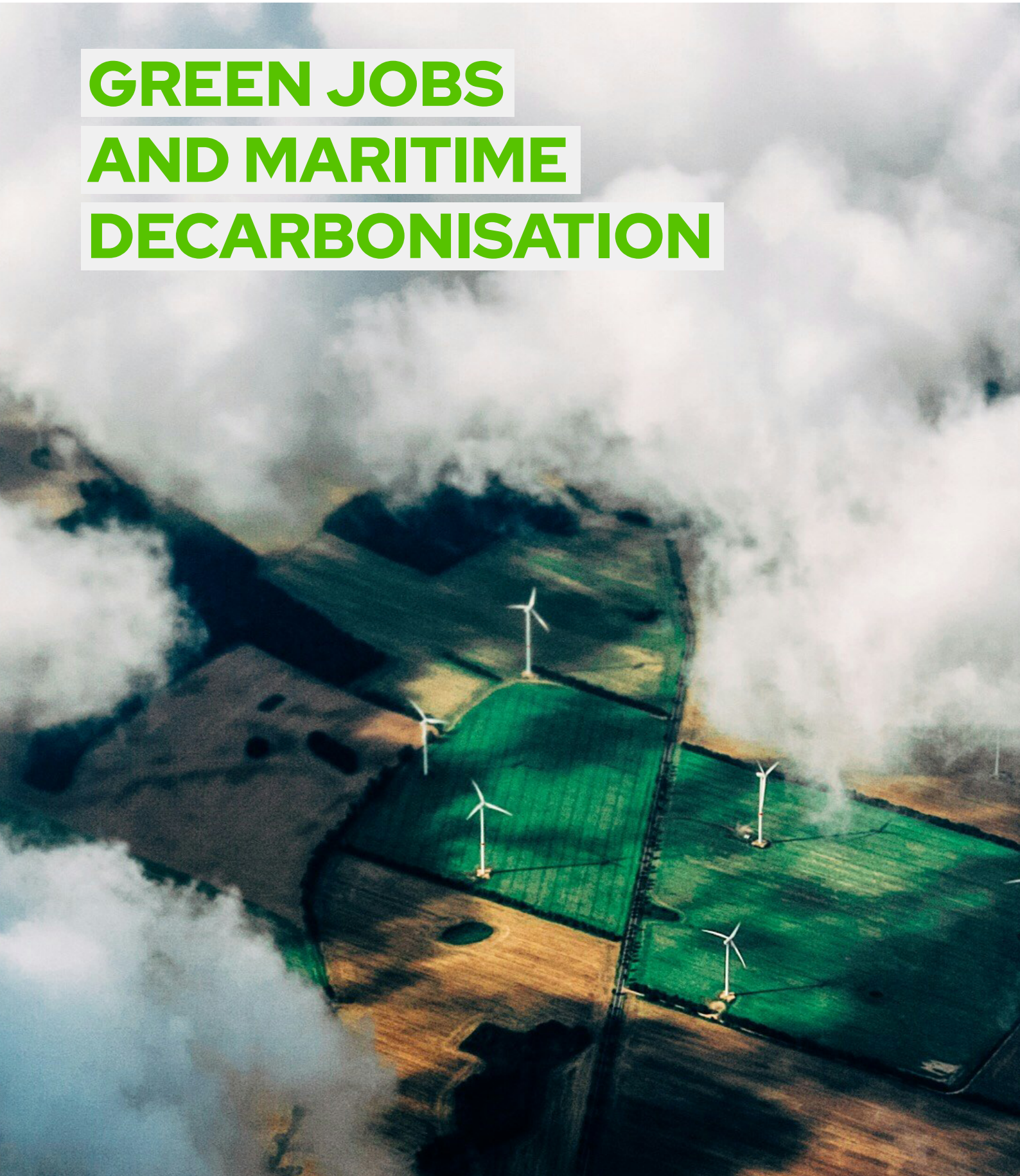
GETTING TO ZERO COALITION

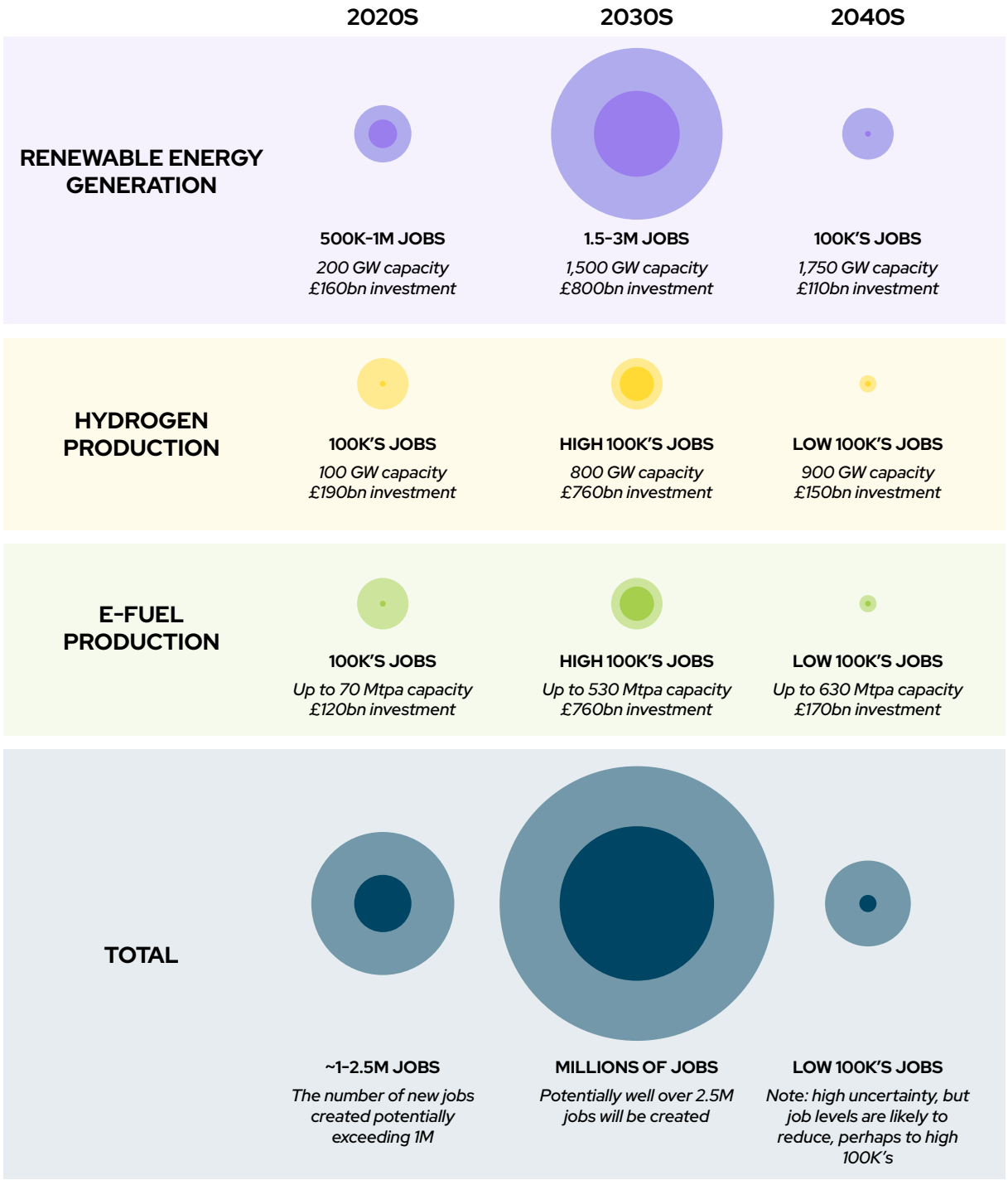
GLOBAL MARITIME FORUM

GREEN JOBS AND MARITIME DECARBONISATION



Executive summary

The transition to scalable zero-emission marine fuels has the potential to create up to **four million jobs across the energy supply chain by 2050**.



The majority of these jobs will come from investments in building out of renewable energy generation capacity and will mostly be created over the 2030s when the intensity of investment will be highest. This scale of potential job creation means that the maritime industry could be a driver for wider decarbonisation across national economies, in addition to helping to promote benefits for countries considering becoming more active in supplying e-fuels to international shipping.

Introduction

The transition to scalable zero-emission marine fuels has the potential to create up to **four million cumulative jobs across the energy supply chain by 2050**. To put this number in perspective, today's global merchant seafarer workforce totals roughly two million.

The creation of these jobs is vital in supporting a just transition to clean sources of energy, furthering climate ambition within shipping and the wider economy, and ensuring that the sector's energy transition creates real opportunities for the people affected.

