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# Energy trade in the Netherlands

## Past, present and future

**Irina Patrahau, Lucia van Geuns and Michel Rademaker**

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**Cover photo source:**
Rising prices and positive percentage price changes on a trading screen for commodities, iStock

January 2023

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# Table of Contents

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# Trends in European and global energy trade

Trade volumes in EU | Trade volumes globally | Increase | Decrease | Stable

| | Trade up to 2030 | Foresight after 2030 |
|---|---|---|
| **Crude oil and oil products** | • ARA (Amsterdam-Rotterdam-Antwerp) is an essential trade hub for oil and oil products<br>• European sanctions on Russian oil are changing oil trade routes<br>• Global oil demand shrunk due to high prices but expected to rebound in 2023 | • Oil demand decreases in the EU, remains stable or on the rise in East Asia<br>• ARA loses importance for global oil trade in the long-term<br>• Supply, demand and trade hubs shift to the Middle East and East Asia |
| **Natural gas** | • The Netherlands is a critical link in the European natural gas landscape<br>• LNG is essential for EU's energy security<br>• Europe is shifting LNG flows away from East Asian markets, increasing global prices | • In the EU natural gas demand stabilizes or decreases slightly after 2030, but decreases significantly in the 2040s<br>• Natural gas demand in China and India is still on the rise |
| **Critical Raw Materials** | • China is a quasi-hegemon in mining and refining critical raw materials (CRM) as well as producing semi-finished and end-products<br>• Other suppliers of CRM (Democratic Republic of Congo, Russia, Brazil, Peru) face domestic instability and/or have tense relations with the EU<br>• Trade platforms for minerals exist (e.g., London Metal Exchange) | • In the next 10-15 years, global supply scarcity of CRM and instability of prices is expected<br>• Critical minerals are likely to become one of the most desired commodities worldwide<br>• Increased governmental involvement in the CRM market given their importance for national climate and strategic goals |

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| | Trade up to 2030 | Foresight after 2030 |
|---|---|---|
| **Hydrogen** | • Limited use of hydrogen-based fuels<br>• Liquefied hydrogen is costly and energy-intensive to transport<br>• Compressed hydrogen efficient to transport via pipeline on short distances<br>• Liquid organic hydrogen carrier (LOHC) technology promising for long-haul transport | • Substantial increase in hydrogen trade, especially from countries with relatively cheap green electricity<br>• The global hydrogen market will likely be fragmented due to different consumer needs and application areas (some industries will need hydrogen as gas, others as liquid etc.)<br>• Gaseous hydrogen will likely be traded regionally, whereas LOHC and other carriers internationally |
| **Synthetic fuels** | • Global markets for synthetic fuels are rapidly developing in the transport sector<br>• Synthetic fuels still produce greenhouse gas emissions when burnt but much less compared to fossil fuels | • Likely to (partly) replace fossil fuels in the shipping and aviation industries<br>• Likely to be internationally traded commodities |
| **Green Ammonia** | • Green ammonia does not cause emissions when used<br>• Difficult and costly to handle due to its toxic and corrosive properties | • Likely to facilitate the decarbonisation of the shipping industry |
| **Electricity** | • High-voltage cables are the most efficient way to transport electricity over short distances<br>• Trade of electricity over long distances is inefficient and expensive | • Global trade in renewable energy technologies and components is more likely than trade in electricity itself<br>• Most electricity likely to be traded regionally through cables rather than globally |

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| | Trade up to 2030 | Foresight after 2030 |
|---|---|---|
| **Waste** | • The global waste market is not fully adapted to the production of biofuels due to the hazardous nature of waste<br>• The EU is one of the main exporters of waste | • Decrease in the global trade of waste due to strict legislation, esp. in the EU<br>• Increase in domestic and regional use of waste |
| **Biomass** | • Bioenergy accounts for 60% of the EU's renewable energy production<br>• Woody biomass is the dominant source of bioenergy in the EU<br>• Biomass is largely produced and transformed within the EU | • European subsidies for woody biomass are likely to be removed due to sustainability concerns |

Note: This is not a quantitative study but a qualitative assessment of trends in energy markets. The trade volume assessment is an approximation.

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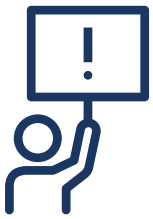
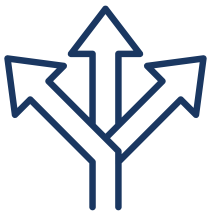
# What does it take to be a trade hub for energy commodities?



**High regional demand** to stimulate the development of a competitive market and create economies of scale.

**Extensive and well-connected infrastructure** offering large-scale storage capacity, a variety of transport means (ship, barge, pipeline, truck, train), a wide range of consumers, and efficient processes.



**Optionality** across different functions such trade, industry, logistics, and bunkering making it cost and time efficient to be located in close proximity and offering high liquidity of available products.

**Legislation and incentives from the government** to create a secure and attractive investment environment and encourage innovation.

**Geographical or technological advantages** making it faster and/or cheaper to transport products from producers toward consumers.

# List of abbreviations

| | |
|---|---|
| API | American Petroleum Institute |
| APS | Announced Pledges Scenario of the International Energy Agency |
| ARA | Amsterdam-Rotterdam-Antwerp |
| CAGR | Compound annual growth rate |
| CCUS | Carbon capture, utilization and storage |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| CRM | Critical raw materials |
| DAC | Direct air capture |
| E&P | Exploration and production |
| EBN | Energie Beheer Nederland |
| ETD | Energy Taxation Directive |
| EU | European Union |
| FF55 | Fit for 55 |
| G7 | An informal grouping of seven of the world's advanced economies, including Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States, as well as the European Union |
| GHG | Greenhouse gases |
| H-gas | High calorific gas |
| IEA | International Energy Agency |
| IMO | International Maritime Organization |
| IRENA | International Renewable Energy Agency |
| JKM | Japan Korea Marker |
| L-gas | Low calorific gas |
| LOHC | Liquid organic hydrogen carrier |
| LNG | Liquefied natural gas |
| Mb/d | Million barrels a day |
| NBP | National Balancing Point |
| $NO_x$ | Nitrogen oxides |
| OECD | Organization for Economic Co-operation and Development |
| OPEC+ | Organization of the Petroleum Exporting Countries and 11 other non-OPEC oil producers |
| RED III | Renewable Energy Directive |
| REE | Rare Earth Elements |
| SAF | Sustainable aviation fuel |
| SPK | Synthetic paraffinic kerosene |
| TAP | Trans Adriatic Pipeline |
| TTF | Title Transfer Facility |
| UAE | United Arab Emirates |
| UCO | Used cooking oil |
| UK | United Kingdom |
| US | United States |
| VGO | Vacuum gas oil |
| WTI | West Texas Intermediate |
| WTO | World Trade Organisation |

# Introduction

For a long time, energy trade has been a closed sector that very few managed to disentangle.[1] Outside of the complex and often concealed workings of commodity traders, hosting an energy trade hub can have important advantages for a region. The ARA region – Amsterdam, Rotterdam and Antwerp – is one of the largest liquid bulk trade hubs in the world. It reached this position gradually, due to extensive infrastructure, private investments, targeted legislation, regional industry and geographical location.

Today, energy trade finds itself in transition. The global energy system has shaped geopolitics for the last two centuries, fossil fuels being at the centre of the modern world's economic and social development. The emergence of a global oil market also gave room to the financialization of oil trade. It is now the largest commodity market in the world. Yet the energy map will significantly change over the next decades. Hydrogen, synthetic fuels and bioenergy are replacing fossil fuels. Trade routes will shift, new suppliers will emerge, and new interdependencies will be established. Being a trading centre for new energy sources is by no means a given. Governments and the private sector must take joint deliberate action and redesign their position in the newly emerging low-carbon markets.

Using publicly available data, this report sheds light on some of the intricacies of energy trade, specifically focusing on the role of the Netherlands as an international hub. It looks back at the country's development as an international hub of oil and natural gas, and forward at the main characteristics of emerging commodity markets. What is the current role of the ARA region in energy trade? How did it reach this position? What are the characteristics of emerging markets and what role can North-Western Europe play?

1 A notable title is 'The World for Sale: Money, Power and the Traders who Barter the Earth's Resources' by Javier Blas & Jack Farchy, published in 2021. For a thorough book review, see Keith Johnson, 'Meet Today's Masters of the Universe', *Foreign Policy* (blog), 2021, https://foreignpolicy.com/2021/03/01/world-for-sale-book-review-masters-universe-commodity-traders/.

# The basics of international oil trade

## Supply and demand

Oil price is affected by supply and demand. After the Covid-19 pandemic when oil demand decreased significantly, 2021 saw a quick economic rebound. By November 2021, global oil demand had returned to about 101 million barrels per day (mb/d). A short period of demand destruction followed as a result of the high prices in the second half of 2022, but an even higher oil demand of 102-103 mb/d is expected throughout 2023.[2]

On the supply side, the decrease in global investments in the exploration and production (E&P) of crude oil since 2014 has put a strain on many producers, including OPEC+ (Organisation of Petroleum Exporting Countries and their partners) and the United States.[3]

The role of OPEC in balancing the market is weakening. For a long time, OPEC members – specifically Saudi Arabia – would step in and expand oil production when prices would sharply increase. However, the OPEC+ decision to decrease output with 2 mb/d starting in November 2022 aggravates pre-existing market tightness and increases energy security risks worldwide.[4] Even though the decrease would realistically be of 1 mb/d according to the IEA, it shows that the group is aligned with Russia's goals at the expense of balancing the international oil market.

Even if they did want to step in, many members of OPEC+ have been facing difficulties in reaching production quotas because of domestic instability and insecurity. In Libya, anti-government protests and domestic conflict have led to blockades over oilfields and terminals.[5] In Nigeria and Angola, domestic corruption and lack of investments led to technical and operational problems at oil facilities.[6] Iraq's internal security situation and instability, as well as water shortages, inhibit the country's ability to increase its oil production capacity.[7]

Russia's role as Europe's main energy supplier radically changed within the span of a few months, bringing the global market in disequilibrium. From a geological perspective, most of

2 IEA, 'Oil Market Report', November 2022.

3 Irina Patrahau, Lucia Van Geuns, and Jilles Van den Beukel, 'From the War in Ukraine to the Energy Transition: Searching for a New Balance in the Oil Market' (The Hague Centre for Strategic Studies, 2022), https://hcss.nl/report/searching-for-new-balance-in-the-oil-market/.

4 'Oil Market Report - October 2022', IEA, 2022, https://www.iea.org/reports/oil-market-report-october-2022.

5 Charles Kennedy, 'Libya Declares Force Majeure On Biggest Oilfield', OilPrice.com, 2022, https://oilprice.com/Latest-Energy-News/World-News/Libya-Declares-Force-Majeure-On-Biggest-Oilfield.html.

6 IEA, 'Oil Market Report', June 2022, https://www.iea.org/reports/oil-market-report-june-2022.

7 Meghan Gordon and Dania Saadi, 'Iraq Not Likely to Increase Oil Exports, Backs OPEC Cuts as a Success: Finance Minister', 20 April 2022, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/oil/042022-iraq-not-likely-to-increase-oil-exports-backs-opec-cuts-as-a-success-finance-minister.

Russia's oil comes from brownfields that have been in operation for decades.[8] Increasingly high costs as well as depletion rates of these fields make it challenging to maintain production levels. Although unconventional (offshore) reserves have been discovered for instance in the Arctic, technological limitations constrain the development these fields. Other conventional reserves exist, though they are small fields scattered around the country, which require large investments in infrastructure to connect them to existing facilities.[9] Geopolitical, financial, and technological challenges affect Russia's ability to remain the world's third largest oil supplier and therefore cause volatility in the market.

The United States (US) could be emerging as the main energy superpower. The US is well positioned to become the global energy leader, due to its promising shale oil industry, expected fall of Russia as an energy superpower and issues within OPEC+. However, the US itself has been facing under-investments given the tense relations with investors that became disillusioned with the financial attractiveness of shale oil.[10]

## Financial markets and geopolitical events

The oil market is very inelastic, meaning that neither supply nor demand can be easily increased or decreased in the short term. This makes oil trade very dependent on the financial oil market which, in turn, is extremely vulnerable to geopolitical events (Figure 1). Market shocks like the global financial crisis in 2008 or the 2022 Russian invasion of Ukraine bring uncertainty to energy markets and lead to speculation.

