CLEAN ENERGY MARINE HUBS

AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

MARITIME INFRASTRUCTURE FOR CLEAN ENERGY COMMODITIES

INSIGHTS FROM PRIVATE SECTOR LEADERS

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Shaping the Future of Shipping

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About CEM-Hubs

The Clean Energy Ministerial Hubs (CEM-Hubs) initiative is a first-of-it-kind partnership between the private sector and governments across the energy-maritime value chain – the International Chamber of Shipping (ICS), the International Association of Ports & Harbors (IAPH) and the Clean Energy Ministerial (CEM), led by governments of Brazil, Canada, China, Greece, Malta, Norway, Panama, Uruguay and the UAE. The International Renewable Energy Agency (IRENA) and the Global Centre for Maritime Decarbonisation (GCMD) support the initiative together with ABS, Lloyds Register, OCIMF and the World Economic Forum. All collaborating to unlock the production, transportation and use of low-carbon fuels for the world at scale.
www.cleanenergyministerial.org

About the International Chamber of Shipping

The International Chamber of Shipping (ICS) is the global trade association representing national shipowners' associations from Asia, Africa, the Americas and Europe and more than 80% of the world merchant fleet. Established in 1921, ICS is concerned with all aspects of maritime affairs particularly maritime safety, environmental protection, maritime law and employment affairs. ICS enjoys consultative status with the UN International Maritime Organization (IMO) and International Labour Organization (ILO).
www.ics-shipping.org

1.EXECUTIVE SUMMARY

Transporting clean energy commodities across the globe is a complex undertaking, requiring large investment across a long lead time, but with the potential to deliver high economic and environmental rewards if managed correctly by regulators, investors and industry players.

This paper captures high-level insights about creating a global clean energy maritime transportation infrastructure from 19 private sector CEOs and leaders. It offers guidance for governments, regulators, and other stakeholders that enable them to by collaborate and create the conditions needed to enable clean energy hubs worldwide at ports and increase security of supply of low-carbon fuels.

Private sector leaders agree that low-carbon fuels will play an important role in the future energy landscape, especially in cases where electrification is not possible. The opportunity of a long-term demand and the current technological readiness for production positions suppliers to potentially scale up production to match demand.

However, the substantial investment in current fossil-fuel assets and infrastructure create an economic incentive for various industries to focus on energy-efficiency, making the payback timeline uncertain.

Timely action must be taken to facilitate the creation of a sustainable value chain for emerging fuels, but this requires a coalition of the willing to create a favourable environment. This is particularly the case since leaders anticipate a multi-fuel future with different stakeholders investing in a fuel that meets their specific needs, thus limiting global scalability of the emerging fuels market.

Strategic collaborations, such as the cross-sectoral, public-private Clean Energy Ministerial (CEM) initiative, could change this by combining knowledge and resources from the public and private sectors.

Governments were identified as holding the greatest power given that regulation is a powerful lever to drive consumer demand and build market confidence. If designed with a focus on industry decarbonisation in a fuel agnostic manner, stable regulations could drive the creation of long-term demand and spur technological advancement.

Green-lighting high value public infrastructure investments in new fuels would signal stable support to both producers and consumers. Additionally, repurposing funding instruments for unconventional fuels and establishing global fuel and safety standards are likely to de-risk the energy transition and be accepted by the finance and insurance sectors. Scalability of the clean fuels market relies on the ability to connect producers with consumers around the globe.

Maritime infrastructure such as ports were seen as ideally placed to act as Clean Energy Marine Hubs (CEM-Hubs) for the import and export of low-carbon fuels. Not only would such locations work to aggregate demand from various sectors, but they can facilitate the import of other materials for semi-finished goods.

Furthermore, existing transport connections to the hinterland would create economic opportunities for sparsely populated areas to create new links in the fuels value chain. Interviewees suggested that implementing learnings from other fuels, such as LNG and biomass, would speed up the market adoption of emerging fuels.They also highlighted that creating a shared roadmap for governments, industry and any other relevant stakeholders is likely to build confidence and maximise value.

The information in this paper can be used to create a blueprint for relevant stakeholders to de-risk opportunities to produce, transport and use low-carbon fuels at scale for shipping to transport and use.

2. KEY FINDINGS FROM LEADERS

Key finding 1: Current investment expectations from industry

- **Limited access:** The private sector leaders interviewed for this paper do not expect any substantial increases of alternative fuels in the global fuel mix until after 2030-2035. This assumption from interviewees is based on three factors: the current investment pipeline (which is insufficient for significant change); the amount of time it takes to develop the infrastructure; and market conditions. However, it is possible that policy implementations and market conditions could increase the share of low-carbon fuels after this period.
- **Slow pace of growth:** The rate of change or low-carbon investment is currently linked to the 'timing of renewing or changing end-of-life assets', limiting the pace of growth for alternative fuels.
- **Investment conditions:** In all cases, investments from CEOs and energy-maritime value chain leaders depend on the size of investment required, local and international long-term regulation, and the economic lifetime of past investments (locking in current progress).