This insight brief does not attempt to cover all aspects of the green job creation and maritime decarbonisation. It should be considered a starting point for further work on exploring the scale of this opportunity and how to turn this potential into action.

Maritime decarbonisation

Last year, member states of the International Maritime Organization (IMO) agreed to an end date for fossil fuel consumption by targeting net-zero greenhouse gas (GHG) emissions "by or around" 2050. This cut-off date is supported by indicative checkpoints that call for reducing emissions by 20% (striving for 30%) by 2030 and 70% (striving for 80%) by 2040. Next to this, the industry has a target of at least 5% (striving for 10%) zero-emission fuel uptake by 2030.

Large volumes of scalable zero-emission fuels will be required to achieve the IMO's new net-zero target and indicative checkpoints. This will likely include a significant share of e-fuels based on hydrogen, which will make up part of a broader multi-fuel landscape.[1] The production of these fuels can create opportunities for the wider economy while supporting the development of renewable energy projects and the uptake of green hydrogen across other sectors.

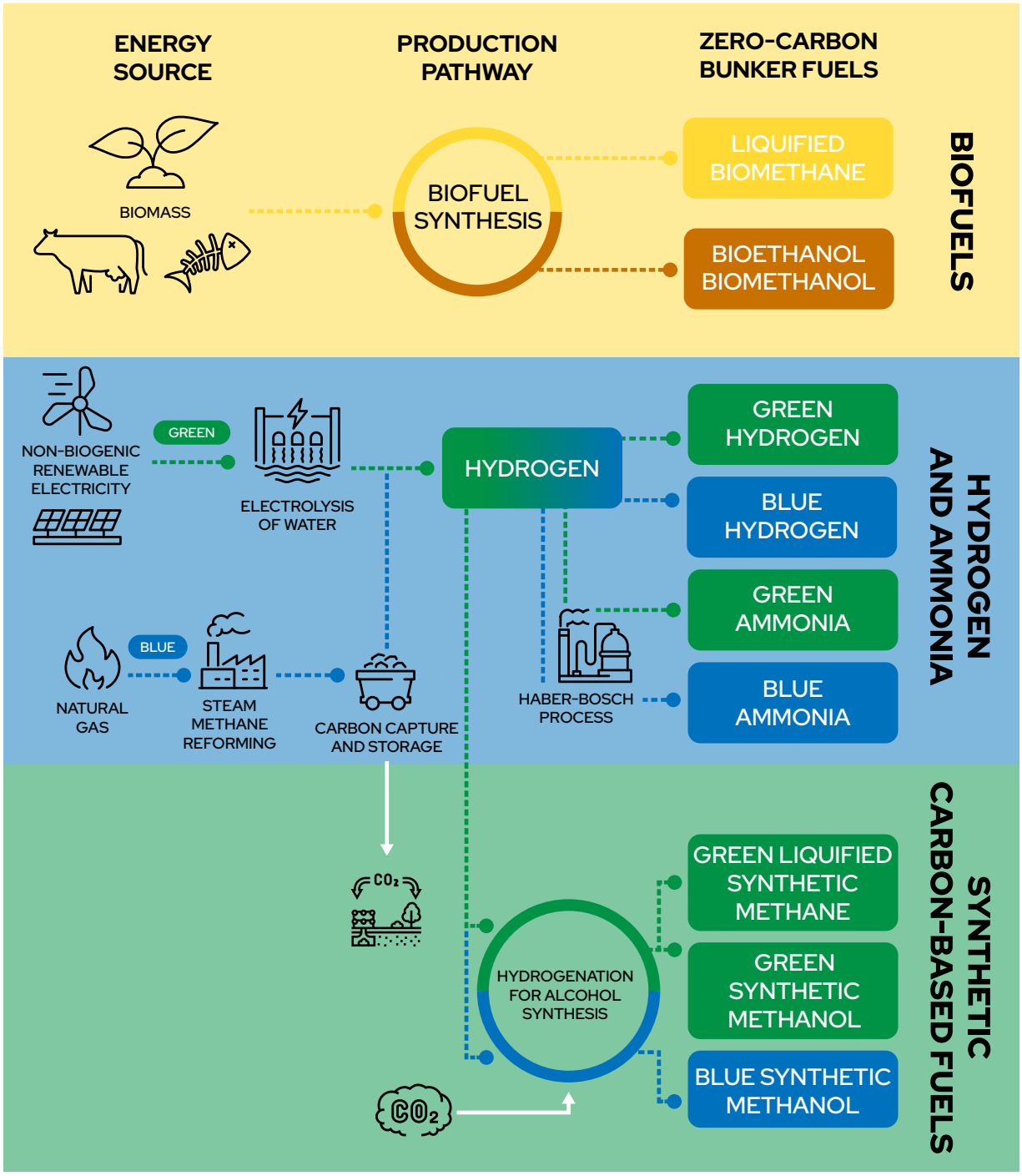
Previous studies have suggested that the scale of investment needed to decarbonise international shipping could approach $2 trillion. However, the positive spill-over effects of these investments are less known. One opportunity is the potential for maritime decarbonisation to support the creation of jobs within the energy sector.

