The Hague Centre
for Strategic Studies

European tank storage in today's global value chains

What role does it play in our economy?

Irina Patrahau, Michel Rademaker, Lucia van Geuns, Jilles van den Beukel

February 2022

The Hague Centre
for Strategic Studies

European tank storage in today's global value chains

What role does it play in our economy?

Authors:
Irina Patrahau, Michel Rademaker, Lucia van Geuns,
Jilles van den Beukel

Contributors:
Sarah Ojukwu, Nora Nijboer , Philip Geurts

Cover photo source:
Federation of European Tank Storage Associations (FETSA)

ISBN/EAN: 9789492102966
February 2022

The conclusions and recommendations presented in this paper are the result of independent research. Responsibility for the content rests with the authors and the authors alone. The research was made possible by a financial contribution from VOTOB (The Dutch Association of Tank Storage Companies) and FETSA (Federation of European Tank Storage Associations) to the The Hague Centre for Strategic Studies.

Table of Contents

Executive summary

The tank storage sector is a key component of the European economy, one that is relatively unknown to the public. Tank storage companies, represented in Europe by national associations through the Federation of European Tank Storage Association (FETSA) are essential players in our energy, transport, manufacturing, agricultural and food industries.

The tank storage sector balances the physical supply and demand of (mainly) liquid products, ranging from kerosene to sunflower oil. Tank storage contributes to price stability, reduces market uncertainty and ensures strategic storage in case of disruptions. The services that tank storage companies provide are not limited to specialized and safe storage and handling of products. Blending products, such as bioethanol with gasoline, is carried out by storage companies as well, to help end users comply with legal quality standards. All European economies have well developed storage sectors that support industrial activities. For instance, the Netherlands stands out as a globally important hub for energy products, chemicals and edible oils. Additionally, storage hubs are present in Hamburg, Germany; Fos-sur Mer, France; Tarragona, Spain and Genoa in Italy to name a few examples.

The tank storage sector supports a complex network of actors, from domestic industry players to residential consumers and international traders. Tank storage companies fulfill four broader tasks in the European economy, which are described in this paper: (1) they facilitate domestic consumption of products like transportation fuels and vegetable oils; (2) they support European industries; (3) they strengthen Europe's trading hub and international price-setting status; and (4) they safeguard emergency and military stocks.

From an economic perspective, constant flows of fuels and chemicals keep European industry alive. The tank storage sector is part of international and regional supply chains and domestic industrial ecosystems that function in a reliable and cost-effective way. Thousands of manufacturing companies depend on oil products and natural gas for their industrial processes. The chemical, health, steel, construction, agricultural and automotive sectors are only some of the constituents of Europe's industrial clusters. By fulfilling a part of domestic demand and supporting exports, the European industry brings enormous added value, provides jobs, enriches human capital, and fosters innovation and competition.

Vast storage capacity is a strategic asset for Europe. The availability of reliable and cost-effective infrastructure supports the competitive position of European industries. A strong and (partly) self-sufficient domestic industry also strengthens Europe's strategic autonomy. Strong maritime and aviation sectors supported by the tank storage sector are not only beneficial for the European economy, but also for its geopolitical position. Tank storage and the associated pipelines contribute to the strategic autonomy of the European defense sector, as they are critical to the functioning of NATO and European defense capabilities. Emergency stocks of fuels strengthen Europe's energy security of supply, increase freedom of action in foreign policy and mitigate the consequences of short-term geopolitical and logistic disruptions.

Executive summary (NL)

De tankopslagsector is een belangrijk onderdeel van de Europese economie, een die relatief onbekend is bij het publiek. Tankopslagbedrijven, in Europa vertegenwoordigd door nationale verenigingen via de Federation of European Tank Storage Association (FETSA), zijn essentiële spelers in onze energie-, transport-, productie-, landbouw- en voedselketen industrieën.

De bulkopslagsector balanceert de fysieke vraag en aanbod van (voornamelijk) vloeibare producten, variërend van kerosine tot zonnebloemolie. Tankopslag biedt prijsstabiliteit, vermindert marktonzekerheid en zorgt voor strategische opslag bij verstoringen. De diensten van tankopslagbedrijven zijn niet beperkt tot gespecialiseerde en veilige opslag. Het mengen van producten, zoals bio-ethanol met benzine, wordt ook gedaan door opslagbedrijven, om eindgebruikers te helpen voldoen aan wettelijke normen. Alle Europese economieën hebben goed ontwikkelde opslagsectoren die industriële activiteiten ondersteunen. Zo onderscheidt Nederland het zich als een wereldwijd belangrijke hub voor energieproducten, chemicaliën en eetbare oliën. Daarnaast zijn er opslaghubs in Hamburg, Duitsland; Fos-sur-Mer, Frankrijk; Tarragona, Spanje en Genua in Italië om maar een paar voorbeelden te noemen.

De tankopslagsector ondersteunt een complex netwerk van actoren, van spelers uit de binnenlandse industrie tot residentiële consumenten en internationale handelaren. Tankopslagbedrijven vervullen vier bredere taken in de Europese economie, die in dit document worden beschreven: (1) ze faciliteren de logistiek voor binnenlands verbruik; (2) ze ondersteunen de Europese industrie; (3) ze versterken Europa's handelscentrum en internationale prijszettingsstatus; en (4) ze waarborgen noodvoorraden en militaire voorraden.

Vanuit een economisch perspectief houden constante brandstofstromen de Europese industrie in leven. De tankopslagsector maakt deel uit van een ecosysteem bestaande uit industriële en chemieclusters, dat efficiënt en kosteneffectief functioneert en faciliteiten, infrastructuur en energiestromen deelt. Duizenden productiebedrijven zijn voor hun industriële processen afhankelijk van olieproducten en aardgas. De chemische, gezondheids-, staal-, bouw-, landbouw- en automobielsectoren zijn slechts enkele van de sectoren van de industriële clusters van Europa. Door een deel van de binnenlandse vraag te vervullen en de export te ondersteunen, levert de Europese industrie een enorme toegevoegde waarde, zorgt voor banen, verrijkt het menselijk kapitaal en bevordert innovatie en concurrentie.

Grote opslagcapaciteit is een strategische troef voor Europa. De beschikbaarheid van betrouwbare en kosteneffectieve infrastructuur houdt de concurrentiemarge van de Europese industrieën in stand. Een sterke en (deels) zelfvoorzienende binnenlandse industrie versterkt de strategische autonomie van Europa. Sterke maritieme en luchtvaartsectoren ondersteund door de tankopslagsector zijn niet alleen gunstig voor de Europese economie, maar ook voor haar geopolitieke positie. Tankopslag en de bijbehorende pijpleidingen kunnen de Europese defensiesector helpen om autonomer te worden, aangezien ze cruciaal zijn voor het functioneren van de NAVO en de Europese defensie capaciteiten. Noodvoorraden brandstoffen versterken de energievoorzieningszekerheid van Europa, vergroten de vrijheid van handelen in het buitenlands beleid en verzachten de gevolgen van geopolitieke en logistieke verstoringen op korte termijn.

VOTOB

FETSA
Federation of European Tank Storage Associations

The Hague Centre for Strategic Studies

European tank storage in today's global supply chains

What role does it play in our economy?

Domestic consumption

Tank storage fuels households, cars, industries and strategic assets like ports, airports and military assets.

International trade

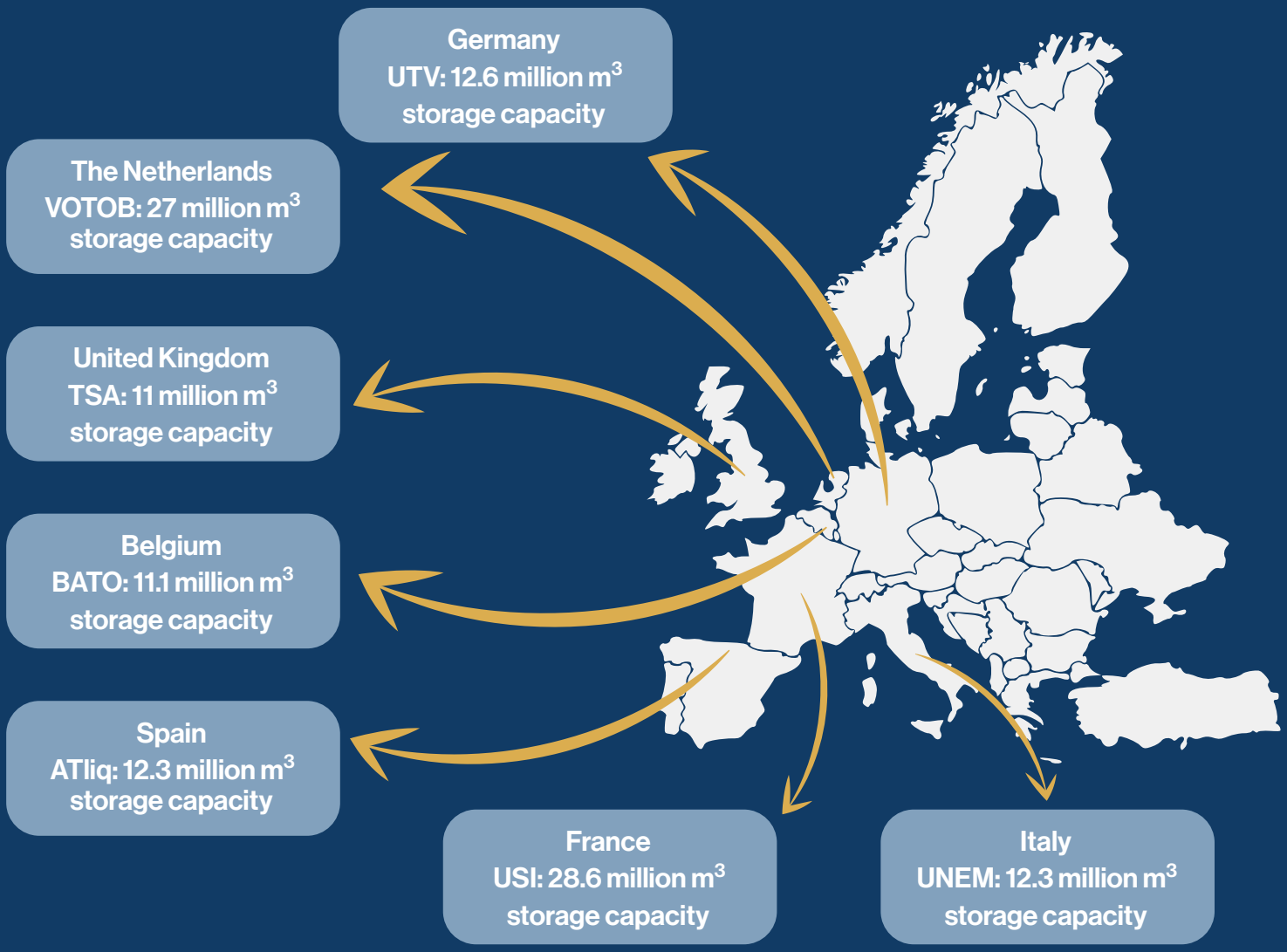
Tank storage acts as a buffer in the international energy market, contributing to price stability and reducing uncertainty.