Key finding 2: Fuel type preferences

- **Fragmented market:** Unless there are clear demand signals on types of fuels to be used, companies and investors have diverse preferences for different low-carbon fuels with limited scale. Most tend to choose only one of these fuels (e.g. methanol, ammonia or biofuels), which will hinder scalability as demand will take longer to reach production tipping points.

Key finding 3: Investment barriers

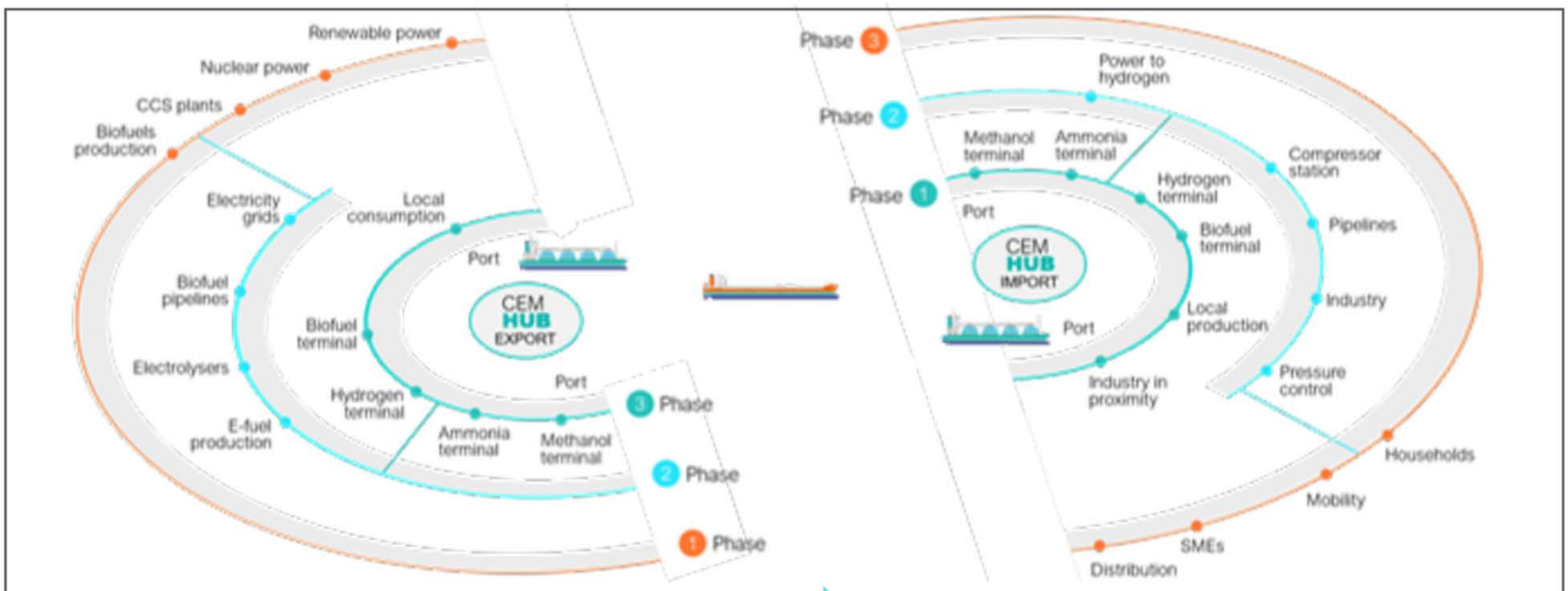
- **Need for sustained demand:** The biggest barrier for investment is related to the need for long-term contracts (15 years or more) as these low-carbon fuels have higher cost than conventional options, lack market confidence regarding long-term demand, and are yet to establish international standards for trade.
- **Insufficient green finance:** Green finance mechanisms are not yet seen as dealmakers for investors interested in low-carbon fuel infrastructure projects. Support by governments would de-risk investment and drive demand generation. Instruments such as green bonds, climate-related financial support, etc. would be suitable means to drive change and also signal high-level support for the energy transition.
- **Need for internationally-recognised framework:** The low-carbon fuel market is expected to become global in nature, and thus must be designed for multi-regional access with international standards and transparency. This could mimic existing structures such as the current global fuel markets for oil, gas and coal, which would guarantee familiarity.
- **Geo-political tensions:** CEOs and industry leaders have concerns about indicators of political fragmentation as well as the availability of fuel for specific sectors such as aviation and maritime.

> **CEO Interview**
>
> *Customers are not willing to pay the higher product prices for green hydrogen in comparison – hence the economics of projects is a challenge.*

Key finding 4: ‘ Aggregating demand using hubs

- **Ports as CEM-Hubs:** The creation of CEM-Hubs at ports could be a short-term driver to aggregate low-carbon fuel demand across multiple sectors and develop the maritime infrastructure that enables clean energy commodity trade on a global level.
- **Collaboration is essential:** Isolated efforts or developing a single hub will not work as a global network is required to consolidate demand as well as benefit from economies of scale (see infographic). A coalition of governments and private stakeholders could support the enabling factors that will position global maritime infrastructure and CEM-hubs as an accelerator of the energy transition.
- **Infrastructure timeline:** As maritime infrastructure development will take decades to develop, the timeline to increase the share of low-carbon fuels in the future global fuel mix will play a big role in the success of the energy transition. Taking action as early as possible will increase the likelihood of success, particularly if large scale projects or contracts are green-lit.