Engineering consultancy Arup examined the potential scale of green jobs linked to shipping decarbonisation, with a focus on renewable energy development and e-fuel production. The study is based on high-level infrastructure capacity-based and investment-based job metrics, where available. The initial findings on the potential scale of the green jobs opportunity should be seen as an exploration of a complex and uncertain topic that can shape the framework for further study and analysis.

Zero and near-zero GHG fuel supply chain

Maritime decarbonisation will ultimately be enabled through the use of low-carbon energy vectors (electricity and fuels) and energy efficiency improvements. The fuel/energy categories include e-fuels, blue fuels, biofuels, electricity, and hydrogen. Different production pathways within each of these will impact the extent of job creation supported through investments in the development of different energy sources, feedstocks, and production facilities.

1 This assumes that the entirety of shipping's energy demand will be met by e-fuels (i.e. green hydrogen, green ammonia, and green methanol).

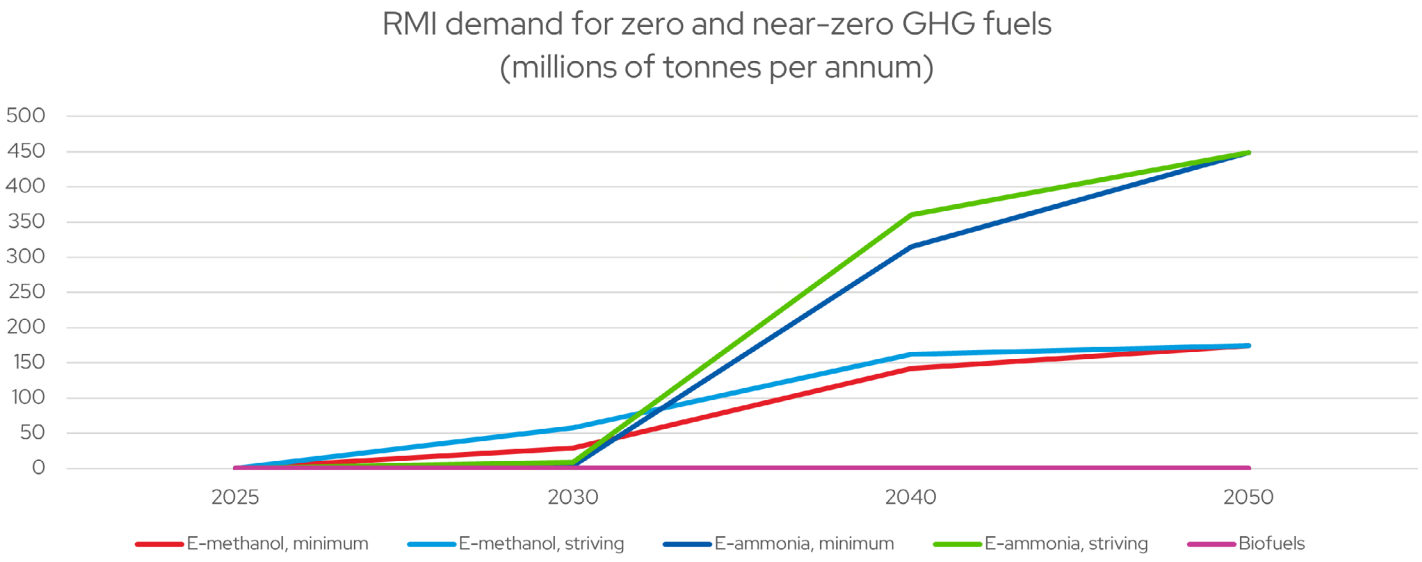


Zero-carbon bunker fuel options for shipping

Source: World Bank (2021). The Potential of Zero-Carbon Bunker Fuels in Developing Countries.