Strategic storage

Tank storage is an essential part of emergency response to logistic or geopolitical disruptions in energy supply chains.

Regional industry

Clusters of import terminals, storage facilities, oil refineries and chemical production sites function in an efficient and interconnected way.



List of abbreviations

ARA	Amsterdam-Rotterdam-Antwerp
ARRRA	Antwerp-Rotterdam-Rhine-Ruhr-Area
ATliq	Asociación de Terminales Líquidos (Spain)
BASF	Baden Aniline and Soda Factory (Germany)
BATO	Belgian Association of Storage Companies
BFOET	Brent Blend, Forties Blend, Oseberg, Ekofisk, Troll crudes
CEFIC	European Chemical Industry Council
CEPS	Central European Pipeline System
CIM-CCMP	Compagnie Industrielle et Maritime (France)
CLH	Compania Logistica de Hidrocarburos (Spain)
CORES	Corporación de Reservas Estratégicas de Productos Petrolíferos
COVA	The Netherlands Petroleum Stockpiling Agency
DPO	Defensie Pijpleiding Organisatie
FETSA	Federation of European Tank Storage Association
GHG	Greenhouse gas
HCSS	The Hague Centre for Strategic Studies
HSSE	Health, safety, security and environment
ICE	Intercontinental Exchange
IEA	International Energy Agency
IMO	International Maritime Organization
km	kilometer
kt	kilotonnes
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
m^3	Cubic meter
mb/d	Million barrels per day
NATO	North Atlantic Treaty Organization
NBP	National Balancing Point
NEPS	Northern European Pipeline System
NWE	Northwestern Europe
OPA	Oil and Pipeline Agency (British)
OPEC	Organization of the Petroleum Exporting Countries
OPEC+	OPEC and non-OPEC oil producing partners
R&D	Research and development
SAGESS	French Agency for Strategic Reserves
TSA	Tank Storage Association (UK)
TTF	Title Transfer Facility
unem	Unione Energie per la Mobilità (Italy)
USI	Union of Tank Storage Operators (France)
UTV	Independent Tank Farm Association (Germany)
VERNOF	The Association of Dutch Producers of Edible Oils and Fats
VOTOB	Dutch Association of Tank Storage Companies
VTTI	Vitol Tank Terminal International (Netherlands)
WTI	West Texas Intermediate

Acknowledgements

For this series of papers, interviews were conducted with representatives from tank storage companies (incl. VOPAK, Koole, Oiltanking, ETT, LBC, Scandinavian Tank Storage), from the Port of Amsterdam and Port of Rotterdam, Shell, COVA, DPO, MVO. The seven national tank storage associations within FETSA (Belgium, France, Spain, the Netherlands, Germany, Italy, UK) provided valuable inputs for these papers. We would like to thank the representatives of these companies and associations for sharing their insights. The information was used to gain a better understanding of the context in which tank storage companies operate and to collect a wide range of perspectives regarding the energy transition, from some of the main stakeholders in the industry. We would further like to thank Insights Global and CEFIC for supporting the series of papers with data regarding the tank storage sector and European industry.

1. Introduction

The next decades will be transformative for the world economy. Global value chains of fuels, chemicals, and food will be impacted by decarbonization policies, technological innovation, digitalization, as well as major geopolitical shifts. The energy transition will change the architecture of economies by gradually replacing the traditional types of fuels that power our societies with new energy carriers.

Tank storage companies are essential components of Europe's energy, manufacturing, agricultural and food industries. Their role in logistics and strategic storage, international trade and European industry is crucial. Like many other participants in energy supply chains, storage companies must shift their focus from conventional fuels to renewable and low-carbon energy carriers. Technological innovations in hydrogen storage, e-fuels or flow batteries in the next 10 to 15 years could create significant opportunities for the tank storage sector to play an important role in the energy transition, although the way in which this will take place is still unfolding. With the appropriate investments in innovation, resilience and adaptation, tank storage can be a part of the solution to the challenges ahead.

This paper belongs to a series of four reports analyzing the role of tank storage in the energy transition. The first paper set the scene by discussing the European tank storage sector in the global energy landscape. This paper is the second of the series, outlining the current role of the tank storage sector in maintaining Europe's prosperity, competitiveness, and geopolitical position. In other words, it provides a snapshot of the tank storage sector today. The third paper will analyze the mid-term outlook (2030-2035) for tank storage, in light of European energy and strategic ambitions. The fourth one will look ahead to 2050-2060 and map out the newly emerging role of the storage sector.

2. Background: European tank storage

Tank storage is one of the sectors that strengthen Europe's prosperous international position. Storage companies are part of a large international ecosystem of producers, traders, shipping companies and consumers. The sector's contribution to the European economy and geopolitical influence is often overlooked. FETSA, the Federation of European Tank Storage Associations, represents the European bulk liquid storage sector. National tank storage associations from seven European countries are part of FETSA, as well as four associated members from three other countries. National associations represent 141 companies across Europe (see Appendix 1 – National associations and member companiesfor a complete overview). Together, these companies operate 125.7 million m^3 of storage capacity with a yearly throughput of 1 billion tons of liquid bulk.[1] The European tank storage sector currently employs 46 000 people and will facilitate investments of more than 5 billion euros in the next five years.[2] This section outlines some of the main characteristics of FETSA members, which tend to fulfill different functions depending on their geographical location and domestic conditions.

1 FETSA, "Tank Terminals in Europe - Key Figures," 2020, 4.

2 FETSA, 4.

French USI and Dutch VOTOB are the largest associations within FETSA in terms of storage capacity that their members operate.[3] The French association is the largest in this regard, with a total capacity 28.6 million m^3. In France, storage companies fulfil primarily a logistic function as they store products for domestic consumption. The two most important hubs are Le Havre and Marseille, from where imported products are delivered to consumption centers through pipelines. Strategic storage in France is primarily underground, but above ground tank storage also plays a role in holding emergency stocks.

Dutch tank storage companies represented by VOTOB operate 27 million m^3 of liquid bulk, the second largest capacity in FETSA. VOTOB members largely store oil products, but biofuels, chemicals and edible oils are highly important too. The Netherlands is a key player in the international trade of oil products, edible oils, biofuels and liquefied natural gas (LNG). The country is part of the Antwerp-Rotterdam-Amsterdam (ARA) trade hub for crude oil, refined products, chemicals and food products. For that reason, a large part of stored products in Dutch harbors is aimed at re-export rather than domestic consumption. At the same time, the Netherlands hosts the largest European trade hub for LNG, the Title Transfer Facility (TTF). Its advantageous location at the North Sea coast and well-developed storage infrastructure, among others, support its position as an important player in global supply chains.

The Italian national association unem is more wide-ranging than the other FETSA members, as they represent not only independent tank storage but also the refining sector. Unem members operate a capacity of 12.3 million m^3.[4] Italy is a large oil refiner, using the products both to fulfil domestic demand and to export. Except for jet fuel, the Italian industry is largely self-sufficient in terms of refined oil products. Among others, Italy exports diesel within Europe and gasoline to the United States. Small LNG depots are under construction, a facility in Sardinia having been opened in 2021. Moreover, Italian demand for biofuels has sharply increased over the years. An important biofuel production facility is found in Sicily, though significant imports are still required to fulfill domestic demand. Unlike other European countries, the pipeline network is not very extensive in Italy. Therefore most transport is done by road or railway.