CEM HUBS: CREATING THE ENABLING INFRASTRUCTURE ECOSYSTEM REQUIRED AT PORTS



SCALING THROUGH MULTIPLE HUBS AGGREGATION OF DEMAND AND SUPPLY OF ALTERNATIVE FUELS

To scale alternative fuel exports at ports for multiple sectors to benefit, substantial development of infrastructure is required in **multiple Hubs (export and import)**

- Safety, future fuel risk assessment and international best practices from industry are key to reduce the risk to increase adoption of these fuels.
- Decision between local consumption and export is driven by economics.
- Transparency and cross-border cooperation are needed, supported by international standards.
- Maritime infrastructure allows excess amounts to export to global markets that would help other regions to decarbonise through imports.
- Electricity grids and large off-grid projects enable large electrolysers and e-fuel production.
- Vast areas can be used to produce alternative fuels with access to a port and export them to densely populated areas.

ORGANISATIONS WHOSE LEADERS CONTRIBUTED INSIGHTS

- BP, United Kingdom
- CEFIC, Belgium
- E. ON, Germany
- Engie, France
- En2X, Germany
- Equinor, Norway
- Fafalios, Greece
- Fleet Management Ltd, Hong Kong
- Hamburg Port Authority, Germany
- HIF Global, Chile
- Höegh Autoliners, Norway
- North Standard, United Kingdom
- Pacific Basin Shipping, Hong Kong
- Pilbara Port Authority, Australia
- Port of Açu, Brazil
- SEFE, Germany
- Sohar Port, Oman
- Uniper, Germany
- XPF, Singapore

FINDINGS PRESENTED TO CEM GOVERNMENTS



CEM Hubs meeting in Busan, Korea in August 2025

3. CEM HUBS INITIATIVE: CORE AREAS OF FOCUS

Regulatory support	Market certainty	Pooling via hubs
Regulation is a key driver of change, combating the risk of remaining locked into systems that do not meet GHG emission reduction goals. Many industries are presently focused on reducing fuel consumption via energy efficiency. Regulation can be used to support greater production of and access to low-carbon products in the global fuel mix, which is necessary to decarbonise hard-to-electrify sectors. Emission-focused and fuel agnostic regulation could assist in the creation of a global market with suitable technologies and internationally-accepted fuel standards. It would also facilitate fuel risk assessments for insurance and finance processes.	The biggest barrier for investment in low-carbon fuels continues to be the lack of long-term contracts, such as offtake agreements for future production. Despite progress in Asian markets, there is an ongoing lack of confidence in future demand. Although the Technology Readiness Levels (TRLs) for investment are not viewed as a problem, it is challenging to incentivise demand for diverse stakeholders across industries with different asset portfolios. Without growing demand and a willingness to move away from operations that are embedded in existing long-term infrastructure, the global energy transition is likely to take decades.	Matching global production of low-carbon fuels to market demand across various regions and sectors would accelerate the energy transition. Maritime infrastructure can be a key enabler as it has the ability to transport clean energy commodities and match demand with production. It is particularly powerful if numerous cross-sectoral demands can be pooled together in specific locations, i.e. ‘hubbing demand’. CEM-Hubs at ports would deliver economies of scale by harnessing the existing global transport network. A coalition of governments and private sector stakeholders across the energy-maritime value chain can drive concentrated demand through these hubs.

> CEO Interview
>
> *Ideally, export and import hubs will be developed synchronously in various regions, with the strong demand of industrialised areas giving the investment signals. International cooperation and coordination of a few countries with critical size will then kickstart the global development.*

> CEO Interview
>
> ***Clean Energy Hubs will become industrial centres and benefit from the ability to trade with alternative commodities as well as with semifinished and finished goods.***

4. BRIDGING THE GAP

Today's world is deeply interconnected with its trading flows, especially those pertaining to energy, critical materials and electronics. Global trade - underpinned by the flexibility that maritime infrastructure provides - helps to mitigate the risks of supply concentration and facilitates movement of energy commodities. In previous crisis situations in the fossil fuel markets, maritime transport facilitated a relatively easier replacement of suppliers, despite potential economic costs.

Nevertheless, as the 2021-2022 gas supply crisis demonstrated, markets can react extremely quickly to disruptive changes. This is likely to be the case for alternative fuels, which requires efforts to scale up the maritime infrastructure across different regions of the world in order to maintain a sufficiently high level of security of supply.

The development of global markets for emerging fuels as feedstock as well as energy carriers will take place at different paces depending on the fuel type and the region. Most existing production is currently in proximity to consumption jurisdictions, but this could change in the near future as a result of market participation by 29 CEM member countries. Additionally, CEM-Hubs located in the global south may reconfigure value chains to deliver emerging fuels as well as a growing number of semi-finished products to the global markets.

The CEM's ability to connect government energy and infrastructure planning, industry recommendations and key global trade stakeholders in emerging fuels is a powerful lever. This goes beyond technical expansion and physical infrastructure, and encompasses regulation, investment and cooperation to enable smooth, cost-effective and safe trade in these low-carbon fuels.