Speculation is put in practice through arbitrage and drives the international financial trade of oil. Arbitrage in time relies on the shape of *the forward curve,* which reflects expectations of supply/demand over the next 12 months and largely dictates oil movements. A *downward sloping curve*, known as *backwardation*, implies that supply is expected to be higher relative to demand in the future and oil prices are expected to decrease. Traders thus remove oil from inventories in order to sell as much as possible in present time. The first months following the Russian invasion of Ukraine (March and April, 2022) saw energy prices reaching record high prices, with the expectation that the market price will decrease in the future (Figure 1). The year 2022 was a time of backwardation.

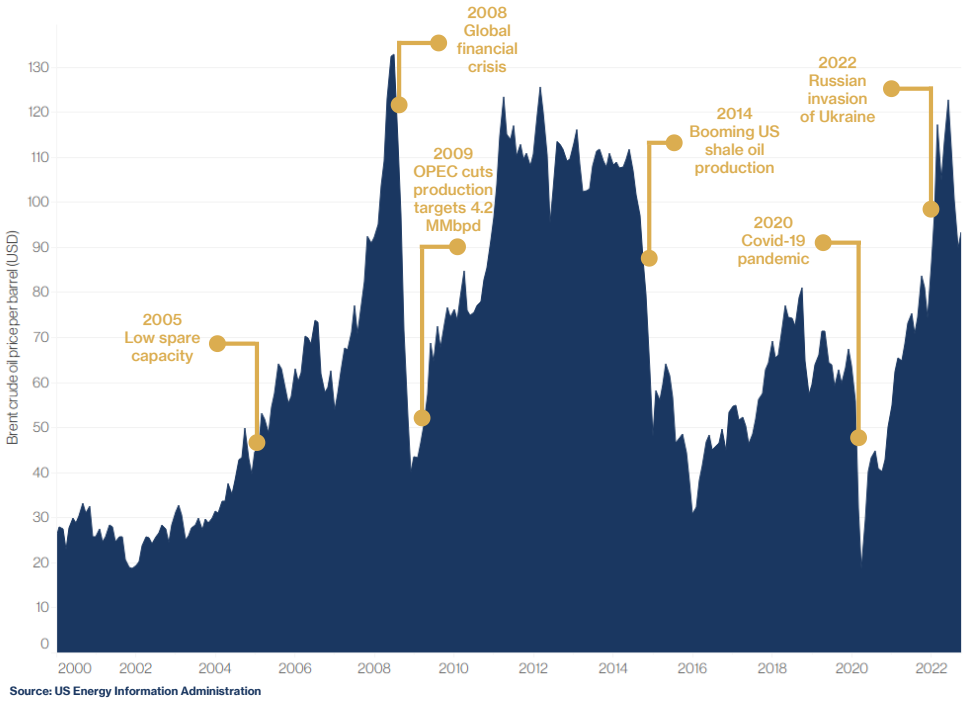
An upward *contango* curve indicates that the market expects higher prices in the future, implying that demand is expected to be higher relative to supply in the future, that spare capacity may become limited in the future or that the current market is well supplied but is expected to be tighter in the future. In this case, traders take advantage of oil storage capacity, for instance by purchasing oil on the physical market and storing it, with the purpose of selling it later at a larger price. The Covid-19 pandemic caused contango in the oil market given the sharp decrease in global demand, surplus of oil and low prices (Figure 1).

8 Jilles van den Beukel and Lucia van Geuns, 'Russia's Unsustainable Business Model: Going All In on Oil and Gas' (The Hague Center for Strategic Studies, January 2021), https://hcss.nl/sites/default/files/files/reports/Russias%20Unsustainable%20Business%20Model.pdf.

9 Tatiana Mitrova, Ekaterina Grushevenko, and Artyom Malov, 'The Future Of Oil Production In Russia: Life Under Sanctions' (Skolkovo, March 2018), 30.

10 Rystad Energy, 'Shale Getting Stingy? Reinvestment Rates in the US Hit Historic Lows in Q3 Shaping Record Free Cash Flow', 22 November 2021, https://www.rystadenergy.com/newsevents/news/press-releases/shale-getting-stingy-reinvestment-rates-in-the-US-hit-historic-lows-in-Q3-shaping-record-free-cash-flow/.

## Figure 1. Brent crude oil prices and key geopolitical and economic events




Source: US Energy Information Administration

Whether it is the trading department of a large oil and gas company like Shell and BP, or a commodity trading company like Trafigura and Vitol, traders are at the centre of the international oil market. They match the available supply with demand in different regions around the world, balancing the market. For traders, 2022 has been one of the most profitable years until now given the large increase in prices and uncertainty caused by Covid-19 and the war in Ukraine.[11] The aggregated profits of the five largest international oil and gas companies more than doubled in the second and third quarter of 2022 compared to previous years (Figure 2). This was primarily due to their trading departments.

While political attention is primarily focused on international oil and gas companies, commodity traders Trafigura, Vitol or Glencore continue scoring high profits. In 2021, the top 350 employees of Vitol shared a performance-based bonus pool of £2.1 billion.[12] Vitol's profit in 2022 reached $4.2 billion given the high energy prices.[13] Glencore is furthermore expected to reach record trading profits in 2022, especially as a result of the rebound of coal after the invasion of Ukraine.[14]

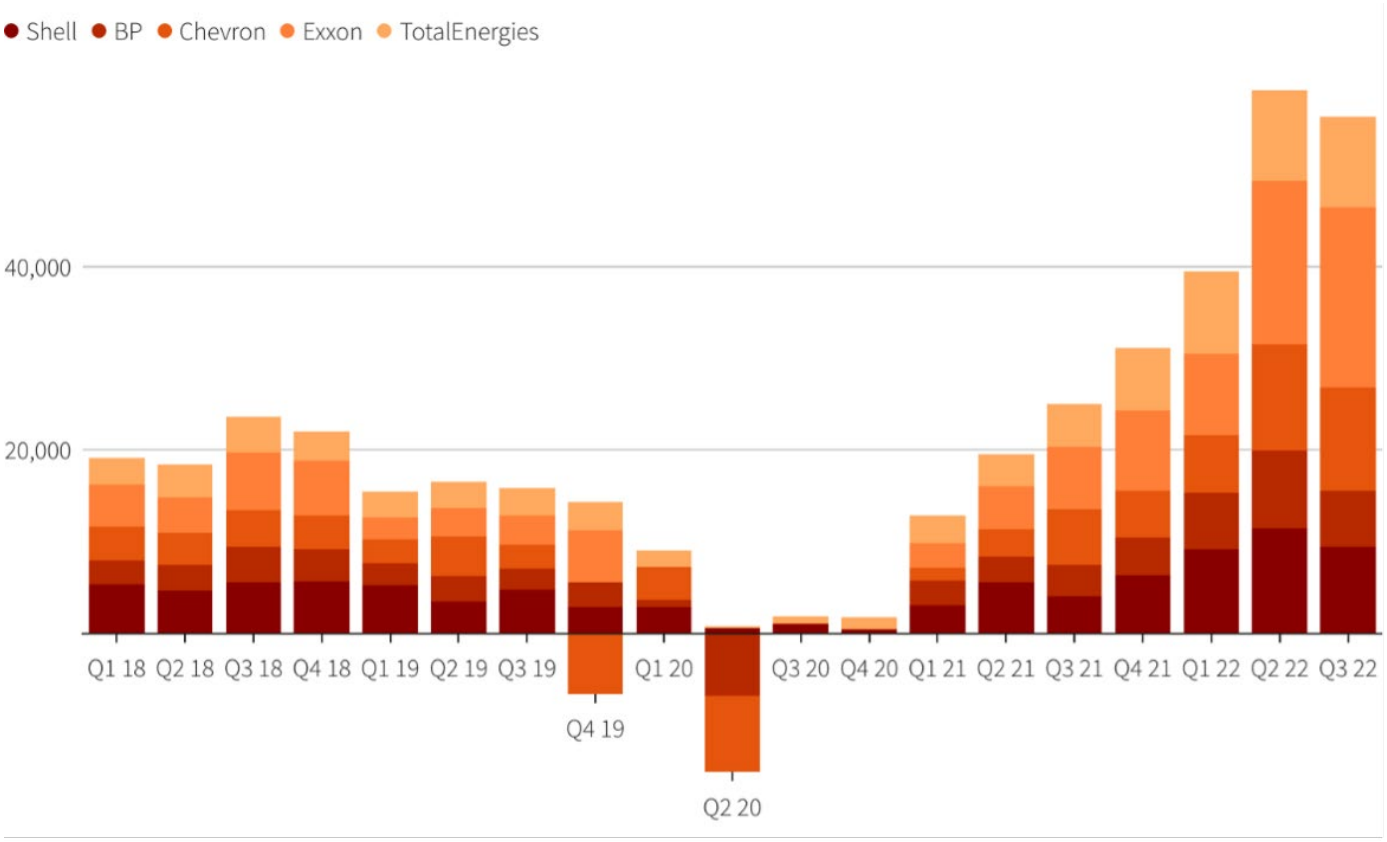
11 Tom Wilson and Neil Hume, 'Trade Secrets: Oil Majors Keep Quiet on a Key Profit Driver', *Financial Times*, 10 May 2022; Sabrina Valle and Ron Bousso, 'Oil Giants' Massive Profits Revive Calls for Windfall Taxes', *Reuters*, 28 October 2022, sec. Energy, https://www.reuters.com/business/energy/wrapup-global-oil-giants-rake-massive-profits-third-quarter-2022-10-28/.

12 Alex Lawson, '"Greed and Fear": How BP and Shell Oil Profit Is Boosted by Own Traders', *The Guardian*, 12 May 2022, sec. Business, https://www.theguardian.com/business/2022/may/12/trading-in-turbulent-market-helps-bp-and-shell-secure-record-profits.

13 Jack Farchy and Archie Hunter, 'Oil Trading Giant Vitol Posts Record Profit of $4.2 Billion', *Bloomberg*, 2 August 2022, https://www.bloomberg.com/news/articles/2022-08-02/oil-trading-giant-vitol-posts-record-profit-of-4-2-billion.

14 Tom Wilson, 'Glencore Posts Record $18.9bn Profit as Coal Enjoys a Renaissance', *Financial Times*, 4 August 2022.

## **Figure 2. Reported and forecasted profit of five large oil and gas companies, 2018-2022.** Measured in $ billion[15]



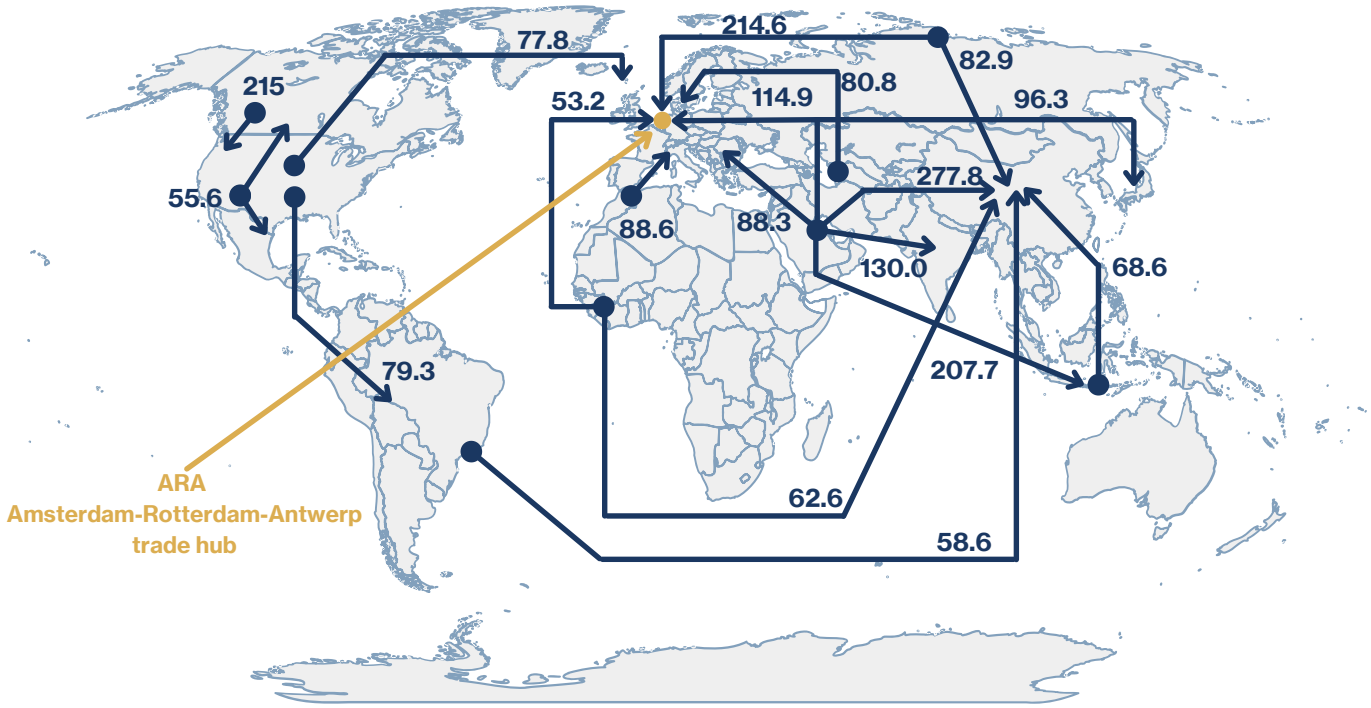

15 Valle and Bousso, 'Oil Giants' Massive Profits Revive Calls for Windfall Taxes'.

# Oil trade in ARA

## ARA: Europe's main trade hub

Oil trade is the largest commodity market in the world. It is facilitated by public and private entities, supported by infrastructure and transport networks, and dominated by traders. Supplying countries, notably Saudi Arabia, Russia, United Arab Emirates, Iraq and the United States deliver oil to consumers like the European Union (EU). Within the EU, a large part of this oil is delivered to the ARA (Amsterdam-Rotterdam-Antwerp) trade hub (Figure 3).