Germany's UTV represents companies with a total capacity of 12.6 million m^3 of liquid bulk. Along the German coast, large scale storage terminals are used for trade of largely petroleum products. The Wilhelmshaven-Hamburg-Rostock range is particularly important both for imports of oil products and for storage in times of market imbalances. Diesel and light heating oil are the two most used oil products in Germany, given the former's role in road transport and the latter's in household heating. From the northern part of Germany where products are imported, they are transported toward inland terminals either by block trains or barges. Inland terminals also receive petroleum products from domestic industries, particularly refineries in Ruhrgebiet, Karlsruhe or Bavaria. From these inland terminals, households or petrol stations, among others, receive the products directly. Lastly, approximately 20 % of independent storage capacity in Germany is used for emergency stockholding obligations.

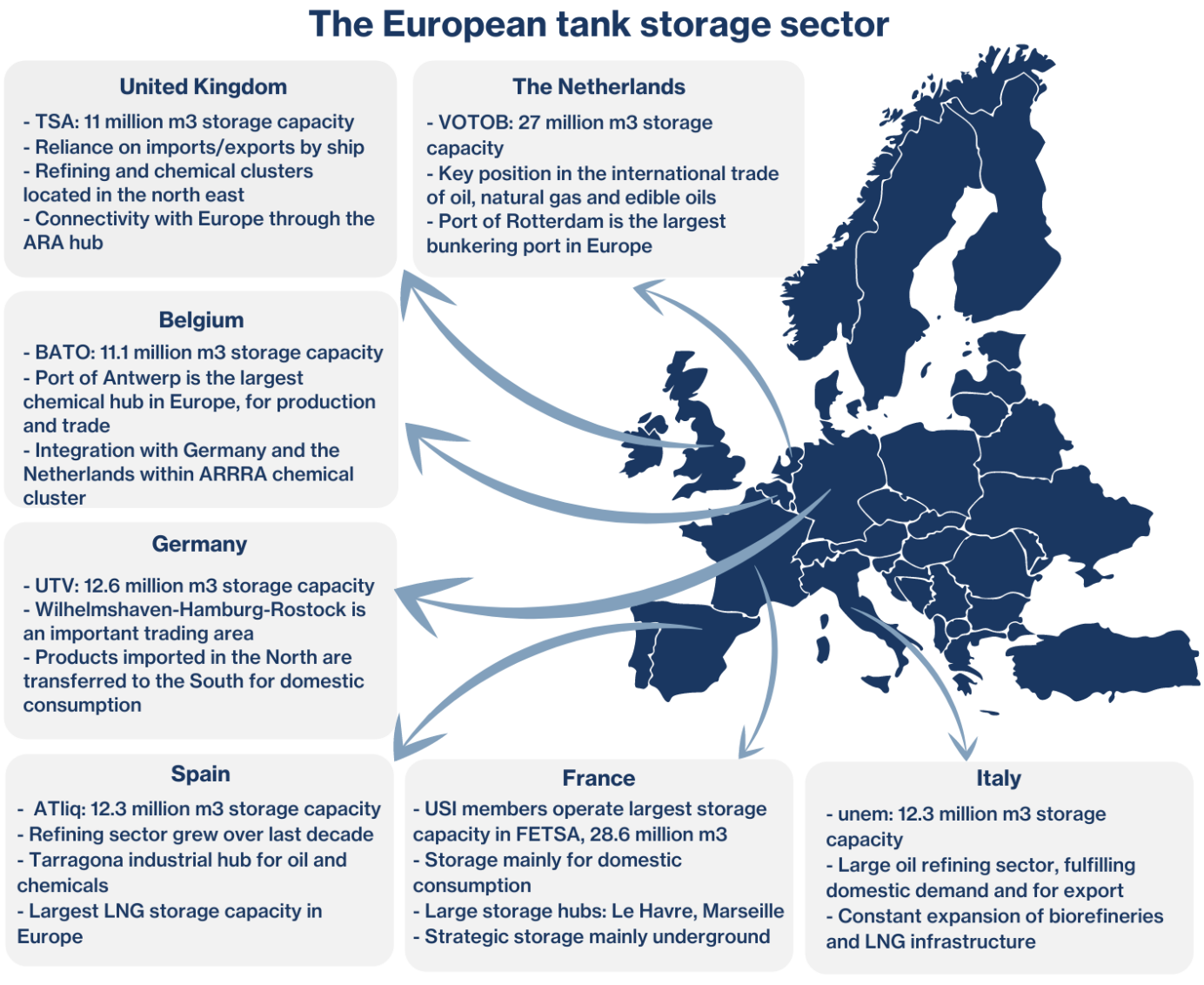
3 FETSA, "Tank Terminals in Europe - Key Figures," 2018, 6; "Key Figures of the USI," USI, accessed October 5, 2021, https://www.stockistes-usi.fr/en/union-of-tank-storage-operators.php#presentation.

4 FETSA, "Tank Terminals in Europe - Key Figures," 2018, 6.

5 Data from FETSA, 2021.

Spanish ATliq manages companies with a total storage capacity of 12.3 million m^3. Although European refineries faced economic difficulties in the last 10 years, the Spanish refining sector has expanded, enjoying large investments into new modern facilities. At the same time, a large part of Spanish refineries has been retrofitted to handle biofuels, biodiesel in particular, instead of oil products. The Spanish pipeline network is one of the most extensive in Europe, ensuring the interconnection of most refineries, ports and industrial facilities. Tarragona is the largest Spanish industrial hub, both for oil products and chemicals, other examples including Huelva and Barcelona (for fine chemicals). Spain is strategically located at the intersection between the Mediterranean, North-West Africa and the Atlantic Ocean, therefore playing an important role in connecting these regions with Europe. Lastly, Spain has the fourth largest LNG storage capacity in the world and the largest in Europe. Facilities in Barcelona, Torrejon, Huelva or Bilbao contribute to energy security of supply not only in Spain, but in the rest of Europe as well.

Figure 1. National associations within FETSA and their main characteristics[5]



In Belgium, the tank storage sector has a particular focus on chemicals, given that Port of Antwerp is one of the largest chemical hubs in the world. BATO is the tank storage association of Belgium and is integrated within Essenscia, the national organization representing the chemical industry and life sciences. Its members operate approximately 11.1 million m^3 of storage capacity, approximately 20 % of which is taken up by chemicals and 70 % by mineral oils. A large number of international chemical and pharmaceutical companies have a production facility or research center in Belgium. For instance, Pfizer and GSK have production sites for COVID-19 vaccines while companies like Ineos, BASF and Covestro have facilities producing chemicals used in the automotive sector, personal care and household products, electronics and construction. The tank storage sector in Belgium therefore supports the health industry while also facilitating international trade of chemicals.

The UK is a net-importer of aviation fuels and diesel. It also imports approximately 1/3 of the gasoline used domestically. Being an island surrounded by the Atlantic Ocean and bordering with the North Sea in the East, all products are imported by ship. Many terminals are designated as critical national infrastructure by the British government, as they are essential to provide transport and heating fuels to the UK market. The Tank Storage Association (TSA) members operate around 11 million m^3 storage capacity of liquid bulk. Approximately 60-65% of liquids that are stored are hydrocarbons, 35% of products are chemicals and fluids like edible oils, acids and animal feeds, and only a small percentage consists of crude oil Nevertheless, the UK has a relatively large refining sector, with three main chemical and refining clusters in the north east and south of the country, as well as in Scotland.

FETSA does not only consist of national associations from the various countries. Several independent tank storage companies from Sweden, Poland and Turkey are also members. Scandinavian Tank Storage operates almost 4 million m^3 of capacity for petroleum products.[6] Storage facilities support international trade as they are strategically located between American ports and Baltic states. Unlike companies using mainly tanks for storage, Scandinavian Tank Storage relies heavily on caverns to store products.[7]

Pern is the Polish associate member of FETSA and the leading crude oil logistics company of Poland. The company manages a total of 6.3 million m^3 storage capacity for crude oil and liquid fuels.[8] Apart from storage, Pern also ensures transport and handling of products.

Solventaş and Poliport are the two Turkish companies within FETSA. Solventaş has sustained a leading position among other terminals in Turkey and in the Mediterranean, operating a total storage capacity of 333.000 m^3.[9] The Turkish company Poliport owns one of the biggest terminals, accounting for a total of 237.000 m^3 storage capacity, at the Kocaeli Port. The Kocaeli Port is one of the largest in Turkey and an important industrial trade area for the EU.[10]

6 Scandinavian Tank Storage, "Company Presentation," 2022, 2, https://scandinaviantankstorage.com/wp-content/uploads/2021/12/STS-CP2022.pdf.

7 Scandinavian Tank Storage, 3.

8 Pern, "About Us," accessed January 19, 2022, https://pern.pl/en/about-us/.

9 Solventaş, "About Us," accessed January 19, 2022, https://www.solventas.com.tr/en/solventasa-ilk-bakis.php.

10 Poliport, "About," accessed January 19, 2022, https://www.poliport.com/en/about.html.

3. The basics of the tank storage sector

Before outlining the system in which tank storage companies operate in the rest of the report, this section introduces the basics of tank storage: economic and geopolitical functions, products that are stored in tanks, the different types of companies, as well as a specific look at the European tank storage sector. The focus lies on independent above-ground tank storage of liquid bulk.[11]

3.1. Why is storage important?

The role of tank storage comes into play in different stages of supply chains, depending on the products involved. Liquid bulk can be stored in tanks for strategic or logistic purposes. Crude oil and refined oil products are kept as strategic stocks. Logistic stocks of liquid bulk can include a variety of products, ranging from energy products and chemicals to vegetable oils, fats and agricultural products. Liquids in several different processing stages are stored in tanks. In the petrochemical value chain, for instance, a product may be stored three times: as

11 Water storage is outside of the scope of this paper.

raw material, as semi-finished and as finished product. Liquid bulk is used to produce energy, but also as feedstock for soap, detergents or margarine. Chemicals stored in tanks are used in the health industry for the production of pharmaceuticals and vaccines, for instance. Table 1 illustrates some examples of the liquid products that are stored in tanks.