This study considers an illustrative scenario in which e-fuels become the future energy source for international shipping based on energy demand projections conducted by RMI. To simplify the present analysis and initially illustrate the upper end of the scale of the opportunity for maritime decarbonisation to contribute towards green job creation, this brief focuses solely on e-ammonia. It is worth noting that if e-methanol were used instead, there would be only a minor difference in overall job creation.

The upper estimate for the total scale of jobs that e-fuels could supply assumes an almost universal uptake of e-ammonia across tankers, bulkers, and liners. However, a mixed fuel picture is likely, so these figures should be seen in the context of framing the opportunity and setting a likely theoretical upper bound.



E-fuel demand

RMI's projections show that shipping's demand for e-fuels could rapidly scale to over 500 million tonnes by 2040 if e-fuels dominate the fuel mix and decarbonisation aligns with the IMO's striving indicative checkpoints. In this scenario, demand growth beyond 2040 would be more modest, rising to around 600 million tonnes by 2050. This brief's findings are based on this assumed demand profile and an e-ammonia supply chain.

The scale of infrastructure required

The scale of this demand would mean that an additional two terawatts (TW) of renewable energy generation capacity (made up of wind and solar energy) and 1TW of hydrogen production capacity could be required by 2050 to support shipping decarbonisation. For scale, these installations would represent a land area of around 93,000km² for onshore wind, 31,000km² for solar and 155km² for hydrogen, this could require development of land around the size of Greece (for renewables, in conjunction with other uses).

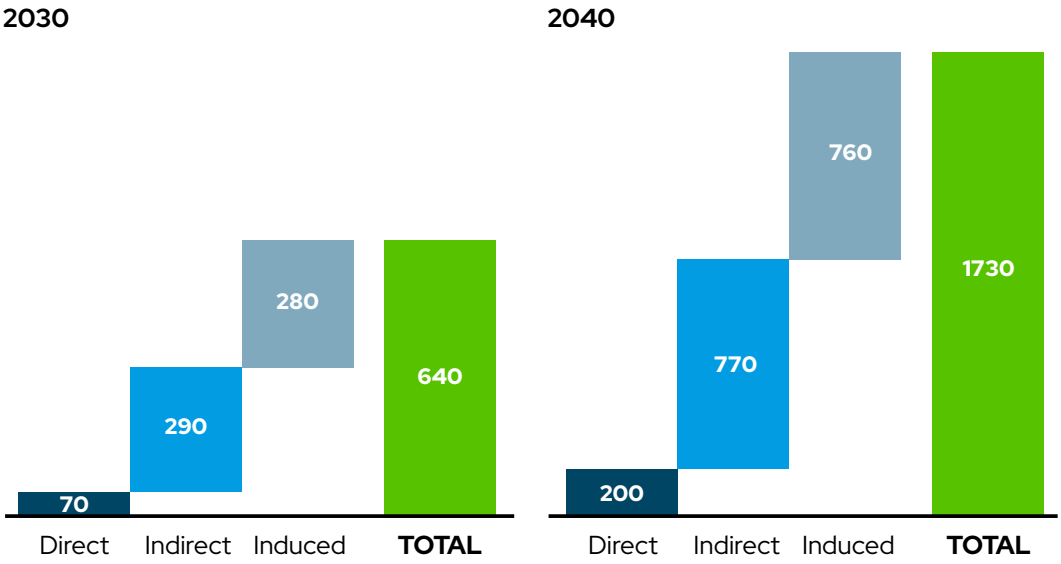
This build-up of infrastructure capacity means that around $4 trillion of investment could be required to develop renewable infrastructure, hydrogen production, and fuel production facilities for e-ammonia for shipping. A mix of various e-fuels will affect the numbers, but as mentioned, the scale will be largely similar. A role for biogenic fuels would likely reduce these overall numbers.

Impact on job creation

The jobs outlined in this study include direct jobs created through specific investments and indirect jobs created within the supply chain to support direct investment. The study does not capture the impact of wider skills developments in other e-fuel intensive sectors (for example, steel or cement) or induced jobs created by increased household expenditure from direct/indirect workers.