**Figure 3. Major oil trade movements 2021** (measured in million tonnes)




Source: BP Statistical Review of World Energy 2022

The ARA region is a highly interconnected network of ports, widely recognized as a key player in the international oil market and an energy gateway into Europe. Large scale optionality offered by the refineries, petrochemical industry, well developed infrastructure, storage and blending services, and transport modalities, provide time effectiveness and cost savings to traders. Port of Rotterdam is the primary crude oil trade hub, Port of Antwerp is known for its chemical industry, while the Port of Amsterdam specializes in logistics and blending, being the global hub for blending different grades of gasoline.[16]

16 Van den Berghe, K. B. J., Peris, A. F. T., Meijers, E. J., & Jacobs, W. (2022). Friends with benefits: the emergence of the Amsterdam–Rotterdam–Antwerp (ARA) polycentric port region. Territory, Politics, Governance. https://doi.org/10.1080/21622671.2021.2014353

Although the ARA region is not officially recognized or institutionalized, it is one of the most closely integrated and well-known oil trade hubs. Its early development did not depend on purposeful spatial planning or governmental efforts. Instead, it was a spontaneous fragmented effort of (mainly) private actors who built oil terminals, refineries, chemical and petrochemical plants, but also pipelines connecting the various facilities.[17] Most importantly, they established an industrial ecosystem that functions as Europe's oil hub. International corporations opened headquarters, research facilities and other offices in the Netherlands, but also invested in housing, schools and leisure activities for their employees.

Within ARA, the Netherlands' dominant position in international trade emerged from the confluence of several favourable conditions. First is the geographical position at the North Sea, close to several offshore oil platforms and advantageous for oil tankers coming from Russia through the Baltic Sea.

Large scale public infrastructure projects such as Rotterdam's *Nieuwe Waterweg* canal of 1872 connected the port directly to the North Sea. This brought significant advantages over neighbouring ports once ships started increasing in size and the *supertanker* was introduced. This is when the position of Rotterdam as the main hub consolidated, because it was physically impossible for these large ships to enter neighbouring ports.[18]

Because of the growing energy demand in the Rhine-Ruhr area of Germany after the Second World War, oil companies found it particularly appealing to open refineries and invest in infrastructure in the Netherlands as a transit hub.[19] Rotterdam is connected to North-Rhine Westphalia through the river Rhine, meaning that it is logistically easier to deliver fuels from the Netherlands than from Hamburg or other German ports. The Brent market in the North Sea remains the global benchmark for over 75% of globally traded oil, even though the Brent oil field is now depleted and in the process of decommissioning.[20]

As Europe was Russia's largest export market until 2022, the Port of Rotterdam was located in prime position to handle, use and re-distribute this large amount of fuel. Figure 4 shows that Rotterdam handles the largest amount of liquid bulk throughput in Europe. On the Baltic route from Russia to the Netherlands, small tankers can bring Russian fuel due to the relatively shallow depth of the channel. For a long time, large-scale ships could only travel to Hamburg at high-tide, limiting the flexibility of the port.[21] As such, Rotterdam is used as an assembly point, whereby a part of the fuel collected from multiple smaller ships is loaded on massive tankers and re-exported elsewhere. Another part of the fuel is re-distributed within Europe and the final part is processed in refineries in Rotterdam.

17 Karel van den Berghe et al., 'Friends with Benefits: The Emergence of the Amsterdam–Rotterdam–Antwerp (ARA) Polycentric Port Region', *Territory, Politics, Governance*, 12 January 2022, 1–20, https://doi.org/10.1080/21622671.2021.2014353.

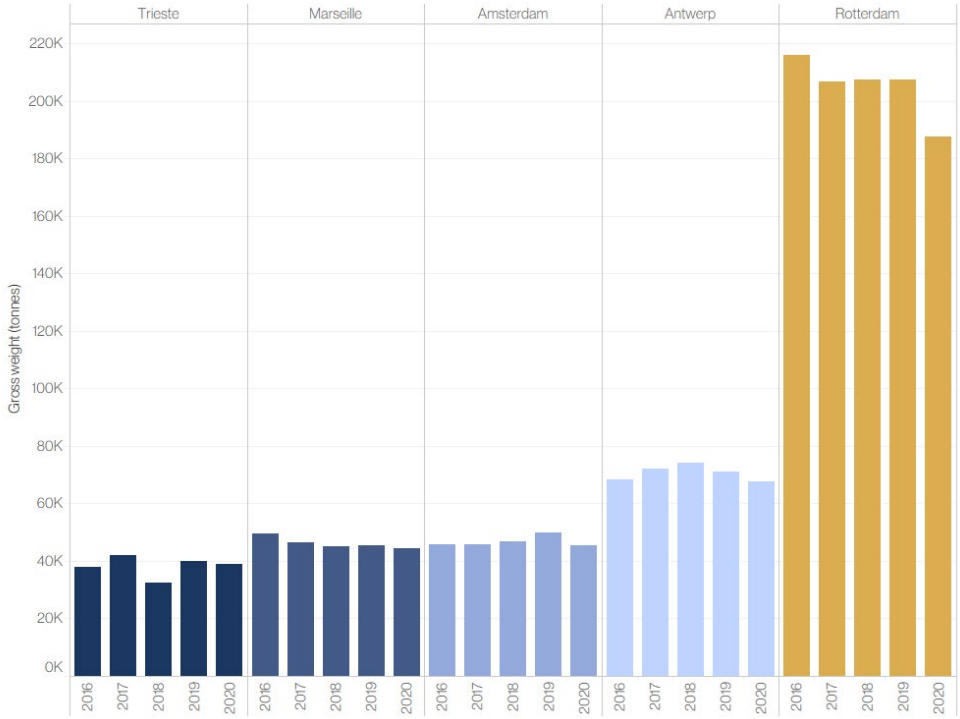
18 Van den Berghe et al.

19 Carola Hein, 'The Global Petroleumscape in the Dutch Randstad', in *The Randstad: A Polycentric Metropolis*, ed. Wil Zonneveld and Nadin Vincent, 1st ed., Regions and Cities (Routledge, 2021).

20 Mike Wittner, 'Brent: The World's Crude Benchmark', ICE, 2020, https://www.theice.com/insights/market-pulse/brent-the-worlds-crude-benchmark.

21 This has partly changed as of the new developments in Port of Hamburg in 2022, but until now has contributed to the competitiveness of Rotterdam.

**Figure 4. Maritime trade of liquid bulk goods in the largest ports in the EU.** Data from Eurostat, 2022

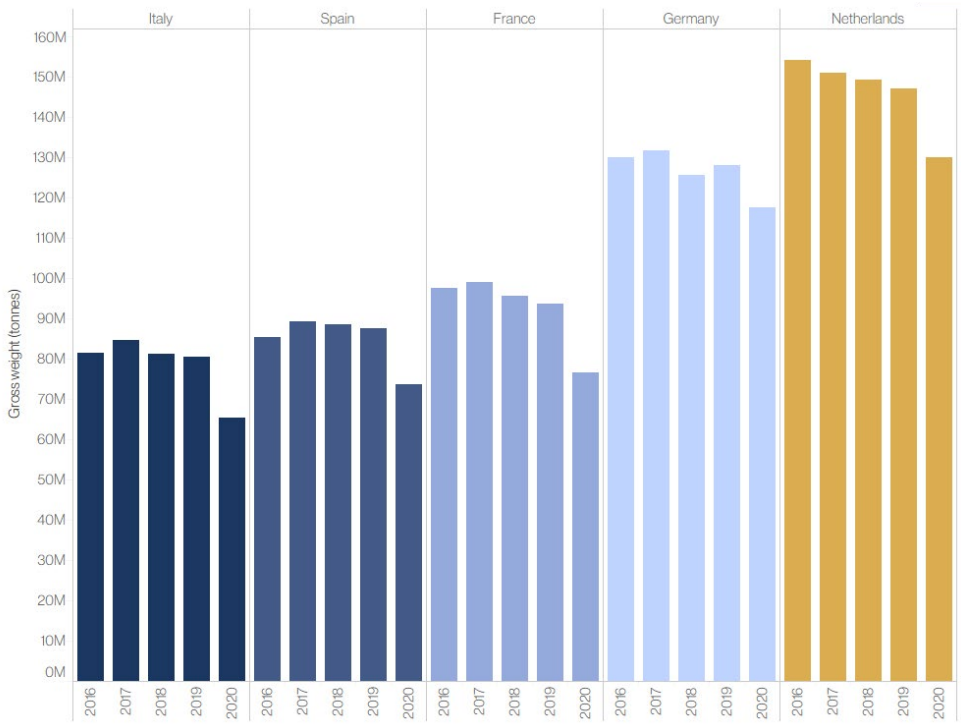



# Economic and strategic value of energy trade in the Netherlands

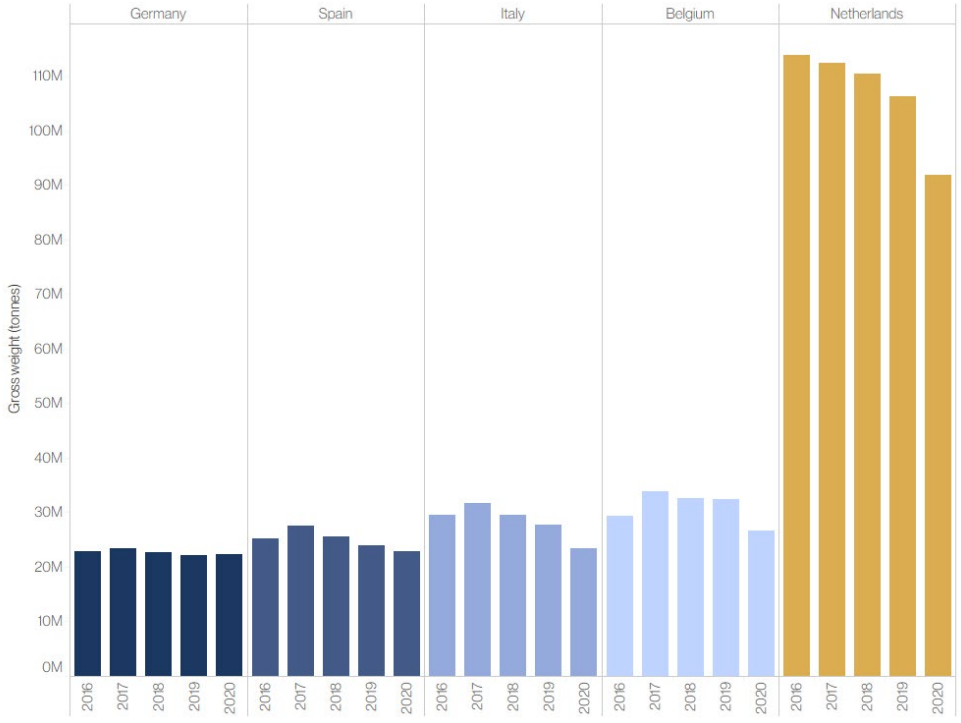
Within Europe, the gross weight of imports in the Netherlands is comparable to Germany or France (Figure 5), but the country exports the most oil and petroleum products, almost four times more than the second largest exporter, Belgium (Figure 6).