Table 1. Examples of liquids stored in tanks

Energy products	Chemicals	Edible oils
• Crude oil • Fuel oil • Gasoil/ Diesel • Gasoline • Jet kerosene • Naphtha • Liquid petroleum gas (LPG) • Liquid natural gas (LNG) • Bioethanol • Biodiesel	• Specialty Chemicals • Intermediate Chemicals • Base Chemicals • Specialty Greases • Lube oils	• Soybean oil • Palm oil • Rapeseed oil • Sunflower oil • Specialty Blended oil • Molasses

Economic value

Products can be stored by independent tank storage companies in import terminals, which facilitate international trade and are often located in ports. Their role is to balance physical supply and demand, contribute to price stability and reduce market uncertainty. Storage companies provide processing facilities such as blending, during which they bring products to their final form required by the customer. Products can also be stored in inland terminals, which are aimed at distribution for end consumers. Inland terminals tend to be located close to distribution centers, with the main purpose of fulfilling domestic demand for liquid products.

Storage facilities can also be integrated with petroleum refineries rather than be independent companies, to facilitate the continuous and efficient functioning of refining processes. At refineries, working stocks and minimum operating requirements are stored. Working stocks, i.e., large varieties of feedstock and product stock, ensure flexibility of end product specifications. At times, refiners in e.g. the Netherlands hold up to 150 different types of crude oil, allowing them to easily respond to end users' requirements.[12] Minimum operating requirements refer to stocks of crude oil held by refineries for technical reasons, such as oil kept in pipelines at the site.[13]

The role of tank storage differs depending on the end use of each stored product. The supply chain depicted in Figure 2 is a simplified representation of the processes taking place within an industrial cluster. After the crude oil has been imported through the port, it is stored in an

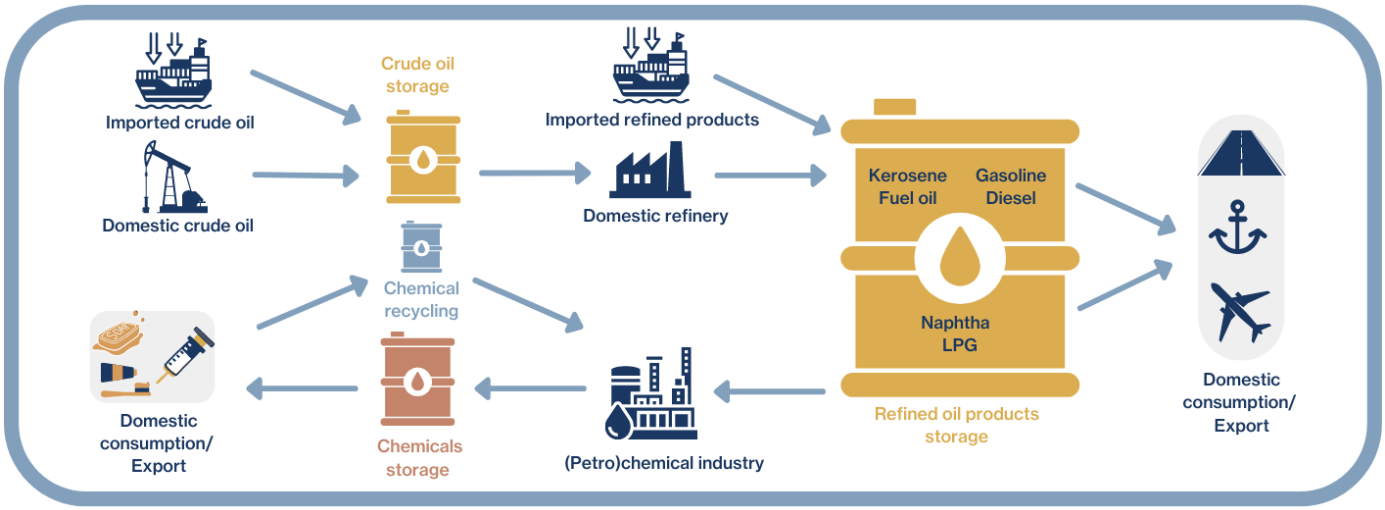
12 Nick van der Lijn et al., "The Functioning and Implementation of Council Directive 2009/119/EC" (Trinomics, 2016), 136, https://ec.europa.eu/energy/sites/default/files/documents/Final%20Report%20Trinomics%20-%20August%202016.pdf.

13 van der Lijn et al., 135.

import terminal before being brought to a refinery.[14] The gasoline and diesel produced there, for instance, are transported to an inland terminal, i.e., a facility aimed at domestic distribution.[15] For some fuels, systems are specifically designed to facilitate efficient and constant deliveries to end users. For example, kerosene from storage facilities in the Port of Amsterdam is delivered to Schiphol Airport through direct pipelines. End users can be either domestic or foreign, i.e., refined products can also be prepared for exports. Chapter 4 discusses the role of tank storage in domestic consumption, while Chapter 6 analyzes the contribution of tank storage to international trade.

Refined products like naphtha and LPG can be used as feedstock for the petrochemical industry. In the petrochemical supply chain (see Figure 2), tank storage facilities are used at least three times. After being refined, naphtha, LPG or other necessary products are stored and transported to petrochemical or chemical factories. The final products are then stored in terminals awaiting export or distribution to consumers or manufacturing industries. Chapter 5 discusses the role of tank storage in supporting European industry. Thousands of manufacturing companies depend on refined oil products and natural gas for their industrial processes. The chemical, health, construction, and automotive sectors are only some of the stakeholders of industrial clusters within Europe. By fulfilling a part of domestic demand and supporting exports, Europe's industry brings in enormous added value, provides jobs, enriches human capital, and fosters innovation. Without adequate feedstock and fuels, European industry would not only lose its competitiveness but also its (partial) self-sufficiency. Depending on foreign actors for strategic goods and technologies is considered undesirable.

Figure 2. The role of tank storage in the refined oil products and petrochemicals value chains



14 As mentioned above, refineries themselves can store products as well, for efficiency as well as to ensure the proper functioning of their systems.

15 Refined products can also be directly imported, which means that they can go straight to an inland terminal rather than having to be domestically produced and then distributed.

Geopolitical importance

Large scale domestic storage capacity can strengthen Europe's strategic autonomy in the energy, industrial, and defense sectors. Energy security of supply is a key strategic interest of every government. Ensuring sufficient and readily available fuels to support daily activity is more than a purely economic endeavor. Consumer countries in the Europe are trapped in dependency relations with states that generally do not share their political and economic values, such as with Russia or Saudi Arabia. When another country has the power to potentially disrupt the entirety of Europe by stopping the supplies of oil and gas, it undoubtedly gains significant geopolitical advantages. Whereas in the long-term such disruptions could be mitigated through diversification, in the short-term they are more difficult to address. As such, sufficient strategic storage that can be used in crises or emergencies is a way to mitigate fuel shortages caused by geopolitical tensions, cyber and physical disruptions to supply lines, as well as climate events. The coordinated release of strategic reserves in 2021 of the US, Japan, China, India and the UK is an illustration of how emergency stocks can be used strategically.[16] The release aimed at addressing the global shortage of oil supply and high prices, related to the quick recovery after the COVID-19 pandemic.

Storage of strategic fuels strengthens Europe's defense sector, providing flexibility to access and transport supplies without being dependent on foreign actors. The NATO pipeline systems across European countries can be used to transport kerosene or diesel in case of a military crisis.[17] Self-sufficiency in the defense sector is a strategic asset, one towards which the EU is taking increasingly large steps.[18]

3.2. What types of storage facilities exist?

Products can be stored in above or underground storage facilities. Any type of liquid bulk or liquefied gas can be stored in above ground in tanks, provided that they comply with design and safety standards. Underground or subsurface storage is typically used for natural gas and oil, as well as military bunkered stocks. By using depleted reservoirs in oil and gas fields, salt caverns or underground tanks, liquid bulk can be kept underground. Salt caverns tend to be very cost-effective compared to above-ground storage as well as more environmentally secure due to the low porosity and permeability of rock salt and their self-healing characteristics.[19] In the US, salt caverns are used to store the country's oil Strategic Petroleum Reserves (SPR), with a combined capacity of 714 million barrels.[20]

In France, salt caverns are used both for strategic stocks of crude oil, diesel or gasoline; and for commercial stocks. An important part of the French strategic stocks owned by SAGESS, the French Agency for Strategic Reserves, are stored in salt caverns in Manosque, close to Marseille, in facilities linked to the Port of Lavera. Contrastingly, in the Netherlands, diesel

16 "President Biden Announces Release from the Strategic Petroleum Reserve As Part of Ongoing Efforts to Lower Prices and Address Lack of Supply Around the World," The White House, November 23, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/11/23/president-biden-announces-release-from-the-strategic-petroleum-reserve-as-part-of-ongoing-efforts-to-lower-prices-and-address-lack-of-supply-around-the-world/.