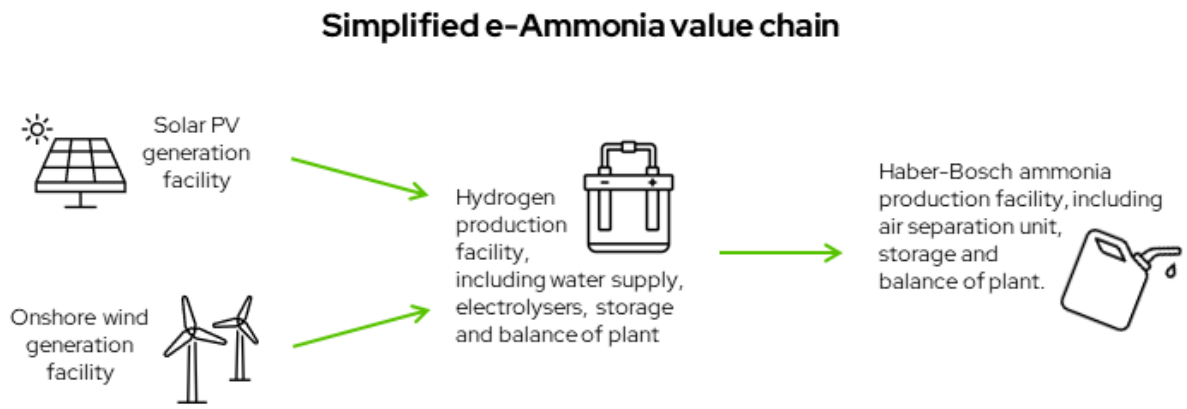
It is worth noting that a study by Spanish oil and gas company Cepsa found that induced jobs could contribute around 30-50% of total job creation, representing a potentially massive source of employment from relevant investments. This shows that there is a strong potential for these investments to provide wider economic benefits not only in the renewable energy supply chain and related industries but also in terms of enhancing people's wealth and ability to engage with their local/national economy.

Direct, indirect, and induced employment (2030-40) (thousands)



Due to the expected rapid scaling of uptake during the 2030s, there will likely be a huge build-out of capacity and capital investment during this decade that would contribute massively towards green job creation. The development and operation of renewables and infrastructure to produce e-fuels for shipping could, according to our projections, create between one and four million green jobs worldwide in the 2030s.

The building-out of this capacity will positively impact job creation across the three main phases of the supply chain: renewable energy generation, hydrogen production, and e-fuel production. This will create jobs in relation to the scale of investment and capacity needed to meet the IMO's interim checkpoints.



Renewable energy generation

The most significant contributor to overall job creation is the building up of renewable energy capacity, which creates jobs across three main markets:

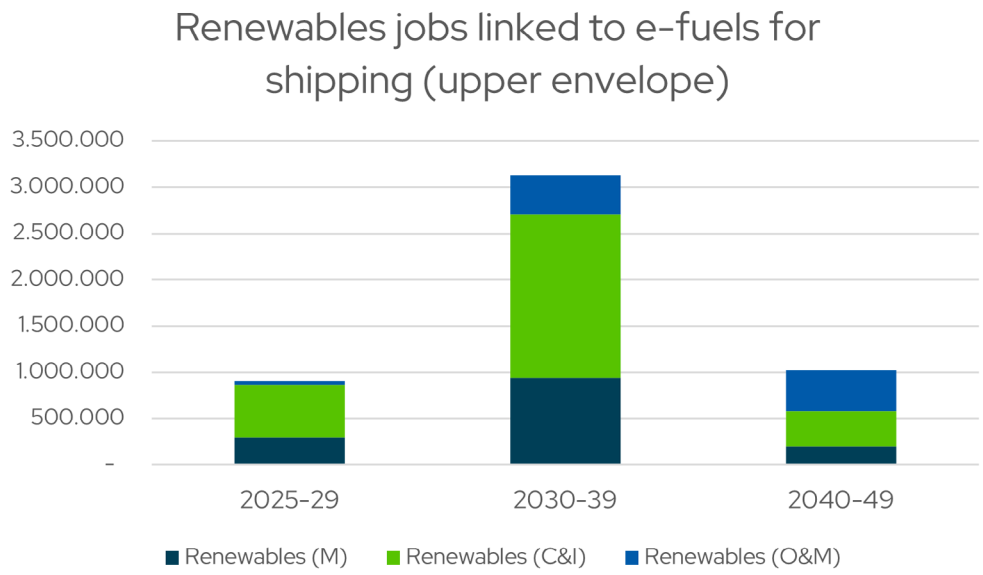
1. Manufacturing (M): The manufacture of component parts from raw materials. Linked to the first few years of a particular project.
2. Construction and installation (C&I): On-site works to construct and commission the generation infrastructure. Linked to the first few years of a particular project.
3. Operations and maintenance (O&M): Ongoing efforts over the life cycle of a generation plant to ensure its ongoing availability

These markets contribute to job creation at different scales, which can be determined in relation to the scale of investment (per million $) or generation capacity (per gigawatt).