North-western European industry and infrastructure are closely intertwined with the Netherlands' hub function. The oil that is brought into the Netherlands is (1) re-exported directly to global destinations or to the hinterland; (2) refined or used in manufacturing and then exported; or (3) used domestically. Supplies are stored in Rotterdam and transported according to market needs. As such, domestic industries always have a wide range of available products and at relatively low costs given that Rotterdam is a logistics hub.

## **Figure 5. Maritime import of oil and petroleum products in top 5 EU countries.** Data from Eurostat, 2022




## **Figure 6. Maritime export of oil and petroleum products in top 5 EU countries.** Data from Eurostat, 2022



The benefits of a hub – availability and diversity of products, flexibility, logistics – attract investments into other related industries too, such as biofuels. The development of vegetable and animal-based biofuels was encouraged by a series of European directives promoting the use of biofuels or other renewable fuels for transport.[22] This led European countries to ramp up production, import and consumption of biofuels. In doing so, the Netherlands was a key location for investment in infrastructure for the trade and production of biofuels. The pre-existing facilities and interconnections caused by the oil trade hub offered significant logistical advantages. The potential of a high demand for biofuels in industry and transport also made the Netherlands attractive for investments. As of 2022, Spain and Germany lead European production followed by France, Italy and the Netherlands.[23]

In the Netherlands, most liquid bulk goods - including oil and petroleum products but also biofuels or edible oils – go through Rotterdam (Figure 4). The direct added value of Port of Rotterdam was estimated at 27.9 and 27.2 billion euros in 2019 and 2020, respectively.[24] Crude and oil products worth 100-150 billion euros have been traded via Dutch ports on an annual basis, as seen in Figure 7. This decreased significantly after the global oil price plummeted in 2014, maintaining a value of about 120 billion until the Covid-19 pandemic hit in 2020. Innovation, employment and investments in different sectors have also been associated with the 'Rotterdam effect'[25], but it remains difficult to accurately assess indirect economic benefits of the hub function for the country.

The Port of Rotterdam and North-Western European industry are important assets for the Netherlands and Europe. Self-sufficiency in the energy, manufacturing and chemicals sector, strengthened by large import terminal capacity, strategic storage, refineries and factories, ensures that essential goods can be produced in Europe in times of crises, like during Covid-19 lockdowns or in war time.

The war in Ukraine has been a wake-up call for European countries that having a degree of autonomy in strategic sectors should be sought after. Strategic autonomy in the energy sector is not a realistic or beneficial target. Yet having control over some areas of international energy value chains is achievable as well as highly beneficial to Europe's geopolitical strength, competitiveness and welfare.

22 'Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the Promotion of the Use of Biofuels or Other Renewable Fuels for Transport' (2003), http://data.europa.eu/eli/dir/2003/30/oj/eng; 'Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC' (2009), http://data.europa.eu/eli/dir/2009/28/oj/eng; 'Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the Promotion of the Use of Energy from Renewable Sources' (2018), http://data.europa.eu/eli/dir/2018/2001/oj/eng.

23 Data from Eurostat, see https://ec.europa.eu/eurostat/databrowser/view/NRG_INF_LBPC/default/table?lang=en&category=nrg.nrg_quant.nrg_quanta.nrg_inf

24 Martijn Streng, Larissa Van der Lugt, and Rosanne Van Houwelingen, 'Havenmonitor 2021' (Erasmus Centre for Urban, Port and Transport Economics, 2021), https://www.eur.nl/upt/media/100229.

25 See for instance Bart Kuipers, 'Het Rotterdam effect: De impact van mainport Rotterdam op de Nederlandse economie' (Erasmus Universiteit Rotterdam, 2018); Frans A. J. van den Bosch et al., eds., *The Strategic Value of the Port of Rotterdam for the International Competitiveness of the Netherlands: A First Exploration: Research Report for the Port of Rotterdam Authority* (Rotterdam: RSM, 2011).

**Figure 7. Value of goods transported via seaports in the Netherlands.** Estimated value* of goods transported to/from Dutch seaports (2011-2020)


*CBS-estimates for value of total inbound + total outbound transport
**For refined petroleum products: widest 95%-CI deviates from the estimate by 12% and 8% for inbound and outbound transport, respectively
***For crude petroleum: widest 95%-CI deviates from the estimate by 21% and 91% for inbound and outbound transport, respectively
**Source: CBS**

# Short term trends: reducing gasoline exports and replacing Russian oil

In the short term, gasoline trade via the Port of Amsterdam is expected to decrease substantially because of the newly passed regulation regarding the quality of gasoline destined for export from the Netherlands. Although fuel and vehicle standards are gradually converging globally, there are still differences in the allowable levels of certain substances in fuels. The blend that was exported until now to West Africa was of a lower quality level that was no longer accepted in Europe.[26] As of 2022, Dutch companies have to obey stricter standards when producing and exporting gasoline, meaning that the volume of trade will decrease in the short term.

26 'Kwaliteit brandstoffen voor export buiten Europa moet omhoog', Inspectie Leefomgeving en Transport (ILT) (Ministerie van Infrastructuur en Waterstaat, 15 August 2022), https://www.ilent.nl/actueel/nieuws/2022/08/15/kwaliteit-brandstoffen-voor-export-buiten-europa-moet-omhoog.

# Crude oil and oil products explained

Crude oil has two main defining characteristics: gravity and level of sulphur.

- Gravity determines the density of oil and is measured on the American Petroleum Institute (API) gravity scale. Crude oil can be heavy (10-20 API gravity), medium (20-25 API gravity) and light (above 25 API gravity). Heavy crude oils have a high viscosity and are more difficult to extract, whereas light crude oils are easier to extract.
- The level of sulphur determines whether the crude oil is sweet or sour. Sweet crude contains less sulphur and can be easily refined into gasoline or naphtha. Sour crude is higher in sulphur and requires a more advanced and expensive refining process. Unlike sweet crude, sour crude can be refined into middle distillates like diesel and kerosene, and yields large amounts of residuals like fuel oil.

Generally, heavy crude oils tend to be sour, whereas light crudes are sweet. Russian oil, but also Iranian, Iraqi, Venezuelan and Norwegian tend to be heavier crudes. Brent oil from the North Sea, West Texas Intermediate (WTI) from the US and Saudi oil tend to be lighter and sweeter.

For a long time, the EU and the US have had a surplus of gasoline given the large supply of domestic light sweet oils. Especially WTI is considered very light and very sweet, meaning that it can very easily be refined into gasoline but does not yield large amounts of middle distillates or residuals.

To fulfill the domestic demand for diesel, European countries would import heavy sour Russian Urals to refine into diesel or ready-made Russian diesel. Moreover, vacuum gas oil (VGO) can be used as feedstock for diesel. Most VGO used in Europe came from Russia and a part of it would even be shipped further to the US.

Russian crude oil and oil products are no longer be accepted in European ports as of December 5, 2022, and February 5, 2023, respectively. The Port of Rotterdam is no longer the main recipient of Russian oil nor an 'assembly point' for re-exporting this oil. The ARA region is simultaneously an industrial centre, trade hub, bunkering port, and logistical knot. If the trade function is reduced, it could have knock-on effects on the other activities. For instance, less available supplies of fuel could negatively impact the flexibility of industries and increase production prices.

In anticipation of the sanctions, many companies took action to adapt to the changing oil market. Imports of Russian oil decreased in the second quarter of 2022 while deliveries from the US, Norway and Brazil are on the rise.[27] To a large extent, Russian oil in the Netherlands has been replaced and the quantity of oil products is not expected to suffer significantly. Prices may increase in the short term given that short term deliveries from Russia are no longer available and tankers must be brought from further distances. Trade routes are shifting,

27 'EU Imports of Energy Products - Recent Developments', Eurostat, September 2022, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=EU_imports_of_energy_products_-_recent_developments.

and the oil market has not yet found a new balance. Refineries in the Netherlands had been optimized to deal with the heavy sour Russian crude but shifting is quite straightforward given the high complexity of most refineries in the Rotterdam area.

The exception is diesel. Replacing Russian Urals with lighter and sweeter crudes causes issues with the supply of diesel. Physical storage units across Europe are already at minimal levels compared to previous years.[28] The high natural gas prices have also led many companies to switch to diesel for electricity generation, further driving supply.[29] The EU is trying to source its diesel from India and the limited supply of the US, but this is putting significant pressure on their respective domestic markets as well. Governments across Europe have increased the share of diesel in strategic reserves in expectation of the high prices in 2023.

## Long term trends: oil trade moving away from Europe

Hubs tend to emerge because of geography, infrastructure and low costs. The steady increase in oil consumption outside of Europe, direct trade routes from Russia to India and China, and the enhancement of production capabilities of Middle Eastern companies, make it unlikely that ARA will remain a key oil trade hub in the long term. Proximity to production and consumption centres decreases supply chain costs – it is more time and cost efficient to travel less. Proximity also increases the possibility to quickly adapt to price movements.

Oil consumption will continue growing in rapidly developing countries like China, India, and more broadly East Asian and African countries, as the standards of living are increasing.[30] Neither China nor India have extensive domestic reserves of crude oil. In response, Russia is establishing alternative routes for its oil toward these consumers. Once EU imports stopped, flows have been to the largest possible extent redirected (Figure 8).[31] At the same time, China is massively investing in its petrochemical industry to expand its capacity of producing plastics and other consumer goods.[32] China will therefore be a massive crude oil consumer in addition to refined products.

28 Benedict George, 'Europe Is Running Low on Diesel When It Needs It Most', 17 October 2022, https://www.argusmedia.com/en/news/2381339-europe-is-running-low-on-diesel-when-it-needs-it-most.

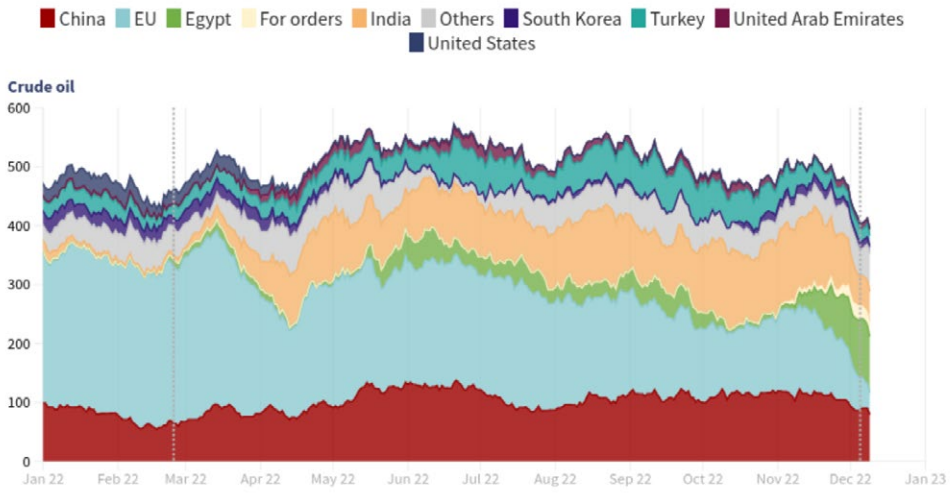
29 Javier Blas, 'Germany's Switch to Diesel From Gas Comes at a Cost', *Bloomberg.Com*, 2022, https://www.bloomberg.com/opinion/articles/2022-08-04/european-energy-crisis-germany-s-switch-to-diesel-comes-at-a-cost.

30 International Energy Agency, 'India Energy Outlook 2021' (IEA, 16 March 2021), 76–88, https://doi.org/10.1787/ec2fd78d-en.

31 Meri Pukarinen, 'Weekly Snapshot: Russian Fossil Fuel Exports 5 to 11 December 2022', *Centre for Research on Energy and Clean Air* (blog), 14 December 2022, https://energyandcleanair.org/weekly-snapshot-russian-fossil-fuel-exports-5-to-11-december-2022.

32 Saket Sundria, Gerson Jr Freitas, and Rachel Graham, 'China to Take Oil-Refining Crown Held by US Since 19th Century', Bloomberg, 22 November 2020, https://www.bloomberg.com/news/articles/2020-11-21/china-is-set-to-eclipse-america-as-world-s-biggest-oil-refiner.