17 NATO, "NATO Pipeline System," NATO, March 9, 2017, https://www.nato.int/cps/en/natohq/topics_56600.htm.

18 European Parliament Directorate General for Parliamentary Research Services., *On the Path to 'strategic Autonomy': The EU in an Evolving Geopolitical Environment.* (LU: Publications Office, 2020), https://data.europa.eu/doi/10.2861/60568.

19 "Strategic Petroleum Reserve," Energy.gov, accessed September 8, 2021, https://www.energy.gov/fe/services/petroleum-reserves/strategic-petroleum-reserve/spr-storage-sites.

20 "Strategic Petroleum Reserve."

is the only petroleum product stored underground, in a 250 000 m^3 salt cavern next to Enschede.[21] This type of underground storage is relatively safe given the lack of fire risk and, at the same time, it prevents the oxidation of the products. In the Netherlands, natural gas is most commonly stored underground in depleted gas fields. Eventually, carbon dioxide (CO_2) or hydrogen could also be stored underground.

3.3. What types of storage companies exist and who are their investors?

Tank storage companies can be independent, semi-captive or captive. Independent storage companies rent their facilities to third parties and do not own any of the products stored in their tanks.[22] In order to provide their safety expertise to a wide range of clients, these tank storage companies function independently rather than being vertically integrated with refineries or other types of businesses. The Spanish company Exolum is the largest storage company in Europe, operating more than 11 million m^3 of storage capacity.[23] The other main independent tank storage companies in Europe are Vopak (largest in the world), Géosel-Manosque, Pern, CIM-CCMP, VTTI, Oiltanking and Rubis Terminals. All of them are FETSA members (see Appendix 1 – National associations and member companies for details).

Semi-captive storage companies use a part of their capacity to store their own products. They can be traders, distributors, refiners, etc. Lastly, captive companies use tanks to store their own products. China's Sinopec is the largest terminal operator and has the most storage capacity in the world, but unlike Vopak, it is also a large oil producer.[24]

Institutional investors are important shareholders in storage companies given their long-term commitments. Examples include infrastructure and pension funds (e.g. Macquarie European Infrastructure Fund), international banking groups (e.g. Mirabaud & Cie) and asset management companies (e.g. Premier Miton Investors). When supported by investors, storage companies can make important changes such as building infrastructure that they can use to handle new low-carbon fuels. Although not immediately profitable, these are necessary long-term investments that will create a sustainable business case and allow them to play a vital role in the energy transition. This becomes more difficult when companies must show quick profits to shorter term investors and therefore lack the flexibility to invest in plans that are now considered risky. For instance, due to lack of demand for hydrogen and uncertainty regarding regulation, some companies find investments in infrastructure for different hydrogen carriers to be risky from a financial perspective. In other cases, such as in the UK, the investment climate is ripe and large scale funding is available for building infrastructure for new energy carriers. The EU Taxonomy supports investments in sustainable activities across a wide

21 Ministerie van Economische Zaken en Klimaat, "Meer informatie over ondergrondse opslag De Marssteden (Enschede)," March 7, 2019, https://www.sodm.nl/documenten/vragen-en-antwoorden/documenten/vragen-en-antwoorden/meer-informatie-over-ondergrondse-opslag-de-marssteden-enschede.

22 Vopak, "Roadshow Presentation 2008," 16, https://www.vopak.com/system/files/roadshow_presentation_q3_2008.pdf.

23 Exolum, "Who We Are," Exolum, accessed December 22, 2021, https://exolum.com/en/about-exolum/who-we-are/.

24 "Who Are the Biggest Players in the Tank Terminal Market?," *Insights Global* (blog), December 5, 2019, https://www.insights-global.com/who-are-the-biggest-players-in-the-tank-terminal-market/.

range of sectors, to help European countries reach climate goals.[25] The tank storage sector is dependent on such new regulations for attracting investments.[26]

3.4. What kind of services do tank storage companies provide?

Tank storage companies offer a wide array of services to their customers. The most important is specialized storage for various products, through which independent tank storage companies provide flexibility to their customers. Customers' (e.g. traders) yearly demand for storing liquid bulk often changes, and it is not possible or profitable for a company to adapt large scale infrastructure every time. It takes time to permit and construct the tanks, jetties, pipelines required to store a product. The barriers of entry are high due to the very large financial expenses and time commitments. As such, customers can rent the specific size and type of infrastructure from independent tank storage companies, according to their needs.

Storage companies also bring raw materials or semi-finished products to the final form required by the customer. Their services consist of blending different products, such as bioethanol with gasoline, to help users comply with legal standards. Additionally, they can mix additives into a product or perform nitrogen blanketing in order to remove unwanted oxygen. Products can be heated or cooled, as well as loaded and unloaded from ships, railcars, trucks, inland barges or pipelines.

3.5. How safe are their operations?

Liquid products require different conditions for storage in order to prevent hazardous materials from affecting human and environmental safety. The European Seveso Directive aims to protect human health, the environment, and the economy from the repercussions of accidents involving dangerous substances.[27] Yet the processing, storage and transportation of hazardous chemicals for certain industrial processes is indispensable. The Seveso Directive legally binds operators and EU member states to fulfill a number of requirements to limit negative consequences.[28] The legal foundation of the Directive follows four action steps, which are part of an improvement cycle for the sector: prevention, preparedness, response, and lesson learning.[29]

The complex services provided by storage companies, such as transferring, blending and storing products, have to obey strict employee and environmental safety standards. The prevention of unwanted spills or leakages, the reduction of operational GHG emissions, and the handling of waste are important concerns of their operations.[30] Responsible processes, robust infrastructure and knowledgeable employees ensure that substances are safely stored.

25 "EU Taxonomy for Sustainable Activities," European Commission, accessed January 27, 2022, https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en.

26 This topic is discussed in more detail in the third part of this paper series "European tank storage in global supply chains: Outlook to 2030".

27 European Commission, "Seveso Legislation - Industry - Environment - European Commission," accessed December 22, 2021, https://ec.europa.eu/environment/seveso/legislation.htm; European Commission, "Seveso - Major Accident Hazards - Environment - European Commission," accessed December 22, 2021, https://ec.europa.eu/environment/seveso/index.htm.

28 European Commission, "Seveso Legislation - Industry - Environment - European Commission."

29 European Commission.

30 "Priorities | FETSA," FETSA, accessed October 13, 2021, https://fetsa.eu/priorities/.

4. Logistics and domestic consumption

Energy, manufacturing, agriculture and food are the main sectors served by the bulk liquid storage sector. Domestic consumption is ensured by vast distribution networks, of which tank storage companies are essential. Tank storage further supports a country's economic and geopolitical position by fueling strategic assets like industry, ports, airports and the defense sector.

4.1. Energy: oil products

European oil demand has decreased over the last decades, but it remains substantial. Gasoil/diesel and gasoline have been the two most used oil products in the EU since 1990, followed by LPG, kerosene and fuel oil.[31] These products remain dominant in transport, with road transport being responsible for 47.5 % of all oil products used in the EU in 2018.[32] Especially in countries like Germany that are located at the center of Europe, the demand for diesel is high compared to other oil products, due to the large scale transit traffic through the country.

31 Eurostat, "Oil and Petroleum Products - a Statistical Overview," 2020, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Oil_and_petroleum_products_-_a_statistical_overview.

32 Eurostat.

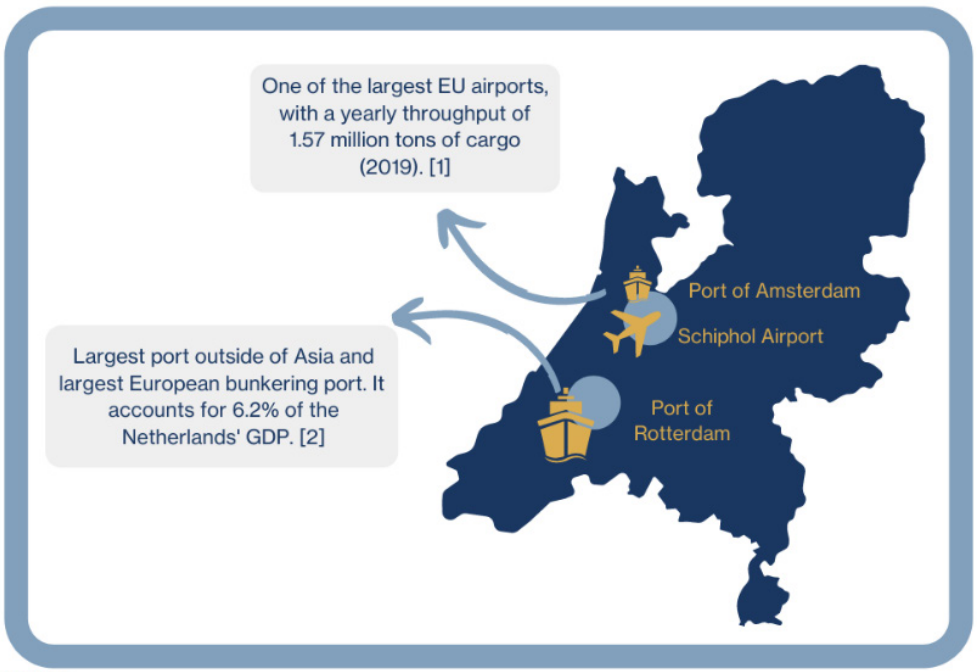
Industrial use (incl. petrochemicals) is the second largest sector in which oil is consumed within the EU (14.1 %), followed by shipping and maritime bunkering (9 %) and aviation (9 %).[33]

Independent tank storage companies support the domestic consumption of oil products within some of the most important economic sectors. This essential economic function of tank storage is present in every country, although individual characteristics of national logistics networks lead to certain differences.