CALL TO ACTION: CEM members, associated countries and relevant initiatives have an opportunity to shape global trade in low-carbon fuels by acting as a bridge between political, economic and technological actors for deployment. The CEM can play a central, supportive role in the transformation of the global maritime infrastructure to accelerate the energy transition and support clean energy supply chains.

Recommendation 1: Demand focus	Recommendation 2: Coordination framework	Recommendation 3: Shared agenda
Policy makers should prioritise triggering demand for low-carbon fuels and infrastructure by using methods such as a quota system or reduced taxes for low-carbon fuels. This is more powerful than supply incentives, which have greater risk and lower effectiveness. As the TRL for suppliers is high enough to allow for investments if there is sufficient stable demand, research should not be the key priority - although it is still needed.	Policy makers should focus on the affordability and security of the supply of non-conventional fuels. They should develop clear and reliable frameworks that allow industries to coordinate their efforts. Technological openness, transparency and international cooperation (particularly on setting mutual recognition of standards) will be critical to improve the pace of the energy transition.	Countries should start building a coalition of the willing with a clear common agenda of promoting cross-border projects with coordinated market ramp-up strategies. This should be an initiative run in conjunction with industry and will support infrastructure readiness as well as enhancing the security of supply and enabling faster demand growth for the new fuels.

5. INVESTMENT CONSIDERATIONS

The current global infrastructure is the result of multiple decades of long and continuous optimisation along all parts of the value chain. ***Low-carbon fuels can be supplied using existing fossil fuel infrastructure without any changes to the current use of assets along the value chain. However, a major stepwise investment will be needed to replace one or more sections of the value chain in order to support multiple emerging fuels, particularly at high volumes.***

Blending of low-carbon fuels allows the use of current infrastructure and plants, without changes to the economic lifespan of assets. A more radical approach to non-traditional fuels is likely to require massive investment and devalue the existing fuel infrastructure. This could create a completely new fuel value chain - which may also come into existence by the inclusion of more semifinished products in the value chain.

Understandably, investors' appetites depend on the size of the investments required as well as the economic lifetime of past investments and assets. Stakeholders with a portfolio of small and modular assets can invest frequently to achieve a gradual change in their portfolio and increase the share of alternative fuels gradually. By contrast, stakeholders with a few, large assets make replacement investments over longer timelines, creating a step-like structure for their contributions to the emerging fuel infrastructure. As the slowest part of the value chain will determine the overall development, organisations with big portfolios are more easily able to invest.

Interviewees stated that investments are driven by capital costs (CAPEX) that are used to buy, maintain, or improve fixed assets) and operating costs (OPEX) which are used to run products, the business, or systems. In many scenarios, OPEX is seen as easier to control as running costs can be adjusted to match demand. However, for long-term commitments, if CAPEX is not expected to be earned with the asset over a reasonable period, companies do not consider these investments as reasonable.

E-Fuels are a particularly good example of a situation in which investors are at risk of high OPEX, as local electricity prices are typically the most volatile cost factor. This risk can be mitigated by using a grid-independent power supply, with an on-site power purchase agreement (PPA). In such cases, the electricity supplier shoulders the CAPEX and sells the electricity to the fuel producer as part of a long-term agreement. This results in very low or zero grid fees, much lower taxation and predictable generation costs. However, this needs the coordination of several industrial players since a completely new value chain must be established. This is also the case with blue hubs, which require coordination with carbon capture utilisation and storage (CCUS) activities.

The scale of cooperation across different players in the whole value chain necessitates an ecosystem-based approach rather than a focus on individual projects - and must be reflected in regulation. The transition diagram below highlights the mutual interdependence in value chains. Drop-in fuels can easily be used to kick-start the process of adoption as they only need a change in the first section of the value chain. By contrast, non-drop-in fuels require radical changes to all parts of the value chain, with very limited use for existing infrastructure.

CEO Interview

> *Global markets react immediately. As soon as distortions can be seen, e.g. undersupply, volumes will be shifted from other suppliers to the undersupplied region, provided the supporting infrastructure is existing.*

INVESTMENT OF NEW INFRASTRUCTURE TO TRANSITION FROM FOSSIL FUELS IN DIFFERENT FUEL PATHWAYS



Current fossil fuel-based pathway	Oil, gas, coal (Extraction)	Refineries & fossil processing	Port infrastructure, pipelines, tankers, fuel depots	Industrial delivery, petrol stations	End use: industry, heating, cars, trucks, ships, planes
Easier integration: drop-in commodities allow for a smooth transition. Hydrogen can replace conventional inputs without significant modifications to facilities or processes.					
Drop-in fuels pathway	Oil, gas, **new** renewables (Biofuels, e-fuels), **new** nuclear, **new** CCS	Refineries and **adapted** processing	**Existing** port infrastructure, pipelines, tankers, depots	**Existing** industrial delivery, petrol stations	End use: **no change** in equipment
More difficult integration: non-drop-in fuels lead to disruptive changes along the full value chain. **Changing the whole mega chain.**					
Non-drop-in fuels pathway	**New** carbon neutral electricity + water	**New** electrolysers and e-chemical plants	**New** port infrastructure, H_2 pipelines, ammonia/fuel tanks	**New** refuelling and industrial interfaces	**New** end use tech: fuels cells, H_2 burners

Interviewees uniformly expected a global market for alternative fuels. However, international demand is yet to be seen as a driver for unconventional fuel projects, despite it being visibly fulfilled in some niches using existing transport infrastructure.