## Figure 8. Crude oil shipment departures from Russia, by declared destination. Thousand tonnes per day, 30-day running average[33]




National oil and gas companies in Saudi Arabia, United Arab Emirates (UAE) and Qatar are investing in expanding their production capacity. The Middle East accounted for 54% of greenfield storage projects in 2020.[34] Saudi Aramco has the world's lowest lifting costs, second-lowest carbon intensity per unit of energy produced, and well-developed expertise and infrastructure within the oil industry.[35] The Port of Fujairah in Abu Dhabi, for instance, bypasses the Strait of Hormuz, the largest chokepoint of the international oil market.[36] It also hosts the largest underground oil storage facility, with an expected capacity of 42 mb of crude oil by 2023.[37] Significant investments in oil infrastructure are taking place in Fujairah, which is also connected to oil production facilities in the UAE. The agglomeration of crude oil producers and refiners in Russia and the Middle East, together with consumers in Southeast Asia, point to the move of oil trade hubs to that region.

33 Pukarinen, 'Weekly Snapshot'.

34 Jacob Van den Berge, 'Global Tank Storage Assets' (Insights Global, 2020).

35 Bassam Fattouh, 'Saudi Oil Policy: Continuity and Change in the Era of the Energy Transition' (Oxford Institute for Energy Studies, 2021), https://www.oxfordenergy.org/publications/saudi-oil-policy-continuity-and-change-in-the-era-of-the-energy-transition/.

36 'The Strait of Hormuz Is the World's Most Important Oil Transit Chokepoint', U.S. Energy Information Administration, 2019, https://www.eia.gov/todayinenergy/detail.php?id=39932.

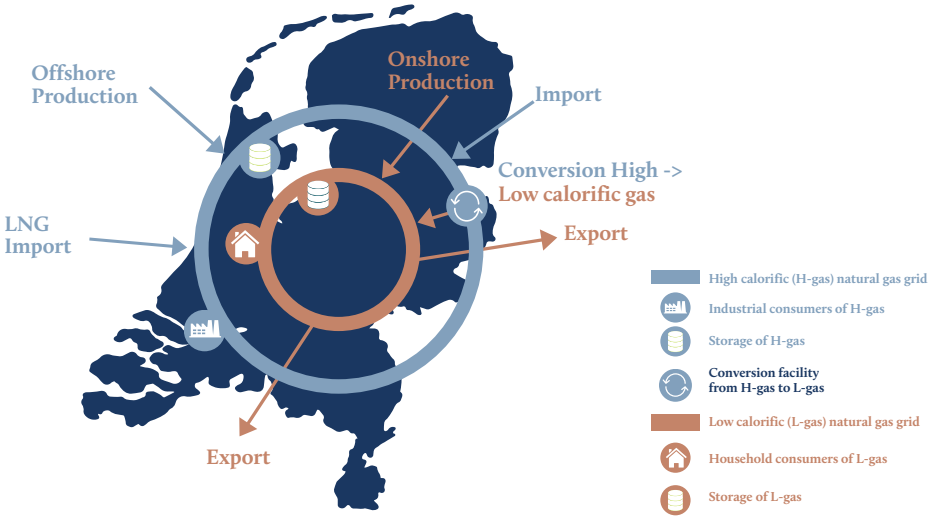
37 Claudia Carpenter, 'ADNOC's Fujairah Crude Oil Storage Caverns Set to Open in 2023: Sources', SP Global, 25 May 2022, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/oil/052522-adnocs-fujairah-crude-oil-storage-caverns-set-to-open-in-2023-sources.

# The natural gas roundabout

The Title Transfer Facility (TTF) is the largest natural gas digital trading platform in Europe. More than 70% of European gas trade took place through TTF in 2020.[38] Although domestic gas production is being phased out in the 2020s, the Netherlands maintains an important position in European natural gas trade due to the TTF, LNG terminals, its large storage sites, conversion plants for low calorific gas as well as very extensive pipeline network.[39]

Over time, the Dutch government has implemented policies and made substantial investments towards making the Netherlands the key European hub for natural gas, also known as 'the natural gas roundabout'. This position, illustrated in Figure 9, resulted from purposeful governmental action, through Gasunie and Energie Beheer Nederland (EBN), both state-owned.[40]

## Figure 9. Illustration of the functions fulfilled by the Netherlands as a natural gas roundabout




38 'Gasunie Jaarverslag 2020', Gasunie, 2020, https://www.gasuniereport2020.nl/en/connecting-europe.

39 'Gasunie Jaarverslag 2020'.

40 'Gas Roundabout: Benefit, Need and Risks', Algemene Rekenkamer (Algemene Rekenkamer, 14 June 2012), https://english.rekenkamer.nl/publications/reports/2012/06/14/gas-roundabout-benefit-need-and-risks.

The flows of natural gas into the EU suffered from the war in Ukraine and the subsequent sanctions packages, particularly the one banning the maritime import of Russian oil. As of August 2022, Russian pipeline gas represented less than 10% of European natural gas imports.[41] Alternative supply came primarily through gas pipelines from Norway, but also from Azerbaijan through the Trans Adriatic Pipeline (TAP). The bulk of Russian pipeline gas, however, is being replaced by liquefied natural gas (LNG) imports from the US, Qatar and, notably, Russia.[42]

For at least another decade, LNG trade will remain essential to Europe's energy supply, and likely for a longer time in other parts of the world.[43] The consumption of LNG depends on coal-to-gas switches, nuclear energy phase-outs or newly build plants and the speed of adoption of renewables.

European countries, notably Germany, are rapidly building their LNG regassification infrastructure, while Spain and France are expanding their interconnections to allow for the LNG imported by Spain to be transported to the rest of the EU. Under the Alternative Fuels Infrastructure Regulation (AFIR), EU member states must develop sufficient LNG infrastructure to encourage its use in the energy transition.[44]

The Netherlands is planning to expand its LNG import capacity at Gate terminal in Rotterdam and the EemsEnergyTerminal in Eemshaven.[45] Given the country's extensive gas infrastructure and trade hub, the Netherlands could play an important role in Europe's natural gas security of supply.

Globally, Europe's diversification plans are adding pressure to the LNG market as flows are diverted towards the EU. European consumers are outbidding China and other East Asian countries that will have to replace supplies with pipeline gas from Russia in the case of China or with other types of fuels.[46] As seen in Figure 10, Asian markets dominated global LNG prices in the last 10 years, which led most LNG suppliers to sell their gas to Japan, South Korea and others in the region.[47]

41 'Quarterly Report on European Gas Markets' (European Commission, 2022), https://ec.europa.eu/info/sites/default/files/energy_climate_change_environment/overall_targets/documents/quarterly_report_on_european_gas_markets_q2_2022_final_0.pdf.

42 'Quarterly Report on European Gas Markets', 16.

43 IEA, 'World Energy Outlook 2021' (Paris: IEA, 2021), 228, https://www.iea.org/reports/world-energy-outlook-2021.

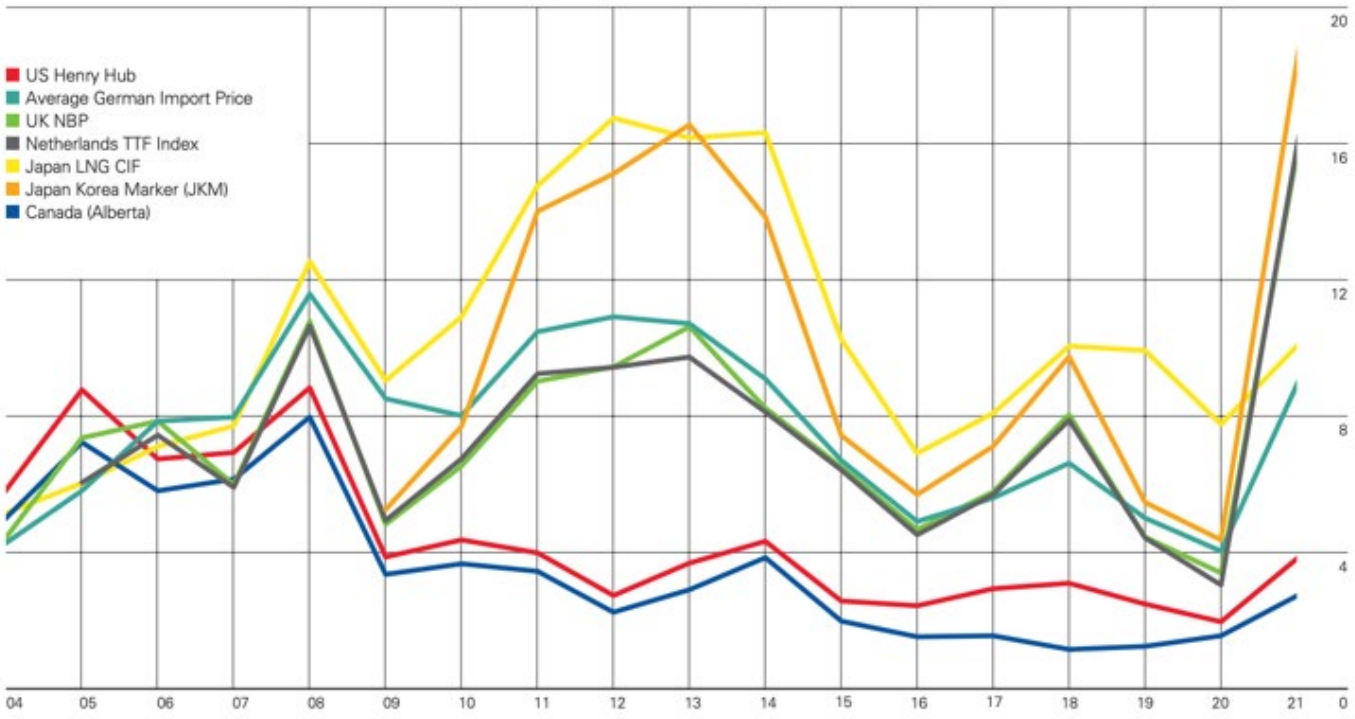
44 European Commission, 'Revision of the Regulation on the Deployment of Alternative Fuels Infrastructure', July 2021, https://ec.europa.eu/info/sites/default/files/revision_of_the_directive_on_deployment_of_the_alternative_fuels_infrastructure_with_annex_0.pdf.

45 'Gasunie Investigates Options for Increasing LNG Imports in the Netherlands', Gasunie, December 2022, https://www.gasunie.nl/en/news/gasunie-investigates-options-for-increasing-lng-imports-in-the-netherlands.

46 BloombergNEF, 'Global LNG Outlook Overview: Tight Supply Expected until 2026', *Bloomberg Professional Services*, 29 June 2022, sec. Commodities, https://www.bloomberg.com/professional/blog/global-lng-outlook-overview-tight-supply-expected-until-2026/.

47 BP, 'Statistical Review of World Energy 2022', 2022, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf.

## Figure 10. Natural gas prices in different trading platforms between 2004-2021.
Measured in dollar per million British thermal unit ($/mmBtu)[48]




Asian and European markets (TTF and NBP – National Balancing Point) became more convergent in the last 5-6 years, but Europe remained the market of last resort, only absorbing excess LNG which was not sold at record prices in Asia. In 2020, the Netherlands TTF sharply increased together with the Japan Korea Marker (JKM), Europe virtually absorbing most of the global LNG due to the high prices. In November 2022, LNG carriers were lined up outside Dutch ports waiting to sell their supplies once prices rise again.[49] Without additional supplies of LNG to the market, tightness and volatile prices will likely continue in the next few years.

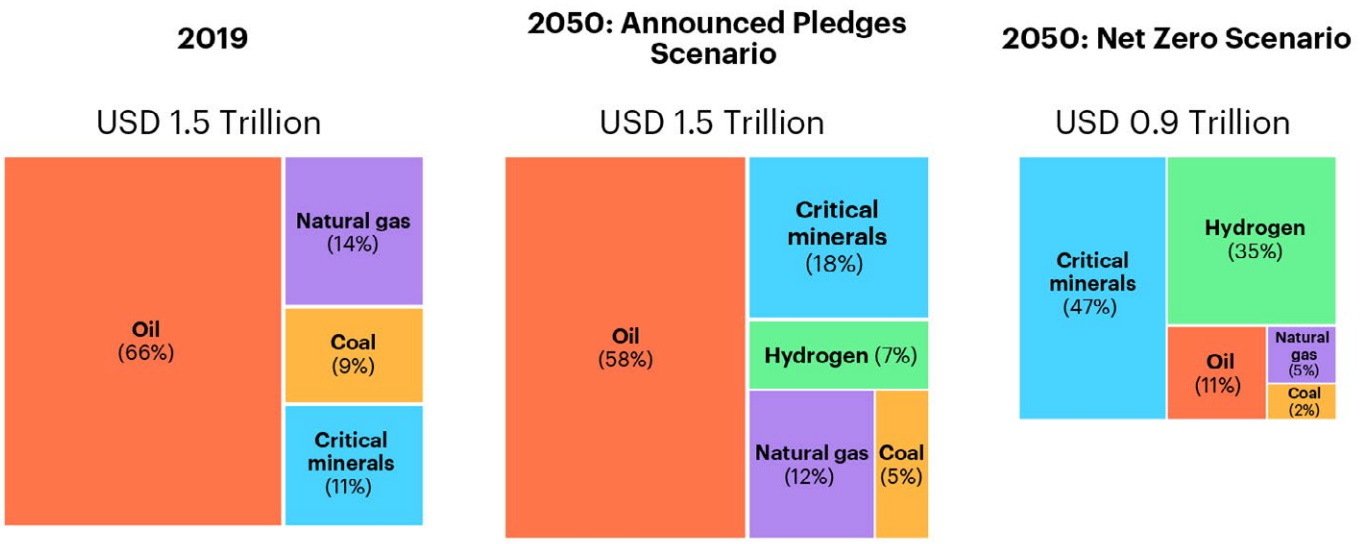
48 BP.

