
- Supply chain and scalability. Efforts on this direction can foster costs competitive.

Main potential market for biofuels

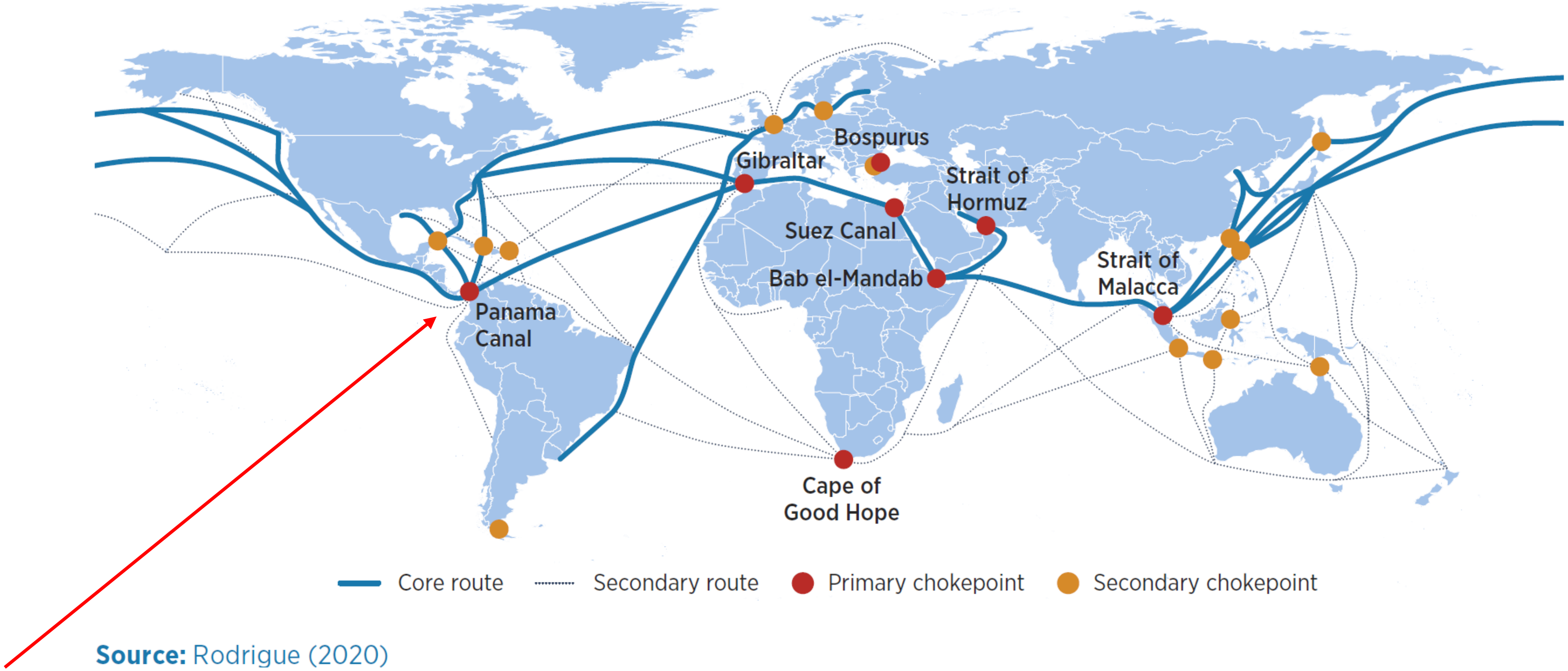


A Pathway to Decarbonise the Shipping Sector by 2050 (IRENA, 2021)

IRENA
International Renewable Energy Agency

It is crucial to identify the geographical locations that could fast-forward the energy transition in the sector

Main maritime shipping traffic routes



Source: Rodrigue (2020)

- **The Panama Canal provides direct access between the Atlantic and Pacific oceans without circumnavigating Cape Horn. In 2019, the Panama Canal reported 13 785 ship passages and a total of around 229 million tonnes of goods.**
- **High need to focus efforts on and facilitating investments in strategic geographical locations.**

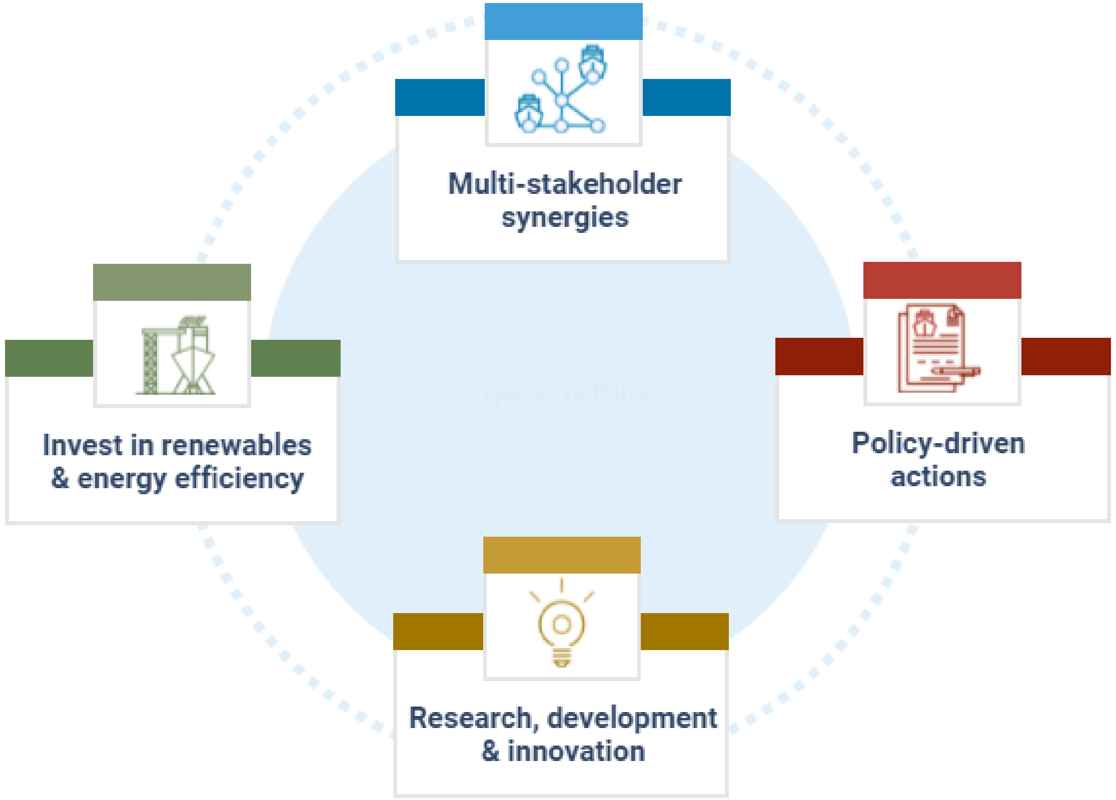
Moving from nearly zero CO2 emissions to net zero requires a 100% renewable energy mix by 2050. To achieve this more ambitious goal, taking early action is critical.