Private-sector leaders overwhelmingly believed that the major short-term driver for such projects would come in the form of local consumption combined with industrial policies to create CEM-Hubs. They also stated that the supply infrastructure for these projects was likely to be built in low-cost electricity areas where other electricity-intense industries would also purchase the low-carbon fuels as feedstock.

Historic experiences from the LNG market show that development of a global fuel market is driven by huge investments backed by long-term commitments from buyers and sellers, who both benefit.

Sellers experience secure demand and thus can invest in supply infrastructure with low risk.

Interviewees highlighted that global regulation could be enormously helpful in providing reliable signals to value chain stakeholders, especially if GHG emissions were the defining element used for pricing. They also pointed out that a global market would increase competition, helping consumers by reducing market prices and triggering technological innovation.

> CEO Interview
>
> ***The easiest way to increase the competitive situation for alternative fuels in cars is a tax exemption for the share of alternative fuels. This would help to create a stable demand and to reduce GHG emissions of road transport.***

6. LEARNING FROM PAST EXPERIENCES WITH THE DEVELOPMENT OF OTHER FUELS (LNG)

When considering how a global market for low-carbon fuels could develop, interviewees considered it vital to apply the lessons learned from other fuels such as LNG. They emphasised that infrastructure to support fuel production and distribution was just as important as supply and demand. This is typically a multi-project endeavour that takes several decades to reap rewards. In the case of LNG, the first commercial plant was built in 1940, but the real scaling only started after a series of technical improvements made in the 1960s.

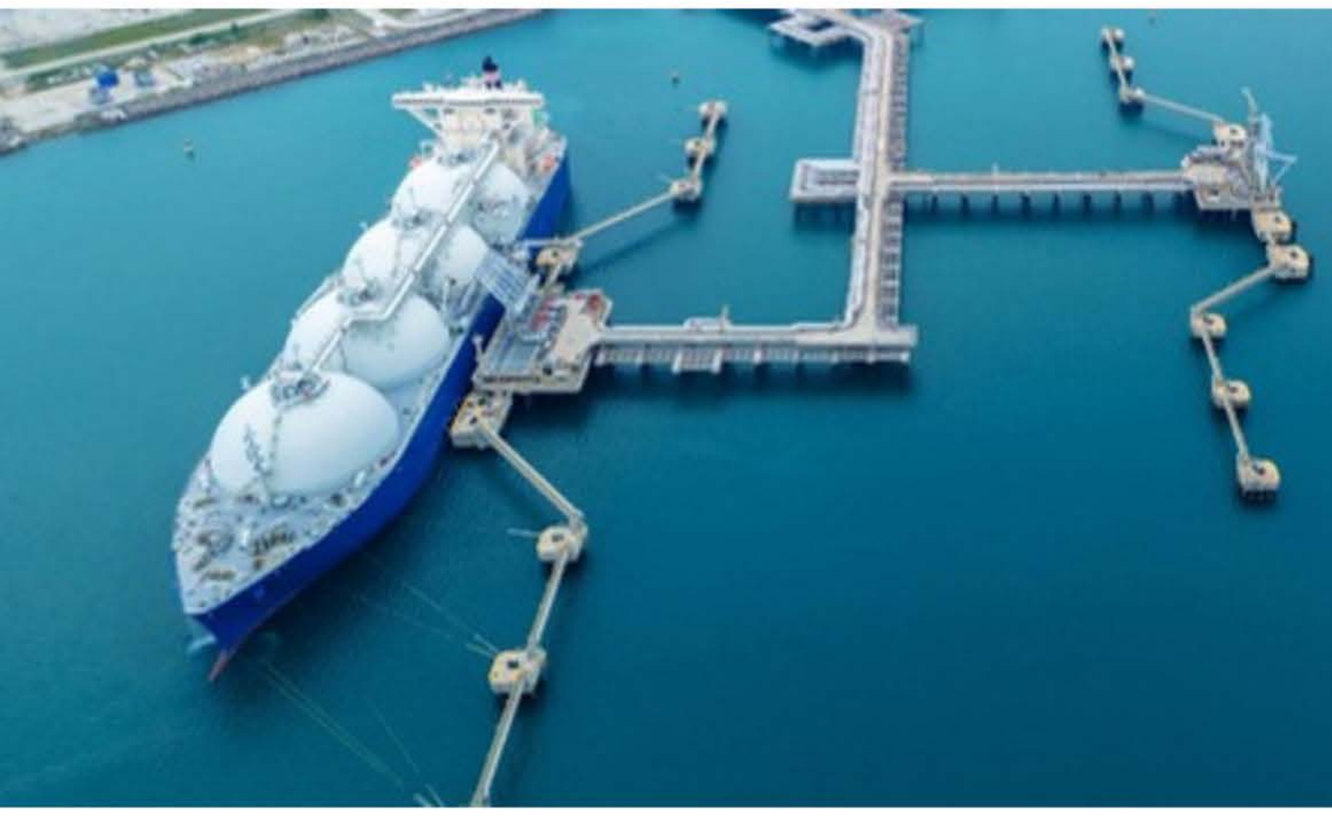
Long-term contracts were a crucial means to initiate LNG infrastructure projects to overcome the extended timescale for payback. These helped infrastructure operators prove the bankability of their projects, and allowed buyers to secure their supply of LNG via a portfolio of long-term contracts with different suppliers. Additionally, from a trading point of view, long-term contracts have not been viewed as instruments of market foreclosure if reselling of the LNG is permitted.