Key inputs on renewables jobs		
Solar PV (M) *job-years per GW*	7,500 av.	*(6,700-9,880 range)*
Solar PV (C&I) *job-years per GW*	17,500 av.	*(5,280-27,640 range)*
Solar PV (O&M) *jobs per GW*	500 av.	*(100-1,050 range)*
Solar PV (total) *jobs per $m*	10 av.	*(5-16 range)*
Onshore wind (M) *job-years per GW*	7,000 av.	*(3,400-12,630 range)*
Onshore wind (C&I) *job-years per GW*	4,000 av.	*(3,000-7,060 range)*
Onshore wind (O&M) *jobs per GW*	500 av.	*(300-540 range)*
Onshore wind (total) *jobs per $m*	18 av.	*(9-32 range)*

Source: Job creation in a low carbon transition to renewables and energy efficiency: a review of international evidence

Consequently, if shipping decarbonisation aligns with the IMO's striving indicative checkpoints of 30% emissions reductions by 2030 and 80% by 2040, with e-ammonia produced from green hydrogen:



(based on levels of investment)

- In the 2020s, between 0.5 and 1 million green jobs could be linked to renewable generation deployment for e-fuel production.
- In the 2030s, there could be between 1.5 and 3 million renewables jobs. It is more likely to be the lower end of the range (1.5m), as the deployment of renewables becomes more labour efficient.
- In the 2040s, job numbers are less clear due to the uncertainty in renewables costs and labour intensity. The number of jobs declines when compared to the 2030s as the rate of renewable generation deployment reduces.
- Renewable jobs are primarily in manufacturing, construction, and installation, whereas jobs associated with operations and maintenance activity grow as a share of total jobs over time.

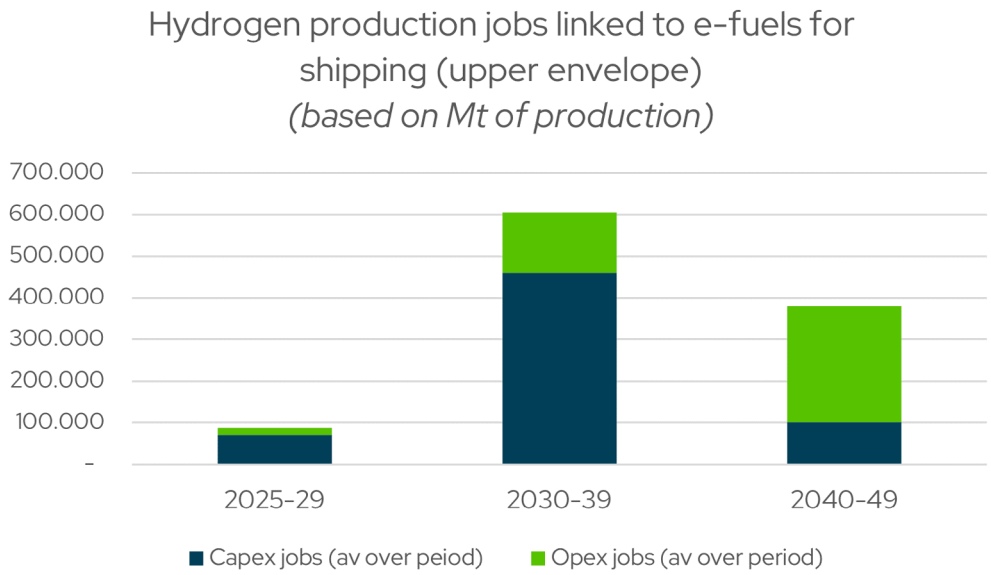
Hydrogen production

For green hydrogen production, the impact on job creation was determined in reference to some key studies, including work by The Navigant and Hydrogen Workforce Australia. As a relatively nascent industry, it is worth noting that there is currently relatively little published research on the relationship between jobs, installed capacity, and investment.

To estimate the number of potential jobs, the following assumptions were made based on these reports in addition to Arup's own experience in developing projects:

1. 5,650 jobs created for every million tonnes of e-fuels produced per year during the initial investment;
2. 2,700 jobs created for every million tonnes of e-fuels produced per year during the ongoing operations; and,
3. 15-20 jobs per $1 million of initial investment

What this means in terms of overall job creation is that:



- In the 2020s, around 100k jobs jobs could be created.
- In the 2030s, jobs are likely to peak and could reach from mid-100ks to over a million.
- In the 2040s, it is uncertain how the technology will be deployed, but job numbers are likely to reduce from their peak to the low hundreds of thousands.