Stakeholders need to develop **broader business models** and **establish strategic partnerships** beyond the traditional players.

e.g. Energy-intensive industries – Power suppliers – Petrochemical Sector, etc.

Enable affordable lines of credit and introduce incentives to foster:

- → Develop **carbon-zero vessels**.
- → Implementation of **retrofits.**
- → **Production of renewable fuels** in resource rich locations.



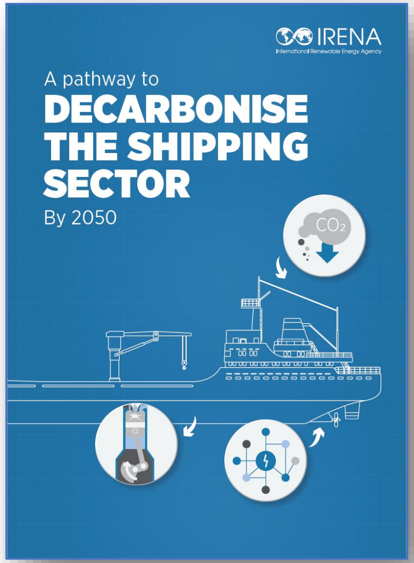
Enable a level playing field for renewable fuels. Early action **will foster employment of renewable fuels and prevent stranded assets.**

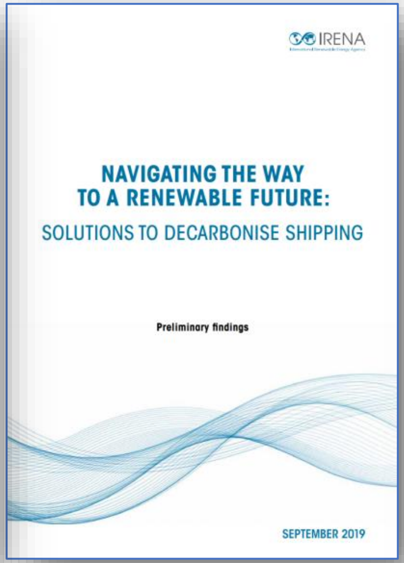
Prompt R&D institutions **to analyse the upstream dynamics of renewable fuels**; **including** the **GHG life cycle analysis** of the different renewable fuels.

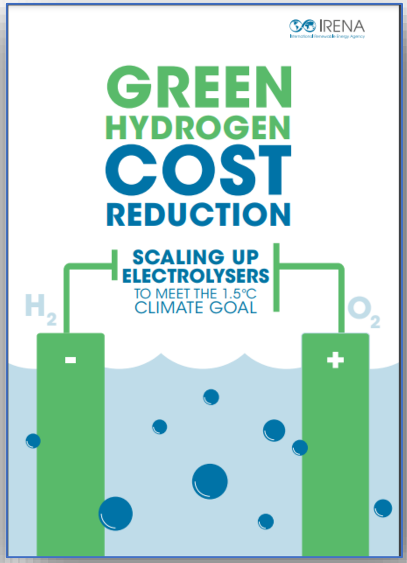
IRENA
International Renewable Energy Agency

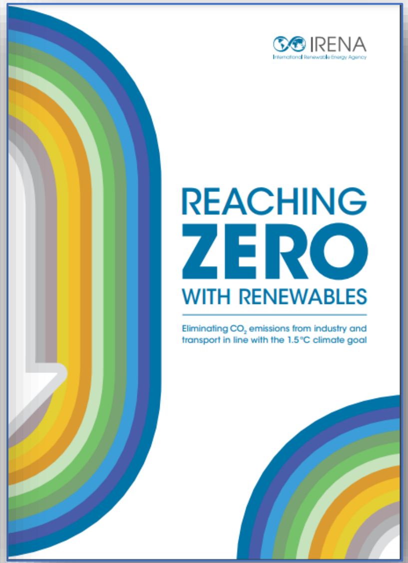
IRENA International Renewable Energy Agency key reports relevant to the shipping sector

Thank you









Gabriel Castellanos V.
International Renewable Energy Agency (IRENA)

Email: GCastellanos@irena.org

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