49 Shotaro Tani, 'LNG Tankers Idle off Europe's Coast as Traders Wait for Gas Price Rise', *Financial Times*, 4 November 2022, https://www.ft.com/content/19ad9f9f-e1cb-40f9-bae3-082e533423ab.

# Emerging commodity markets

The energy transition will lead to deep transformations within international energy trade. Hydrogen based products, including ammonia and synthetic fuels, and critical raw materials (CRM) will gain importance at the expense of coal, natural gas and oil. If governments continue on their current pathway (Announced Pledges Scenarios), the value of energy trade in 2050 will be roughly the same as in 2019-2020, but hydrogen-based fuels and critical minerals will gain ground at the expense of oil products (Figure 11). In the Net Zero Scenario of 1.5-degree temperature increase, the value of energy trade would shrink and CRM and hydrogen will dominate. This section discusses the characteristics of some of the main emerging energy markets.

## Figure 11. Value of trade in energy commodities according to IEA's APS (Announced Pledges Scenario) and NZE (Net Zero Scenario). Hydrogen includes liquid hydrogen, ammonia and synthetic fuels[50]




50 IEA, 'World Energy Outlook 2021'.

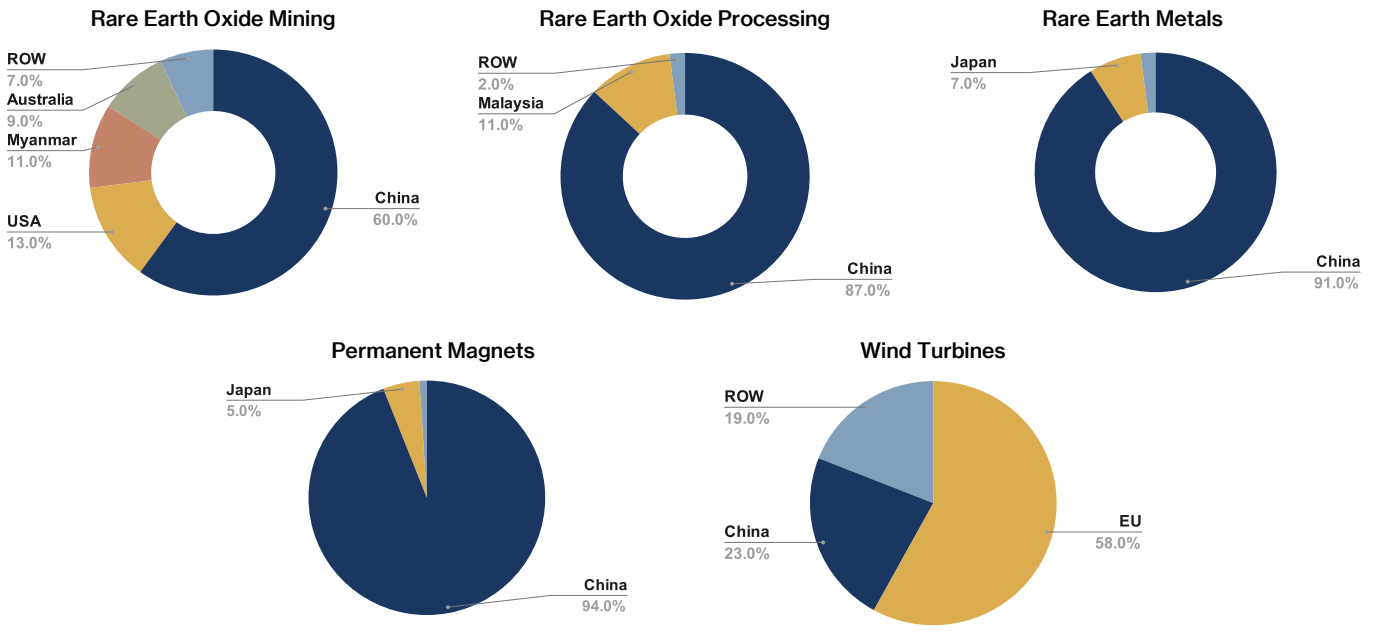
# Critical raw materials

Renewable electricity generation and electrification are key to decarbonizing the EU. Wind and solar power will replace the coal and natural gas used for electricity and heating, whereas the electrification of transport will replace combustion engine vehicles with electric ones. Batteries are at the heart of this transformation, as they can reduce the volatility of wind and solar power by storing electricity, as well as power electric cars. Manufacturing low carbon technologies like permanent magnets and wind turbines, solar panels, batteries and electric motors, requires significant amounts of critical raw materials (CRM).[51]

Rare earth elements (REEs), cobalt, lithium, nickel and copper are some of the minerals that the energy transition depends on. Although reserves are found all over the world, their exploitation is concentrated in very few countries and dominated by China. The enormous surge in demand in the next 10 years is placing CRM markets at the centre of international trade and geopolitics.

Technological value chains of wind turbines, solar panels and lithium-ion batteries are also largely found outside of Europe. In some cases, like REEs, mining and refining is done in China, and manufacturing of permanent magnets for wind turbines is done also in China (Figure 12). Others, like cobalt, are mined in the Democratic Republic of Congo (in mines partly owned by Chinese companies), but refined in China and used in battery cell manufacturing, once again, in China.[52]

## Figure 12. China's dominance over wind turbine supply chains[53]




51 For more information about the European dependence on foreign minerals see Irina Patrahau et al., 'Securing Critical Materials for Critical Sectors Policy Options for the Netherlands and the European Union' (The Hague Centre for Strategic Studies (HCSS), December 2020), https://hcss.nl/wp-content/uploads/2021/01/Securing-Critical-Materials-for-Critical-Sectors.pdf.

52 Arnoud Roelfsema, Irina Patrahau, and Michel Rademaker, 'Cobalt Mining in the EU: Securing Supplies and Ensuring Energy Justice' (The Hague Centre For Strategic Studies, 2022), https://hcss.nl/report/cobalt-mining-in-the-eu-securing-supplies-and-ensuring-energy-justice/.

53 Data from Roland Gauß et al., 'Rare Earth Magnets and Motors: A European Call for Action' (The Rare Earth Magnets and Motors Cluster of the European Raw Materials Alliance, 2021).

Because of the geographical concentration of mining and component manufacturing, global prices are very volatile to domestic events, such as disruptions in industrial processes, high energy prices, strikes and even conflict. Moreover, it is hard to respond to rapid surges in prices since opening a mine can take 8-15 years. Recycling will be essential in increasing European self-sufficiency, but only after 2030-2035, given that technologies with long life cycles are still being installed.

## Increased governmental involvement in CRM trade

The EU can only fulfil its demand for minerals through international trade and partnerships with foreign suppliers. In October 2022, the German government agreed to provide guarantees for Trafigura's $800 million loan, in exchange for providing up to 500,000 tonnes of non-ferrous metals to Germany over the next 5 years. The supply scarcity and risk of disruptions will lead to high price volatility in the next decades. The agreement between the German government and one of the world's largest commodity trading houses is a turning point in governmental involvement in securing supplies of CRM.

Stockpiling minerals could become an instrument to mitigate short-term market disruptions.[54] On the one hand, stockpiles can act as a buffer in case of sudden supply shortages and prices increases, buying some time for companies to find alternative supply sources. On the other hand, setting up stockpiles has the potential of causing disruption in the market when companies or governments start buying more than they need from a market that is already under pressure.

The financialization of mineral trade could develop even further, as they will likely become some of the most desired commodities worldwide. Price setting trade platforms like the London Metal Exchange (although also in Chinese hands) offer opportunities for hedging raw materials like copper and nickel, but also more specific products like battery grade lithium hydroxide.[55] Still, as these minerals are strategic goods for governments all around the world, the CRM market will likely see a lot of governmental involvement in the next 10-15 years.

# Electricity

Assuming that minimal disruptions occur in securing supplies of minerals, the EU will increase its wind and solar power generation capacity to reach Fit for 55 and Green Deal goals. As renewables (wind and sun) are available in all countries, the way in which energy and geopolitics interact will change. As such, most electricity used in Europe will be produced domestically, and dependencies on foreign suppliers will substantially decrease.

54 'Critical Raw Materials Act', European Commission, 2022, https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_22_5523.

55 'London Metal Exchange', LME, accessed 7 September 2022, https://www.lme.com/.

The most efficient way of transporting electricity is through high-voltage cables, such as those in the North Sea connecting Norway with the UK and the Netherlands. Today, most cross-border electricity trade takes place in Europe, followed by Africa and the Middle East.[56] Depending on time zones and weather conditions, the demand for electricity, heating and cooling might differ across regions.[57] Interconnections allow electricity consumption to be efficiently distributed.

Still, laying cables and interconnectors markets is an expensive and complex process. For that reason, most electricity is expected to be traded regionally rather than globally. In Europe, electricity trade is already taking place and will likely expand once more renewable electricity gets installed. Some electricity is lost when transported over long distances, so innovation and research is still required to allow electricity to be a globally traded commodity.[58] Between 2016 and 2020, 5% of electricity transmitted and distributed in the US was lost.[59] There are therefore many challenges to transporting, and therefore trading, electricity outside of regional markets.

# Hydrogen

Green hydrogen will contribute to the decarbonization of hard-to-abate sectors like heavy industry and shipping. Hydrogen cannot be transported in pure form due to its physical characteristics. It needs to be compressed, liquefied, or stored into liquid or solid carriers. The development of international markets for various hydrogen forms will depend on factors like ease and costs of transport and or conversion, as well as volumetric energy density.[60] IRENA estimates that one-third of the hydrogen produced in 2050 will be traded; half of this will be done through pipelines and half will be converted into carriers and shipped.[61]

The hydrogen market will likely be quite fragmented given the many variants in which hydrogen can be stored and transported, and the different application areas requiring different purity, supply stability and distribution models. The types of hydrogen that will be imported are directly connected to the needs of consumers. In the early years of hydrogen trade, up to 2030-2035, the market will be defined by bilateral agreements given the small numbers of both suppliers and consumers.

The development of an international hydrogen market will depend on costs along the entire value chain, geopolitical vulnerabilities, and legal requirements. For hydrogen and its carriers to be economically advantageous, traders and consumers will have to become involved along value chains and try to minimize costs.

56 IEA, 'Electricity Market Report - December 2020', IEA, 2020, https://www.iea.org/reports/electricity-market-report-december-2020/2020-global-overview-trade.

57 'Transcontinental and Global Power Grids', Joint Research Centre Smart Electricity Systems and Interoperability, 2022, https://ses.jrc.ec.europa.eu/transcontinental-and-global-power-grids.

58 IRENA, 'A New World: The Geopolitics of the Energy Transformation' (IRENA, January 2019), 47, /publications/2019/Jan/A-New-World-The-Geopolitics-of-the-Energy-Transformation.

59 'How Much Electricity Is Lost in Electricity Transmission and Distribution in the United States?', Energy Information Administration, 2022, https://www.eia.gov/tools/faqs/faq.php.

60 For more information about the pros and cons of different types of hydrogen carriers, see Irina Patrahau et al., 'The European Tank Storage Sector: 2050 and Beyond' (The Hague: The Hague Centre for Strategic Studies, May 2022), https://hcss.nl/wp-content/uploads/2022/05/European-Tank-Storage-2050-Beyond-2022-HCSS.pdf.

61 IRENA, 'Geopolitics of the Energy Transformation: The Hydrogen Factor' (Abu Dhabi: International Renewable Energy Agency, 2022), 15.