Interviewees cited the importance of stable, technical definitions of fuel quality (such as energy content, pressure etc.), which are an important prerequisite to enable the global trading of commodities and were a primary driver of this market.

These definitions tend to be easily agreed on as they are measurable. By contrast, non-technical criteria are more difficult to standardise, as is seen in the case of bio-LNG, which has various definitions and is typically proven though the use of green certificates.

New forms of LNG (such as bio-LNG and e-LNG) have been successfully integrated into global trading by blending as these were drop-in fuels that used existing infrastructure without modifications. No changes were needed for use by large industrial chemical operations, gas-fired power stations or for residential heating (which has much smaller scale consumption). As demand for LNG already existed and applied to the new forms of the fuel, modifications were only made on the supply side. This is important, since it often takes much longer to roll out technologies on the demand side as compared to the supply side.

Respondents highlighted the benefit of using maritime transport to increase access to multiple fuel providers meaning that if deliveries are missed by one supplier, they can be replaced almost immediately by other suppliers' deliveries. In LNG markets, this flexibility to choose a supplier from across the world enhanced the security of supply, ramped-up infrastructure at a faster



> ***We need all alternative fuels in our industrial processes as feedstock i.e. methanol and ammonia and others. Focusing on a single alternative fuel would not be in the interest of our industry.***
>
> CEO interview

pace and helped to scale the volume of production. It also boosted market competition, which often reduces costs and improves the affordability of fuel access for multiple sectors - an important factor as emerging fuels will almost certainly be more expensive than conventional fossil fuels.

The role of ports and proximity of the fuel to the relevant maritime infrastructure were also talking points for interviewees. They pointed out that the excellent availability of LNG near ports has made these sites attractive to industrial consumers, since it also allows for easy delivery of other raw materials and the easy export of produced goods.

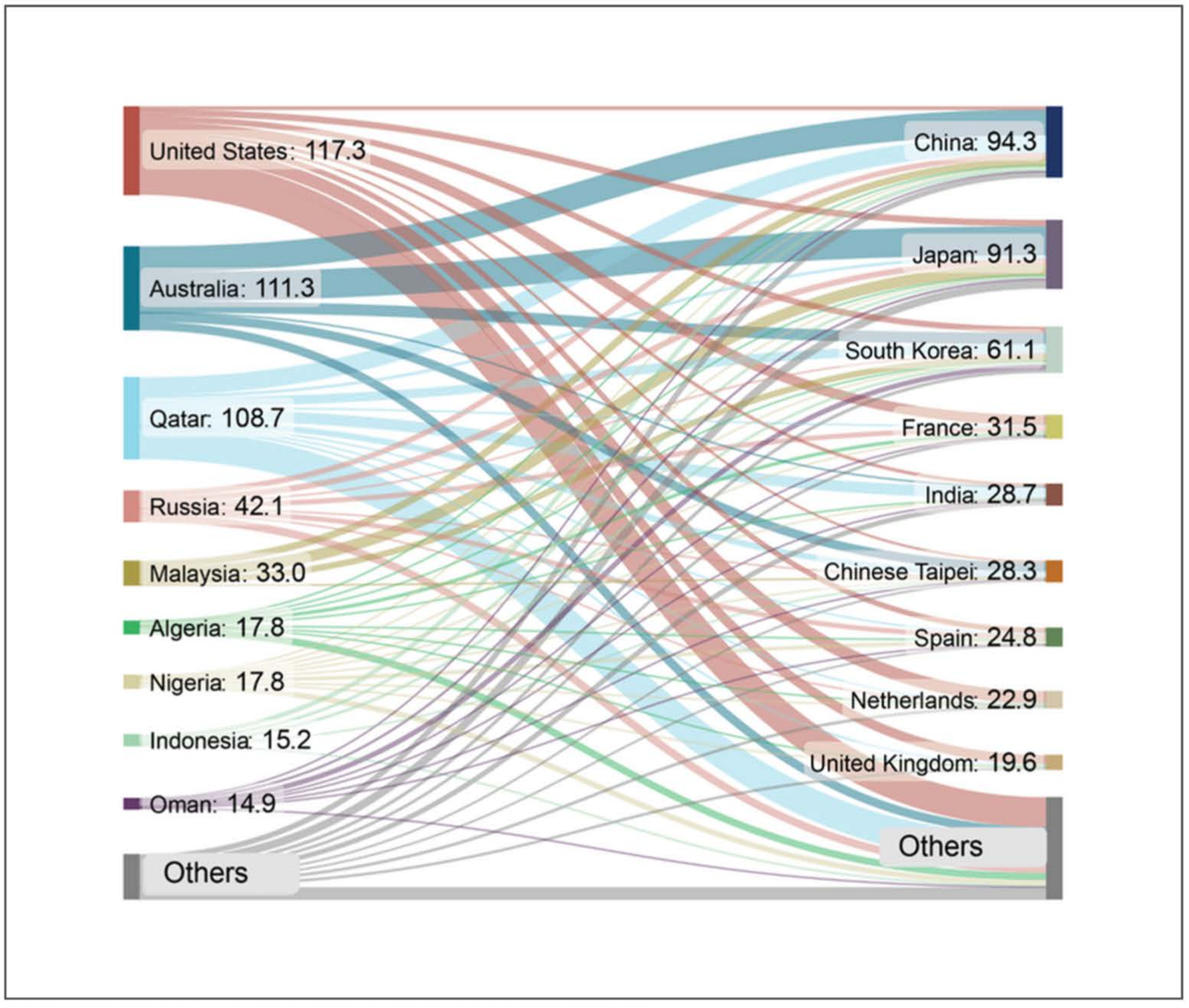
These synergies would be particularly useful for low-carbon fuels given the possibility of a greater number of semi-finished products making their way into the value chain.