The largest ports and airports in Europe are fueled by supply chains comprising of a large number of players. In Southern Europe, the Bay of Gibraltar/Algeciras is a key hub for ship refueling operations, with the ports of Algeciras and Gibraltar being the most important bunkering locations in the Mediterranean.

In Western Europe, the Port of Rotterdam is not only the largest port outside of Asia, but also Europe's largest bunkering port.[34] Figure 3 illustrates the importance of the ports and airports in the Netherlands, as the massive fuel availability is supported by significant storage capacity. Approximately 11 million m^3 of fuel is supplied to vessels passing Rotterdam on a yearly basis.[35] Similarly, Amsterdam Airport Schiphol depends on the Dutch domestic distribution network. Approximately half of the kerosene used in Schiphol (55 %) is transported

Figure 3. Largest ports and airports in the Netherlands, supported by tank storage



Sources:
[1] Schiphol Group, "Key Figures 2019," 2020.
[2] Port of Rotterdam, "Facts & Figures," 2020, https://www.portofrotterdam.com/sites/default/files/2021-06/facts-and-figures-port-of-rotterdam.pdf.

33 Eurostat.

34 "Rotterdam Bunker Port," Port of Rotterdam, accessed August 18, 2021, https://www.portofrotterdam.com/en/logistics/cargo/liquid-bulk/rotterdam-bunker-port.

35 "Rotterdam Bunker Port."

through a 16 km underground pipeline, connecting the airport to storage facilities in the Port of Amsterdam.[36] The other 45 % is transported by DPO, the Defense Pipeline Organization, in times of peace. The substantial kerosene storage capacity in Dutch ports supports Schiphol's position in the top 5 largest European airports both in terms of passengers and cargo.[37]

Ports and airports contribute to the Europe's economic prosperity, while also serving its broader geopolitical interests. They are strategically important parts of infrastructure systems and depend on a compound of services for their uninterrupted functioning. Tank storage is one such essential service. Storing sufficient supplies of jet and shipping fuel allows European countries to excel in the maritime and aviation sectors, while also strengthening Europe's strategic autonomy.

The Spanish national distribution system is well developed and interconnected. A part of it, illustrated in Figure 4, is operated by Exolum, the largest independent storage company in Europe. Some of the largest airports in Spain, like Madrid, Barcelona and Palma de Mallorca, are fueled by pipeline. More than 4000 km of multiproduct pipelines connect 8 refineries, 39 storage terminals, 13 port facilities and the main airports.

Figure 4. The Spanish distribution network operated by Exolum.

Figure from Exolum

36 Port of Amsterdam, "Kerosene: Facilities for Storage and Transport," accessed August 18, 2021, https://www.portofamsterdam.com/en/business/cargo-flows/liquid-bulk/kerosene.

37 Schiphol Group, "Key Figures 2019," 2020.

In France, tank storage companies primarily support domestic consumption of crude oil, refined products and chemicals, as seen in Figure 5.

The most important storage hubs are located around big cities like Paris and Lyon, as well as along the coast in Marseille Fos-Lavera, Le Havre or Dunkerque. Refined products like diesel or gasoline are by far the most commonly stored and used oil products, especially in in-land terminals.

Figure 5. Depots and terminals in France. Figure from USI, 2020[38]

38 "Key Figures of the USI." In the figure, capital letters refer to pipelines. LHP stands for the pipeline system from Le Havre to Paris; ODC for the Oléoducs de Défense commune, the French part of the NATO pipeline system; DMM for the Donges-Melun-Metz pipeline; SPSE for Société du Pipeline Sud Européen; PMR for the Mediterranée-Rhône pipeline; PSM for the ipeline from Fos s/mer to Manosque.

In the UK, many terminals are connected by pipelines, while others are linked through railways, roads or by maritime means. To serve the domestic demand centers, especially the south is strongly dependent on pipelines that connect Fawley, Thames Oilport, Stanlow and Pembroke. Figure 6 shows a part of the pipeline network in the south of the UK, with pipelines owned by large companies and refineries. These are not the only pipelines in the area – another network has been owned and operated by Exolum since 2015, which is discussed in section 7.1 on emergency stocks.

Figure 6. Pipelines in England and Wales owned by refining companies.

Figure from UK pia

The north of the UK relies more on road transport with road distribution terminals located at Stanlow and on the Humber. Scotland is supplied from Grangemouth while Northern Ireland is dependent on imports transported through Belfast port.[39] Terminals on the north-east and southern coasts are connected with the ARA cluster and other harbors in Europe which have an important function in the UK's domestic supply and international trade.

39 UK pia, "Statistical Review 2018," 2018, 9, https://www.ukpia.com/media/1008/ukpia-statistical-review-2018.pdf.

Yet not all countries depend on pipelines as the main mode of transportation. In Germany, inland waters such as the Rhine River provide advantages for transport via barges. In Italy, the pipeline system is not as widely developed. As seen in Figure 7, most pipelines for crude oil and refined products are concentrated in the north of the country, connecting important refineries with storage sites and ports like Genoa, Venice and Trieste. The rest of Italy receives oil products by road or rail.

Figure 7. Oil distribution network in Italy.

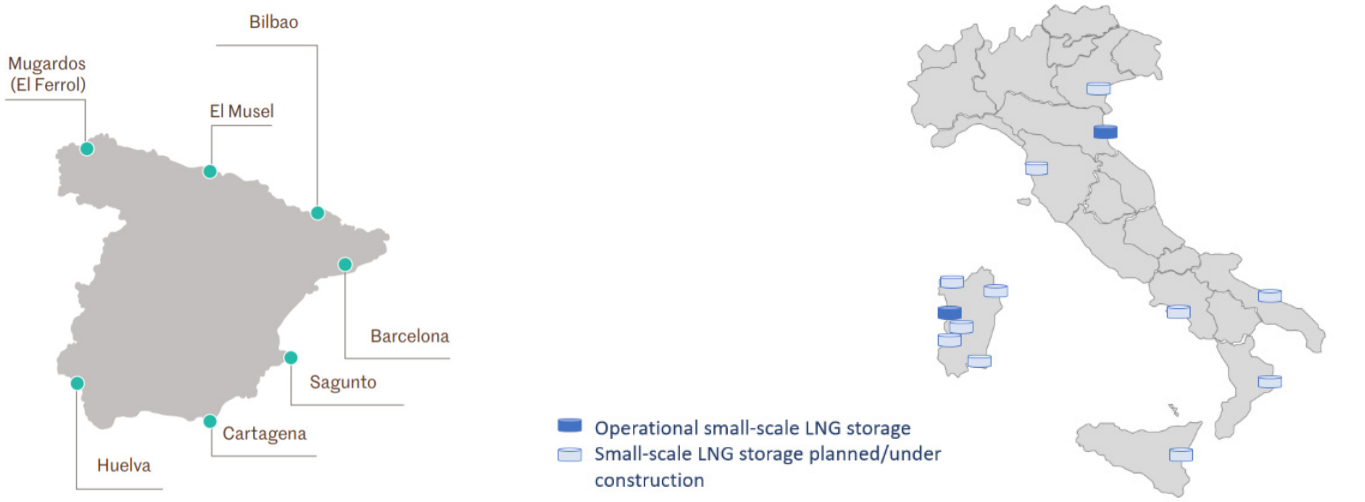
Figure from unem.

4.2. **Energy: LNG**

Coal-to-gas switching together with nuclear phase-outs have led to an increase in gas consumption across Europe. In 2019, gas accounted for 69.3 % of residential energy consumption in the EU.[40] It is primarily used for space and water heating and for cooking. Natural gas is also used in many industrial sub-sectors, including textiles, food and tobacco, machinery, and chemicals.[41] In the chemical industry, gas can be used not only as feedstock for plastics, fertilizers, or fabrics, but also for heat production, specifically in high-heat temperature processes. High-heat is needed for glass, ceramics, cement, and metal casting.[42]

Europe is largely satisfying its domestic demand through imports and LNG is becoming increasingly important for security of supply. The continued importance of gas will require extensive LNG storage and transport infrastructure for at least another decade. Gas storage, both in tanks and underground, is therefore key in reducing volatility and uncertainty in times of supply disruptions. In countries like Germany and the Netherlands natural gas is primarily stored as a gaseous fuel underground, but in others like Spain and Italy LNG plays a larger role. Within Europe, Spain has the most extensive LNG infrastructure, with key hubs in Barcelona and Huelva. As seen in Figure 8, Spain has seven LNG import terminals (six operational) and a storage capacity of more than 3.3 million m^3.[43] Italy is also continuously expanding its LNG infrastructure, with an expected addition of at least 120,000 m^3 in the next years (see Figure 8).