# Applying lessons from the natural gas market to hydrogen

Hydrogen and natural gas display certain similarities that can give insight into the development of the global hydrogen market. At the most basic level, they both have a gaseous and a liquid form – or, in the case of hydrogen, more liquid forms. Gasses are primarily transported through pipelines on relatively short distances. Liquids can be transported on longer distances and facilitate the emergence of international markets, like in the case of liquefied natural gas (LNG).

Nonetheless, liquefying either natural gas or compressed hydrogen adds more energy intensive and expensive processes to their supply chains (conversion and re-conversion). The cost of storing (hydrogenating) hydrogen into liquid organic hydrogen carriers (LOHCs), transporting it in a ship and dehydrogenating it upon arrival is relatively high compared to producing it domestically or importing it through a pipeline.

Natural gas is primarily transported through pipelines, just like compressed hydrogen can be. The LNG market could give some indications of how a global for hydrogen in liquid form can develop. It could be expected to be slower than in the case of pipeline (and therefore regional) trade and remain relatively expensive compared to other energy carriers.

The carbon footprint of hydrogen deliveries will have to be monitored and comply with European legislation, not only in terms of production processes but also looking at the value chain. To ensure that using green hydrogen leads to the desired emissions reduction, strict sustainability standards will be imposed to ensure that it is produced from renewable sources and that transporting, storing and converting the hydrogen would not lead to more emissions than reductions. The Netherlands is the first European country to launch green 'Guarantees of Origin' as of October 2022, to ensure that the imported hydrogen was produced in a sustainable way.[62] Such certification mechanisms require intensive monitoring but, if successful, could accelerate the development of the global trade of hydrogen.

Pure liquid and compressed hydrogen are unlikely to become globally traded commodities due to their very low energy density, complex storage requirements and high costs.[63] LOHC technology is still under development but is very promising for two reasons. First is that LOHCs can be stored and transported at ambient temperature and pressure; and second that they can use existing diesel and gasoline infrastructure. LOHC but also methanol and ammonia, as discussed below, have higher potential to become global commodities because of the reduced costs and (relative) ease of handling.

62 'Field Test Leads to Launch of First Green Hydrogen Certificates in Europe', Port of Rotterdam, 2022, https://www.portofrotterdam.com/en/news-and-press-releases/field-test-leads-to-launch-of-first-green-hydrogen-certificates-in-europe.

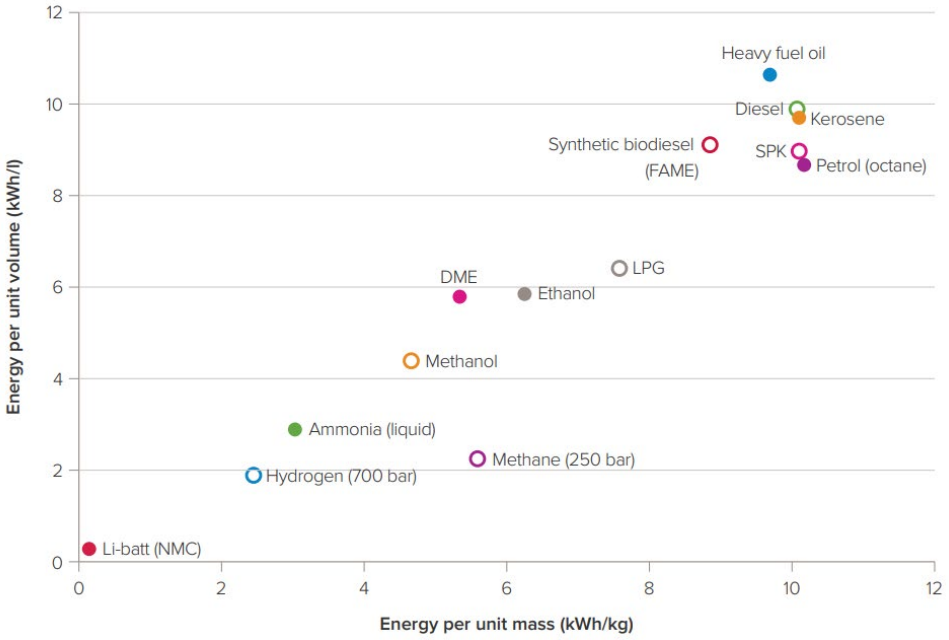
63 Rachel Parkes, 'Commoditising Hydrogen | International Trading of Green Ammonia Could Begin as Soon as 2025: Trafigura', Recharge, 25 May 2022, https://www.rechargenews.com/energy-transition/commoditising-hydrogen-international-trading-of-green-ammonia-could-begin-as-soon-as-2025-trafigura/2-1-1225219.

# Synthetic fuels

Synthetic kerosene, synthetic diesel and green methanol are vital in the decarbonization of transport and industry by 2050.[64] In general, synthetic fuels are relatively easy to use given that they can be blended in fossil fuels or completely replace them in existing ships, airplanes or industrial technologies. They can also use existing fossil fuels storage and distribution infrastructure.

Sustainable aviation fuels (SAF) can be either synthetic or bio-based jet fuels and are the most promising option for the decarbonization of aviation. The IEA expects 15% of total fuel consumption in aviation to be SAF by 2030, and 75% by 2050 – out of which synthetic fuels would cover about 30% and bio-based kerosene 45%.[65] In 2021, the Netherlands set the world record for hosting the first passenger flight powered by synthetic fuels.[66] The Fischer-Tropsch synthetic paraffinic kerosene (SPK) had a 28% SAF market share in 2021, worth $50 million.[67] This is a very promising fuel given that its energy density is only marginally lower than that of fossil-based kerosene, as seen in Figure 13.

## Figure 13. Energy density of different energy sources[68]




64 International Energy Agency, 'Net Zero by 2050 - A Roadmap for the Global Energy Sector', May 2021, iea.li/nzeroadmap.

65 International Energy Agency, 136.

66 'World First in the Netherlands: First Passenger Flight Performed with Sustainable Synthetic Kerosene', Government of the Netherlands (Ministerie van Algemene Zaken, 8 February 2021), https://www.government.nl/latest/news/2021/02/08/world-first-in-the-netherlands-first-passenger-flight-performed-with-sustainable-synthetic-kerosene.

67 'Sustainable Aviation Fuel Market Poised to Reach USD 14768.43 Million by 2030: The Brainy Insights', *Bloomberg.Com*, 11 July 2022, https://www.bloomberg.com/press-releases/2022-07-11/sustainable-aviation-fuel-market-poised-to-reach-usd-14768-43-million-by-2030-the-brainy-insights.

68 The Royal Society, 'Sustainable Synthetic Carbon Based Fuels for Transport', 2019, https://royalsociety.org/-/media/policy/projects/synthetic-fuels/synthetic-fuels-briefing.pdf.

By 2030, the global SAF market is expected to reach $15 billion, up from $216 million in 2021.[69] This compound annual growth rate (CAGR) of 60% is stimulated by large-scale governmental ambitions to decarbonize the aviation sector and increasing efficiency of SAF. The largest market growth is expected in North America and Asia Pacific due to increasing air traffic passengers, SAF mandates and rapid infrastructural developments in emerging economies.[70] SAFs will likely be a large commodity market.

## Green ammonia

Green ammonia is produced from green hydrogen and nitrogen through the Haber-Bosch process. Apart from its use as a fertiliser and feedstock in the chemical industry, ammonia can also be used either as a way of transporting and storing energy and as a transport fuel in itself. Liquid ammonia, like methanol and other hydrogen-based fuels, has a low energy density compared to the currently dominant shipping fuel, heavy fuel oil (Figure 13). Yet unlike synthetic fuels ammonia is a fossil free fuel, meaning that no carbon is used in its production and burning ammonia in combustion does not produce any GHG emissions.[71] MAN is developing an ammonia-based internal combustion engine for its ships by 2024, with the promise of eliminating GHG emissions.[72] Still, ammonia is highly corrosive and toxic, so nitrogen oxides ($NO_X$) are released if strict measures are not taken.[73]

Like synthetic fuels, the production of green ammonia relies on renewable electricity and green hydrogen, making its price dependent on the availability of its energy source and feedstock. Industrial production may emerge in regions with abundant and low-cost green electricity and hydrogen. Flows of green ammonia will likely travel from the Middle East, Latin America and Africa toward East Asia and Europe (Figure 14). Green ammonia is promising in terms of its commoditisation – grey ammonia for fertilisers is already a widely traded commodity and the prospects of decarbonizing shipping using green ammonia are significant.[74]

69 'Sustainable Aviation Fuel Market Poised to Reach USD 14768.43 Million by 2030'.

70 'Sustainable Aviation Fuel Market Poised to Reach USD 14768.43 Million by 2030'.

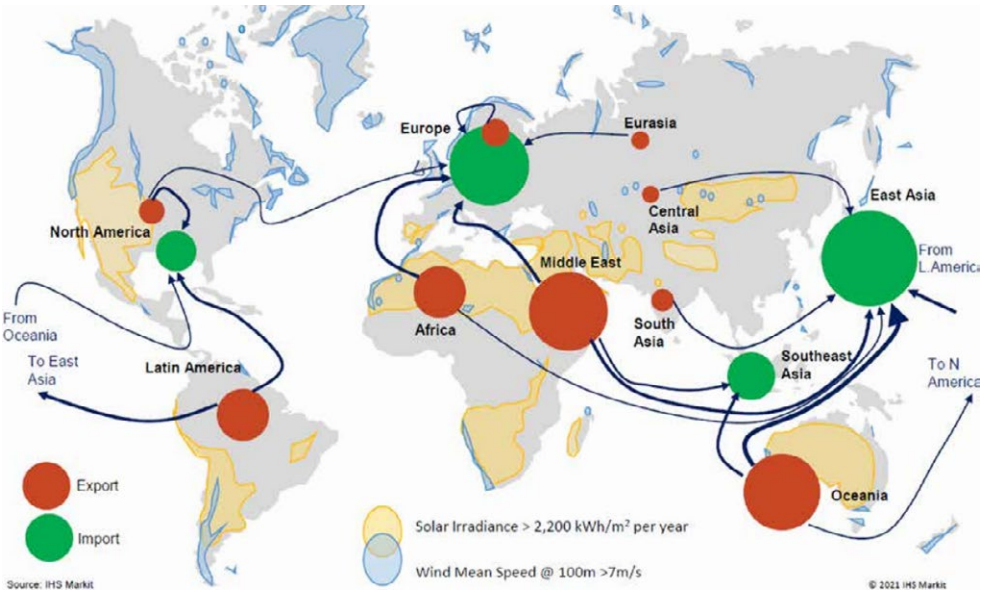
71 Carlos Gervasio Rodríguez et al., 'Possibilities of Ammonia as Both Fuel and NOx Reductant in Marine Engines: A Numerical Study', *Journal of Marine Science and Engineering* 10, no. 1 (January 2022): 43, https://doi.org/10.3390/jmse10010043.

72 Nils Lindstrand, 'The Case for Two-Stroke Ammonia Engines', MAN Energy Solutions, accessed 16 September 2022, https://www.man-es.com/discover/two-stroke-ammonia-engine.

73 Rodríguez et al., 'Possibilities of Ammonia as Both Fuel and NOx Reductant in Marine Engines'.

74 Parkes, 'Commoditising Hydrogen | International Trading of Green Ammonia Could Begin as Soon as 2025'.

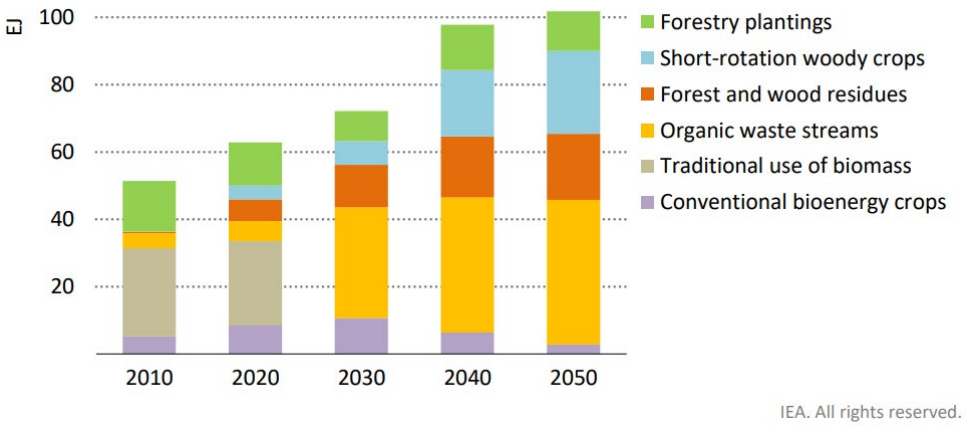
## Figure 14. Possible trade flows for green ammonia in 2040[75]




# Waste

Recycling is a key pillar of the circular economy principles that European governments are working towards. Extracting secondary raw materials from waste can significantly reduce the consumption of primary materials and the GHG emissions associated with their production processes. Moreover, waste (used cooking oil for instance) is becoming the main feedstock for the production of advanced biofuels, which will replace the conventional types made from food crops and vegetable oils, as seen in Figure 15.[76]

## Figure 15. Global bioenergy supply by source[77]




75 'Global Supply and Demand Trade Flow of Green Ammonia', IHS Markit, 7 December 2021, https://ihsmarkit.com/research-analysis/global-supply-and-demand-trade-flow-of-green-ammonia.html.