The graph below demonstrates how different countries have harnessed maritime transportation to fulfil the import and export needs of different regions.

CEO Interview

> ***To establish robust demand for alternative fuels, a global regulation that focusses on carbon intensity as the main criteria would be most helpful.***

GLOBAL LNG FLOWS FOR TOP NET IMPORTERS AND EXPORTERS 2023 (Bcm)



Source: International Gas Union (IGU) and Rystad Energy, *Global Gas Report 2024*

7. CONSIDERATIONS FOR DEVELOPING A BLUEPRINT FOR TRANSPORTING CLEAN ENERGY COMMODITIES FOR GOVERNMENTS

From the private sector perspective, the leaders that were interviewed listed the key elements that governments should be considering when creating a blueprint or strategic plan to advance the development of an emerging fuel market, as well as to increase the share and transportation of these commodities in the global fuel mix. The list is not exhaustive but represents the collective view of those interviewed for this briefing paper.

Political Framework Conditions and Strategic Coordination

- Prioritise demand incentives for fuels over support for the supply side.
- Create binding target paths for alternative fuels (to trigger demand) using levers such as quotas for hydrogen, e-fuels, sustainable aviation fuels (SAFs), ammonia in aviation, shipping, heavy goods vehicles and industry.
- Design tax exemption incentives to stimulate investment, particularly in countries with limited funds to support local fuel development projects.
- Collaborate with relevant stakeholders for market ramp-up strategies, such as joint roadmaps, benchmarks and market indicators.
- Institute a global platform for infrastructure standards and harmonisation of safety, quality and certification standards (filling stations, terminals, standards for SAF, etc.).

Investments and Infrastructure focus

- Coordinate investments for cross-border projects, e.g. large hydrogen/ammonia corridors, import terminals or green export clusters.
- Provide support for the development of global transportation and distribution networks such as international pipelines, port expansion, hydrogen backbones and e-fuel bunker infrastructure.
- Strengthen public procurement with long-term contracts for high value investments such as in state fleets, railroads, airlines or steel production. Ideally G20 countries would function as “anchor customers” for these emerging fuels.
- Permit reselling of low-carbon fuels that have been secured via long term contracts that were issued to ensure bankability. This will prevent suppression of market liquidity.
- Establish best practices and recognition of future fuel risk assessments in order to support de-risking of investments.

Regulation and Certification

- Introduce an internationally recognised certificate system.
- Facilitate the traceability of the origin of sustainable fuels using tools such as‘ Guarantees of Origin’ for hydrogen or ‘Book & Claim’ for SAF. Ideally this system would be based on very simple key performance indicators such as the carbon dioxide footprint of the fuel from wake-to-wheel.
- Harmonise carbon dioxide pricing and climate tariffs on a global level.
- Create international standards that prevent distortions of competition and create fair conditions for climate neutral products. These can be modelled on systems such as those used by the International Organization for Standardization (ISO), by the International Civil Aviation Organization (ICAO) for SAF, or set by the International Maritime Organization (IMO) for marine fuels.
- Work with the insurance industry so projects can be insured as per their risk assessments of fuels.
- Repurpose fossil subsidies to drive up demand for net-zero fuels.
- reprioritise government funding in favour of clean energy and fuel sources.
- Ensure that regulation and political signals enable private long-term supply contracts (PPAs, offtake agreements, etc).

International Partnerships and Justice

- Strengthen global energy partnerships between countries and regions - particularly with the Global South.
- Improve access to technology, training, financing and sales markets.
- Fairly create value in fuel exporting countries by increasing local employment, environmental protections, and the nation’s participation in added value.
- Prioritise technological cooperation and knowledge transfer with relevant stakeholders.
- Pursue joint research projects, joint standards for production processes, such as for electrolysers.

Innovation and Research

- Support joint research and development initiatives for new fuels and applications. Promote next-generation technologies such as liquid hydrogen carriers, liquid organic hydrogen carriers, advanced SAFs and solid oxide fuel cells.
- Encourage cross-sectoral pilot projects like green corridors for shipping or clean energy corridors for trade, steelworks and chemical industry that can operate along the export and import axis.