Figure 8. LNG import terminals in Spain (left).[44] **Small-scale LNG storage terminals, operational and planned/under construction in Italy, as of 2019** (right).
Figure from unem, 2022



40 Eurostat, "Energy Consumption in Households," 2021, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households .

41 Anouk Honore, "Decarbonization and Industrial Demand for Gas in Europe:" (Oxford Institute for Energy Studies, May 2019), 10, https://doi.org/10.26889/9781784671396 .

42 Honore, 10.

43 IEA, "Spain 2021: Energy Policy Review," 2021, 176, https://iea.blob.core.windows.net/assets/2f405ae0-4617-4e16-884c-7956d1945f64/Spain2021.pdf.

44 King & Spalding, "LNG in Europe 2018: An Overview of LNG Import Terminals in Europe," 2018, 21, https://www.kslaw.com/attachments/000/006/010/original/LNG_in_Europe_2018_-_An_Overview_of_LNG_Import_Terminals_in_Europe.pdf?1530031152.

In the UK there are three main import terminals for LNG, and so far, there are no indications for an increase of LNG infrastructure. The UK has historically derived the majority of its domestic natural gas sources from the North Sea. However, since North Sea gas is expected to decline drastically in the next years, the UK will likely become more reliant on gas imports.[45]

4.3. **Energy: biofuels**

Biofuels like ethanol can be made from biomass, such as plant or algae material and animal waste. On the other hand, biodiesel is produced using vegetable oils, recycled cooking grease or animal fat.[46] Biofuels are predominantly used for transportation, mixed with oil products like diesel or gasoline. Biofuel may also be used for heat and power generation, the cleaning of oil spills, as a lubricate or paint removal. The consumption of biofuels in the EU varies per member state and their respective ambitions and obligations in reaching targets under certain Directives. The implementation of the European Renewable Energy Directive (2009/28/EC) was the primary driver of the sharply increasing biofuel consumption, as it mandated that biofuels would be blended with gasoline and diesel for road transport.[47] Up to 2030, member states have to introduce a blending target of at least 14 % for renewable sources into road transport fuels, though this target is likely to increase for the Fit for 55 goals to be achieved.[48]

4.4. **Chemicals**

Chemicals are used in virtually every sector, ranging from pharmaceuticals, cleaning products and plastics, to the construction, electronic, healthcare, textile and automotive industries. Chemicals are used in building insulation, which increases energy efficiency. They are also used in the production of pharmaceuticals, including the recent Covid-19 vaccines. These are only a couple of examples that show the importance of chemicals in people's daily lives.

More than half of the chemicals produced in the EU and UK are supplied to industry. Figure 9 illustrates these industrial sectors, all of which depend on tank storage for logistic support. Rubber and plastics production is the main consumer, with 15.5 % of total chemical consumption. Non-industrial consumption of chemicals accounts for 44.5 % of the total.[49] The health sector is by far the most important such consumer, accounting for 16.8 % of European chemicals. In other words, tank storage facilitates the efficient functioning of all societal sectors, from health to manufacturing and agriculture.

45 UKOOG, "Natural Gas Uses," UKOOG - Onshore extraction, accessed January 24, 2022, https://www.ukoog.org.uk/onshore-extraction/uses.

46 "Biofuel Basics," U.S. Department of Energy, accessed April 7, 2021, https://www.energy.gov/eere/bioenergy/biofuel-basics.

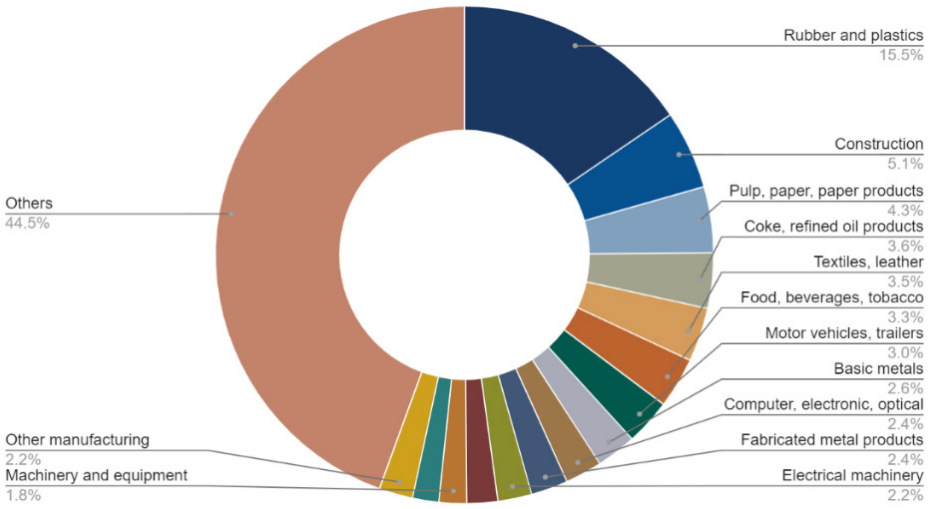
47 European Union, "Directive 2009/28/EC on the Promotion of the Use of Energy from Renewable Sources," accessed September 23, 2021, https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX-%3A32009L0028.

48 European Commission, "Amendment Renewable Energy Directive 2030," 2021, 15, https://ec.europa.eu/info/sites/default/files/amendment-renewable-energy-directive-2030-climate-target-with-annexes_en.pdf.

49 CEFIC, 2021.

Germany, Belgium and the Netherlands account for 40 % of all European chemical production.[50] The Trilateral Chemical Region, consisting of North-Rhine Westphalia, Flanders and the Netherlands, is working to further integrate facilities and turn the chemical industry into a highly efficient and more sustainable sector. Across the EU, the chemical industry employs 1.2 million people directly and 3.6 million indirectly.[51] Some of the largest companies in the world are either headquartered in the ARRRA (Antwerp-Rotterdam-Rhine-Ruhr-Area) chemical cluster or have important production and R&D sites in the region.

Figure 9. Consumer sectors of the European chemical industry in 2017. 'Others' refers to non-industrial consumers. Data from CEFIC, 2021



Port of Antwerp stands out as one of the largest integrated chemical production and trade hubs in the world, both for base chemicals and fine chemicals.[52] Storage facilities, refineries, steam crackers and some of the world's largest chemical companies (e.g., BASF, Ineos, AirLiquide) produce chemicals not only for Belgium, but also for other European countries and international destinations.

In Southern Europe important chemical production centers can also be distinguished. Port of Tarragona functions as an integrated cluster, with the largest chemical producers connected by pipelines. Tarragona is the largest chemical hub in Southern Europe and the chemicals produced there are exported to countries around the Mediterranean.[53]

50 "Refining and Chemicals," Port of Rotterdam, accessed August 16, 2021, https://www.portofrotterdam.com/en/setting/industry-port/refining-and-chemicals.

51 European Commission, "Chemicals Strategy for Sustainability Towards a Toxic-Free Environment," COM(2020) 667 § (2020), 2, https://eur-lex.europa.eu/resource.html?uri=cellar:-f815479a-0f01-11eb-bc07-01aa75ed71a1.0003.02/DOC_1&format=PDF.

52 "Port Of Antwerp - Chemical Park," Chemical Parks in Europe, accessed December 20, 2021, https://chemicalparks.eu/parks/port-of-antwerp.

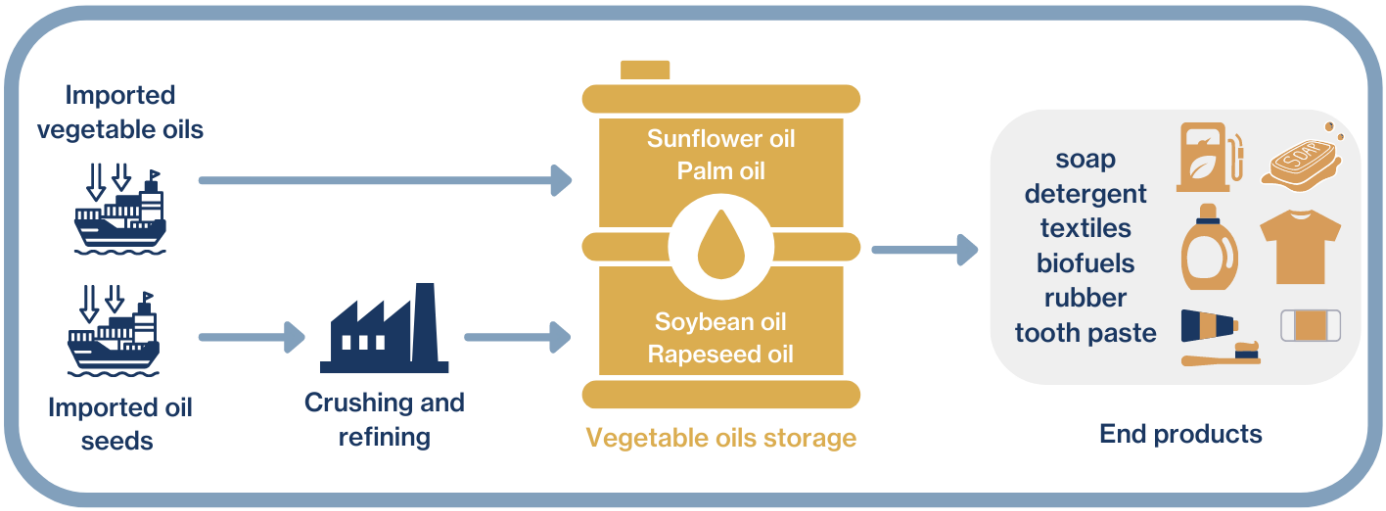
53 ECSPP, "Chemmed Cluster Tarragona - Chemical Park - Spain," accessed December 22, 2021, https://chemicalparks.eu/parks/chemmed-cluster-tarragona.