E-fuel production

The development and operation of ammonia production facilities could result in a total scale of jobs similar to green hydrogen production, but there is a notable lack of available evidence in this space. However, the growth of job numbers would likely follow the same trends as renewable and hydrogen production and decline in the 2040s as capital investment reduces.

It is worth noting here that at plant level the potential scale of jobs relating to e-ammonia is likely to be similar to e-methanol.

Future research agenda

To improve the results of this exercise, modelling should be conducted on the role of other future fuels on job creation, including pathways such as advanced biofuels or green methane. Future studies should use a scenario-based analysis to highlight possible different pathways and their impact on job creation. This could offer a more holistic view of maritime decarbonisation's impact on job creation and result in more concrete projections.

Uncertainty in the future predictions on the eventual cost and efficiency of new infrastructure is likely to affect the gross numbers of jobs created by e-fuels. This is particularly true when it comes to renewable energy installations and hydrogen electrolysers. As such, further analysis will be needed to reduce the wide range in the total job creation numbers predicted here.

More work also needs to be done to understand the different geographical implications of green job creation. What is clear at this stage is that these jobs will mostly be distributed in locations with the most favourable conditions for producing green fuels, likely in the Global South. Investments in developing countries have also been shown to contribute towards significantly higher job creation

than equivalent investments in developed countries, suggesting a high potential for developing countries to leverage investments towards wider green job creation.

Investments in zero-emission maritime infrastructure provide a direct quantifiable contribution to a country's economy through job creation. This could help offset the potential for the green transition to increase trade costs and help shore up support for the energy transition.

There is also a need to develop a deeper analysis of the quality of green jobs expected to be created by the decarbonisation of the maritime sector. This should build on existing work addressing workers' well-being, in addition to looking at the transferability of skills to other sectors and the longevity of these positions once created through initial investment.

Lastly, future studies could also investigate the impact on net job creation by considering the fossil-fuel jobs that will be lost and highlighting how many jobs could potentially transfer out of the existing shipping fuels sector.

Conclusion

There is a strong connection between maritime decarbonisation and a just transition through the stimulation of green job creation. The order of magnitude of up to four million jobs by 2050 is hugely significant, considering that only two million seafarers currently work within the maritime sector.

The majority of these jobs are likely to be tied to the expansion of renewable energy generation capacity. We can also see that much of this job creation will most likely happen in the 2030s due to the enormous capital investments into infrastructure expected that decade.

Stimulating the creation of these jobs will help many countries transition away from fossil fuels in a way that provides opportunities to those workers negatively affected by the phasing-out of carbon-intensive industries. Supporting the development of new skills may also help countries build up the capacity needed to stimulate renewables and hydrogen production nationally. This could support wider decarbonisation across other sectors and help countries develop national hydrogen economies and ultimately contribute towards the increased localisation of specific supply chains (e.g. steel, cement, and/or energy).

In addition to providing a potential alternative for those at risk of losing their current employment, the creation of these renewable jobs is also likely to create better conditions for workers transitioning into the renewables space. This is supported by work conducted by the International Renewable Energy Agency, which shows that jobs in renewables are generally higher skilled, better paid, more gender diverse, and of a higher quality than those within traditional fossil fuel sectors.

To ensure that maritime decarbonisation can effectively contribute towards a just and equitable transition, increased attention must be paid to the interaction between the marine fuel transition and job creation. It is hoped that this insight brief can provide some initial framing for this topic and encourage further discussions on realising the shipping sector's potential to contribute towards a greener, fairer future for workers.

Appendix

PWC (2022). Developing Australia's hydrogen workforce.

IRENA (2023). Renewables 2023: Analysis and forecasts to 2028.

Hanna, R., Heptonstall, P. & Gross, R. Job creation in a low carbon transition to renewables and energy efficiency: a review of international evidence. Sustain Sci 19, 125–150 (2024).

The Navigant (2019). Gas for Climate: Job creation by scaling up renewable gas in Europe.

IRENA (2022). Renewable Energy and Jobs: Annual Review 2022.

CEPSA (2024). Green Molecules: The Upcoming Revolution in the European Employment Market.