Transparency and Monitoring

- Establish a G20 monitoring system for alternative fuels to enhance transparency of supply and demand projects.
- Gather and share comparable data on production, trade and sustainability.
- Publish an annual progress report with best practices and recommendations for action. If a CEM member country, publish a yearly CEM Global Fuel Transition Report that disseminates information in a transparent manner or the IEA Sustainable Fuels Tracking of the 4x Belem pledge.

8. CONCLUSION

Economic leaders participating in this project highlighted the enormous complexity of establishing a reliable and efficient ecosystem for low-carbon fuels. As the existing fossil ecosystem (oil, gas, coal) continues to provide the majority share of energy commodities via global trading, a new fuel ecosystem with a global network of hubs would need significant investment and is likely to take decades to be established. Low-carbon fuels are seen as inevitable for a climate friendly economy, and so, confidence is high for future demand - particularly in cases where electrification is not suitable. However, the pace of progress remains stilted by uncertainty of the payback timeline and internationally accepted standards.

There are a number of recommendations that could be followed to accelerate the pace of infrastructure investment, spur demand, signal confidence and ensure that there is a truly global market.

Governments are seen as having a particularly important role to play in shaping a decarbonised future, as they can craft regulation that prioritises demand creation. The interviewees unanimously shared the conviction that having a stable regulation incentivising industry decarbonisation would have global impact as a technology agnostic means of creating a market for these alternative fuels.

Combined with regulation, public finance instruments were identified as a means to spur investment in large-scale projects that would de-risk investment, signal longer-term demand and even create a suitable environment to create a new value chain that could include semi-finished products.

International cooperation that included both national governments and industry players was also highlighted as an important means to catalyse change. This is particularly important as the industry leaders expect a multi-fuel future, with a variety of companies investing in the fuel of their choice which will vary by individual needs. Industry leaders have emphasised that applying learnings from other fuels such as LNG or biomass would de-risk development of any new fuel market. Areas to collaborate on include: the creation of roadmaps or blueprints to encourage production and demand for low carbon fuels, the establishment of globally-recognised fuel and safety standards, and the creation of widely-accepted industry best practice.

Scalability of the low-carbon fuel value-chain hinges on good coordination between the typical exporting and importing regions to balance fuel supply, demand and infrastructure development - with maritime infrastructure viewed as a key means to service this international market. The transformation of key ports into CEM-Hubs (either for export or import) could aggregate demand from different sectors in one location.

Interviewed leaders were clear that a coalition of governments and industry could support in establishing the conditions for multiple ports to transform into CEMHubs in a cooperative manner, which would have meaningful impact. If suitable regulatory and fuel standard frameworks are put in place, they could facilitate access to cheap electricity production and cheaper low-carbon fuels for CEM-hub ports in the long run. This would lower the costs for production of modern fuels in the vicinity and encourage the transport of other raw materials for the creation of semi-finished goods, which would also bring wider economic benefits.



Using existing global maritime infrastructure where possible will reduce barriers to evolution and harness existing fossil fuel transportation relationships.

Governments and other stakeholders are encouraged to use the information in this paper to develop a blueprint for a shared low-carbon future using CEM-Hubs, and to take relevant, timely actions to harness maritime infrastructure to transport clean energy commodities.

This briefing paper with leading private sector views will serve as basis for developing a blueprint for governments interested in taking action towards establishing CEM-Hubs and accelerating the global energy transition through the transportation of clean energy commodities via the maritime sector.

METHODOLOGY

This CEM-Hubs briefing paper is designed to give CEM Ministers information about industry views, challenges and opportunities regarding future fuel infrastructure to transport clean energy commodities worldwide. A total of 19 major international companies contributed to the inaugural consultation. CEOs and private sector leaders across the energy-maritime value chain were selected for participation based on the reputations of their organisations and as per the recommendations of the CEM-Hubs private sector advisory group.

These individuals have on the ground experience and a critical interest in the energy transition, particularly in developing and using low-carbon fuels. Their investment mandates span varying risk spectrums, including shipping companies, energy companies, port owners and operators, and infrastructure investors across different regions of the world (details included at the end of this paper).

Interviews were conducted online during the summer of 2025 by Professor Dr Stefan Ulreich, University of Applied Sciences, Biberach, Germany, who is also the Chair of the Taskforce Renewables of Energy Traders Europe. Prof. Ulreich is the main author of this paper, supported by Nelson Mojarro, global coordinator of the CEM-Hubs. The CEM-Hubs would also like to acknowledge the input and support of Mr Esben Poulsson, from the private sector advisory group of the CEM-Hubs.

Insights from the interviews were used to summarise the priorities, challenges, opportunities and key recommendations to enable maritime infrastructure for the transportation of clean energy commodities globally. Sections from this paper have been included in presentations by the CEM-Hubs and shared with relevant stakeholders.

The paper was first created in August 2025. The main findings were presented and discussed at the 16th CEM Ministerial, in Busan, Korea. It was edited in early 2026 for wider publication by the CEM-Hubs initiative.