76 International Energy Agency, 'Net Zero by 2050 - A Roadmap for the Global Energy Sector', 90.

77 International Energy Agency, 'Net Zero by 2050 - A Roadmap for the Global Energy Sector', 2021, 91.

Global waste trade has expanded significantly over the last few decades, reaching a trade value of $315 billion in 2019.[78] As the EU is not yet able to process its waste and develop secondary streams of materials, the Union is one of the world's top waste exporters. About 33 million tonnes of waste are exported by the EU yearly, representing 16% of the global trade in waste.[79]

Plastic waste trade is especially problematic, which is primarily exported to East Asian countries instead of responsibly handled and recycled within the EU. China has been the world's largest importer of plastic waste, but over 70% of this was incinerated, left in landfills, or mismanaged.[80] In 2017, China imposed a ban on the import of various plastic waste grades to mitigate the negative domestic environmental consequences.[81] Since then, the trade flows of plastic waste have dramatically shifted and developed countries had to find alternative destinations of their waste. As seen in Figure 16, those were Malaysia, Vietnam and Hong Kong.

The EU is losing important feedstock for secondary materials by exporting waste. Since governments have become more acutely aware of the negative consequences of exporting their waste instead of recycling it, new legislation has been proposed by the EU to address these challenges. Restricting waste trade and processing it domestically is what the European Commission's proposal is based on, with the goal of encouraging circularity, mitigating negative consequences of exports and stopping illicit waste trade.[82]

Concerns have been raised over the unintended negative implications of an EU waste export ban over global recycling efforts.[83] The surplus and deficit of different waste types could no longer be balanced in the global market, leading to inefficiencies, and discouraging a global circular economy. The World Trade Organization (WTO) started an informal dialogue Environmentally Sustainable Plastics Trade in 2020 with the purpose of streamlining waste trade.

Still, the Commission proposal on waste could enter into force by 2024 if accepted by the Council of the EU and the European Parliament. This will have a negative impact on the global trade of waste, which will likely significantly decrease over the next years.

78 Henrique Pacini and Tze Ni Yeoh, 'Success of Circular Economy Hinges on Better Governance of "Waste Trade"', UNCTAD, 5 February 2021, https://unctad.org/news/success-circular-economy-hinges-better-governance-waste-trade.

79 'Our Waste, Our Responsibility: Waste Shipments in a Clean and More Circular Economy' (European Commission, 2021), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0708&qid=1642757230360.

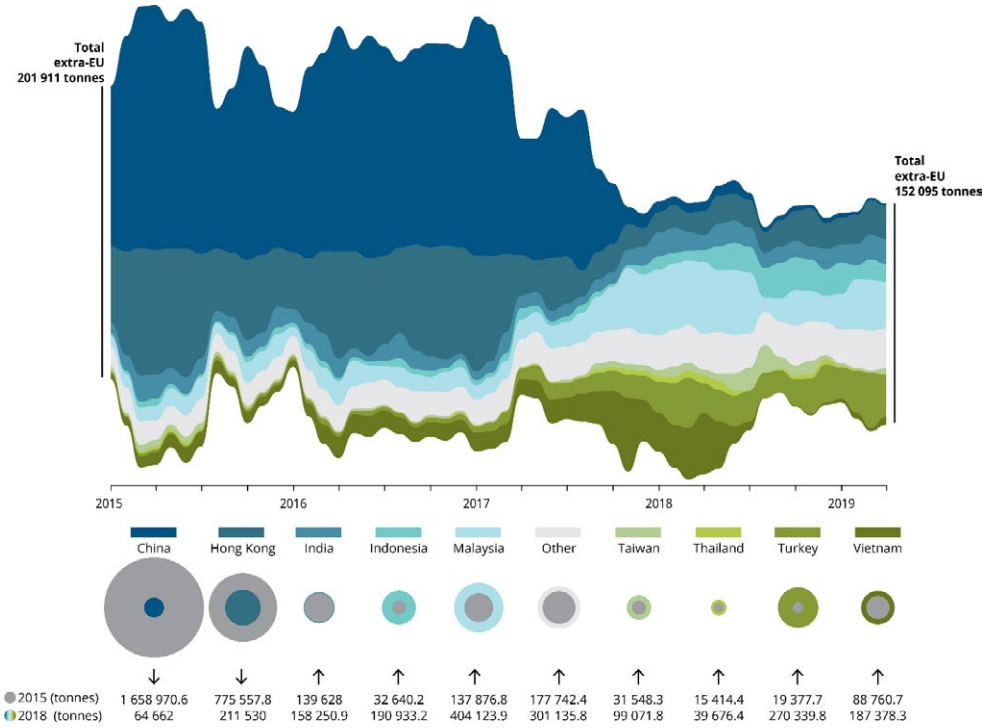
80 Zongguo Wen et al., 'China's Plastic Import Ban Increases Prospects of Environmental Impact Mitigation of Plastic Waste Trade Flow Worldwide', *Nature Communications* 12, no. 1 (18 January 2021): 425, https://doi.org/10.1038/s41467-020-20741-9.

81 Wen et al.

82 'Proposal for a Regulation of the European Parliament and of the Council on Shipments of Waste and Amending Regulations (EU) No 1257/2013 and (EU) No 2020/1056', Pub. L. No. COM(2021) 709 (2021), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0709&qid=1642757230360.

83 Kira Taylor, 'New Restrictions on Waste Exports Risk Hindering Recycling in Europe, Industry Warns', Euractiv, 18 May 2022, https://www.euractiv.com/section/circular-materials/news/new-restrictions-on-waste-exports-risk-hindering-recycling-in-europe-industry-warns/; 'Recycling Industry "Holds Its Breath" Ahead of EU Waste Shipment Recast', *Circular Online* (blog), 15 November 2021, https://www.circularonline.co.uk/news/recycling-industry-holds-its-breath-ahead-of-eu-waste-shipment-recast/.

## Figure 16. Extra-EU-28 plastic waste trade by receiving country[84]




# Biomass

Bioenergy accounts for approximately 60% of the EU's renewable energy generation, which reached 22% of the energy mix in 2020.[85] Woody biomass, including wood pellets and wood-processing residues, is the dominant source of bioenergy, with more than 60% of the total across the EU. Over time woody biomass became a key pillar of the EU's Renewable Energy Directive and Fit for 55 plans. The EU is largely self-sufficient on woody biomass as only 4% of the final consumption was imported from elsewhere. Intra-EU trade is minimal too. Biomass tends to be transformed into energy in the same EU country where it was produced (92.8% compared to 7.2% traded between countries).[86]

The development of an international (or European) market for woody biomass is primarily dependent on sustainability concerns. The European Parliament's Environmental Committee voted in 2022 to limit the types of biomass that are considered sustainable and eligible to reach climate goals, removing subsidies for woody biomass and putting a cap on the amount that can be used for bioenergy.[87] Concerns were caused by the unclear methodology of

84 'The Plastic Waste Trade in the Circular Economy', European Environment Agency, 2021, https://www.eea.europa.eu/publications/the-plastic-waste-trade-in.

85 'Share of Energy from Renewable Sources', Eurostat, 2022, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_ind_ren&lang=en; European Commission and Joint Research Centre, 'Brief on Biomass for Energy in the European Union' (Publications Office, 2019), https://data.europa.eu/doi/10.2760/546943.

86 European Commission and Joint Research Centre, 'Brief on Biomass for Energy in the European Union', 2.

87 Kira Taylor and Valentina Romano, 'Campaigners Hail "historic Breakthrough" on Revised EU Biomass Rules', Euractiv, 20 May 2022, https://www.euractiv.com/section/energy/news/campaigners-hail-historic-breakthrough-on-revised-eu-biomass-rules/.

counting emissions, not properly accounting for the positive impact of forests as natural carbon sinks, as well as for land use competition particularly when demand would increase.[88] As such, the development of biomass trade within the EU will only increase if strict sustainability frameworks are established, so that the negative consequences of producing and burning woody biomass at home and abroad are avoided.[89]

88 S.P. Andersen, B Allen, and G.C. Domingo, 'Biomass in the EU Green Deal: Towards Consensus on the Use of Biomass for EU Bioenergy' (Institute for European Environmental Policy, 2021), 1–3, https://ieep.eu/uploads/articles/attachments/a14e272d-c8a7-48ab-89bc-31141693c4f6/Biomass%20in%20the%20EU%20Green%20Deal.pdf?v=63804370211.

89 Hans Martin Junginger et al., 'The Future of Biomass and Bioenergy Deployment and Trade: A Synthesis of 15 Years IEA Bioenergy Task 40 on Sustainable Bioenergy Trade', *Biofuels, Bioproducts and Biorefining* 13, no. 2 (2019): 257, https://doi.org/10.1002/bbb.1993.

# What does it take to be an energy trade hub?

Crude oil and oil products are the most widely traded in the world. More than 65% of all energy-related trade takes place in the oil market. ARA is one of the largest trade hubs for liquid bulk in the world, as well as an important logistical knot, industrial complex and bunkering harbour. Based on characteristics of the oil market, the location of energy trade hubs is determined by:

- **High regional demand** to stimulate the development of a competitive market and create economies of scale.
- **Extensive and efficient infrastructure**, offering large-scale storage capacity, a variety of transport means (ship, barge, pipeline, truck, train), a wide range of consumers, efficient processes;
- **Optionality** across different functions such trade, industry, logistics, and bunkering making it cost and time efficient to be located in close proximity.
- **Legislation and incentives from the government** to create a secure and attractive investment environment and encourage innovation;
- **Geographical or technological advantage,** making it faster and/or cheaper to transport products from producers toward consumers.

Moving forward, oil products and natural gas could remain important in international trade particularly if net zero ambitions are not achieved. In the next decade, Europe will still require oil products and natural gas but ARA's role as a trade hub may decrease in importance. As oil and gas consumption is moving away from Europe, trade hubs will emerge instead in East Asia and the Middle East. The sanctions on Russia and Europe's ability to rebound from Russian oil will determine how fast the move toward East Asia and the Middle East will take place.

In Europe, new products will lead to new markets but with other characteristics than fossil fuels:

- Liquid bulk markets will no longer be the largest. **Critical raw materials will be the most widely traded energy commodities regardless of the scenario at hand** due to their importance in renewables and low-carbon technologies – wind and solar power, batteries, electric motors, etc.
- **New markets will be characterised by diversified products and niche markets, based on consumer needs.** Hydrogen and synthetic fuels come in a wide variety of forms, such as liquid and compressed hydrogen, liquid organic hydrogen carriers, ammonia, methanol and sustainable aviation fuels. Emerging markets will remain quite niche in the early years given that they will start as bilateral closed agreements. As such, the primary determinants of market development will be the need of end consumers and legislation.
- **Each product has different physical characteristics and legislative frameworks that determine transport and storage costs, and the feasibility of its consumption. As such, new products will be divided into two categories**:
  - **Regional markets**: electricity, compressed hydrogen, waste and biomass
  - **International markets**: ammonia, synthetic fuels and some types of hydrogen, specifically liquid organic hydrogen carriers.

Becoming a trade hub for new products requires targeted action by both the public and private sector. The following measures would help the Netherlands and ARA region strengthen their competitive position as a trade hub for new products.

- **Pair climate goals with a strong industrial strategy** to attract investments and maintain the competitiveness of European countries.
- **Set concrete requirements for the consumption of new products** to encourage the creation of a supply base.
- **Invest in the industrial transition and in adapting infrastructure** to build momentum and ensure first movers advantage globally.
- **Develop a clear legislative framework for new products** to de-risk investments and accelerate the development of supply chains.
- **Coordinate investments and tenders for projects across the value chains of new products** – including the production, transport, storage, distribution and consumption – to accelerate the development of economies of scale and reduce costs.

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