Throughout Europe, the ability of chemical producers to source materials directly from the industrial and petrochemical clusters is highly advantageous. For instance, feedstock like naphtha and LPG are transformed in base chemicals such as ethylene and propylene within the industrial cluster. Since these are essential components in plastics production, it is convenient for factories to be situated in close vicinity.[54] Chapter 5.2 discusses the European chemical industry in more detail.

4.5. **Edible oils**

Edible oils and fats are not just used for (frying) food or animal feed, but also for manufacturing cosmetics or detergents and technical applications like the production of textile, leather and rubber.[55] Oleochemicals are produced from vegetable and animal fats and oils and are further used as raw materials for a wide range of applications. Major products derived from the oleo-chemical industry are personal care items like soap and toothpaste, but also include laundry detergents, paints, candles, and pharmaceuticals. Figure 10 illustrates the supply chain of edible oils and fats, highlighting the role of storage in this wider ecosystem. Over the last decade, there has been a slight increase in the consumption of vegetable oils and fats within the EU: from 22 million tons of vegetable oils and fats in 2010 to 27 million tons in 2020.[56] The increase is partly associated with their role in the production of biofuels.[57]

Figure 10. Simplified supply chain of vegetable oils and fats



54 Jasper Meijering and Jabbe van Leeuwen, "The Dynamic Development of Organic Chemistry in North-West Europe," Cracking the Clean Molecule (CIEP, 2021), 34, https://www.clingendaelenergy.com/publications/publication/the-dynamic-development-of-organic-chemistry-in-north-west-europe.

55 Fediol, "Applications (Vegetable Oils and Fats)," 2020, https://www.fediol.eu/web/applications/1011306087/list1187970105/f1.html.

56 Fediol, "Vegetable Oils Production, Imports, Exports and Consumption - Consumption of Vegetable Oils and Fats," 2020, https://www.fediol.eu/data/oils%20evol.pdf.

57 European Commission, "EU Agricultural Outlook for Markets and Income, 2019-2030," 2019, 26, https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/agricultural-outlook-2019-report_en.pdf.

5. Supporting regional industry

Spatial proximity is an operational advantage in industrial processes. Quick and easy transfers of crude oil from import terminals to refineries and of feedstock from refineries to production plants are cost and time efficient. Clusters of import terminals, storage facilities, oil refineries and (petro)chemical factories, connected through hundreds of kilometers of pipelines, sharing infrastructure, electricity, and heat, can become internationally competitive. This section discusses the role of tank storage as an integral part of the European industry.

5.1. Oil refineries

Refinery output can include fuel oil, gasoil, gasoline, kerosene, naphtha or LPG. As of 2020, 74 refineries were operating in the EU and UK, with a primary refining capacity of 579.2 million tons per year.[58] In the last decade, 24 European refineries were closed due to poor refining margins and highly competitive international facilities, particularly in the Middle East and Russia.[59] In the last 10 years, five refineries in Italy closed down: two of them were turned into biorefineries, while the other three were transformed into storage depots. The Netherlands

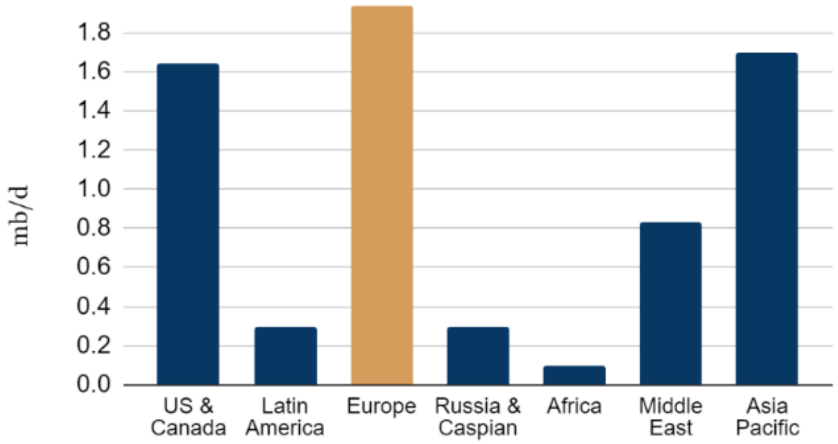
58 Fuels Europe, "Statistical Report 2021," 2021, 40, https://www.fuelseurope.eu/wp-content/uploads/SR_FuelsEurope-_2021.pdf.

59 Fuels Europe, 41; Robbert Van Den Bergh, Michiel Nivard, and Maurits Kreijkes, "Long-Term Prospects for Northwest European Refining" (The Hague, Netherlands: CIEP, 2016), 22–23, https://www.clingendaelenergy.com/publications/publication/long-term-prospects-for-northwest-european-refining.

has six active petroleum refineries, five of which can be found in the Port of Rotterdam and one in Zeeland.[60] These are connected to each other and to other industrial sites by 1500 km of pipelines.[61] Spain has eight oil refineries in its mainland territory, connected to a network of multiproduct pipelines. The UK has six refineries, some of which may seek to invest in infrastructure for the provision of biofuel and hydrogen.

Europe, Asia Pacific and North America are the regions with the most refining capacity closure since 2012, as seen in Figure 11. In the 8 years since then, European refining capacity decreased by 1.9 mb/d, whereas in Asia Pacific and North America it shrunk by 1.7 and 1.64 mb/d, respectively. While many European refineries are projected to close in the following decades as a result of the expected decrease in oil consumption, other countries are ramping up investments in their refining sectors.[62] Spain is an exception within Europe, as the Spanish refining sector has expanded over the last decade.

Figure 11. Refinery closures divided by region, 2012-2020. Data from OPEC, 2021



Before and after the crude oil is refined, as well as prior to being exported or used domestically, it needs to be stored. The close proximity of storage to industrial centers enhances productivity and efficiency. The location of refineries in ports, for instance, provides input flexibility, given that the crude oil from either Russia, the Middle East, or the North Sea region, is brought into import terminals. The European industry is directly supported by tank storage. In the absence of sufficient domestic storage capacity, production sites would struggle to achieve competitive margins relative to other regional clusters in the Middle East or Asia.

Germany has the largest refining capacity in Europe, with a share of 15.7 % of the total EU27+UK (see Figure 12).[63] Germany therefore produces a total output of approximately 24-25 mb/d of refined products.[64] Italy is the second largest European refiner, having produced 18.1 mb/d in 2019 according to Figure 12.

60 C Oliveira and K.M. Schure, "Decarbonisation Options for the Dutch Refinery Sector" (The Hague: TNO, PBL, 2020), 7.

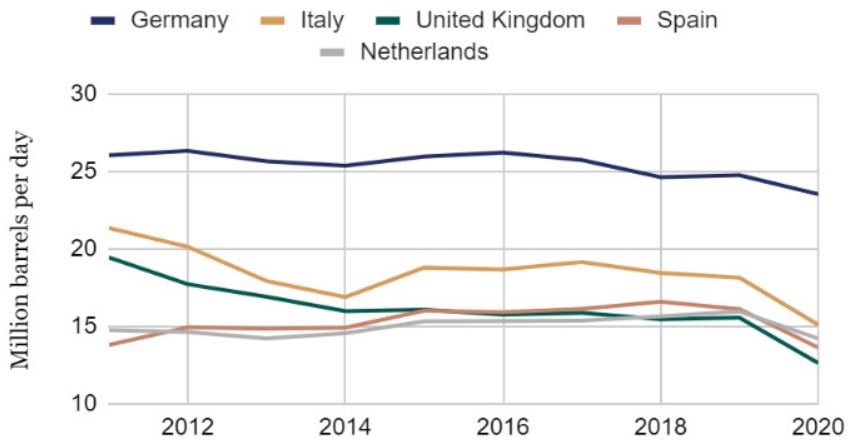
61 Oliveira and Schure, 7.

62 OPEC, "World Oil Outlook 2045," 2021, 216.

63 "Refinery Sites in Europe," *Concawe* (blog), accessed October 6, 2021, https://www.concawe.eu/refineries-map/.

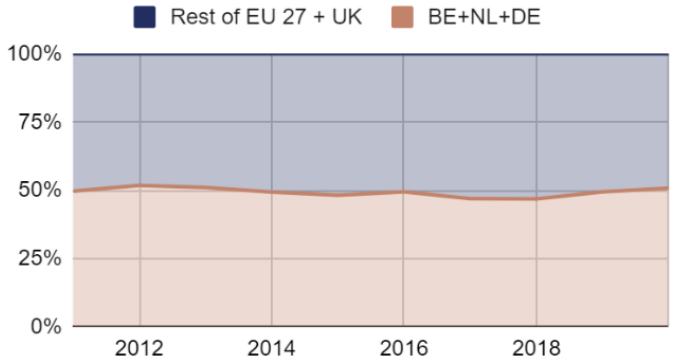
64 Throughout this paper, the most recent data points tend to be 2019 instead of 2020, given that the Covid-19 pandemic had such a distorting effect on key economic functions.

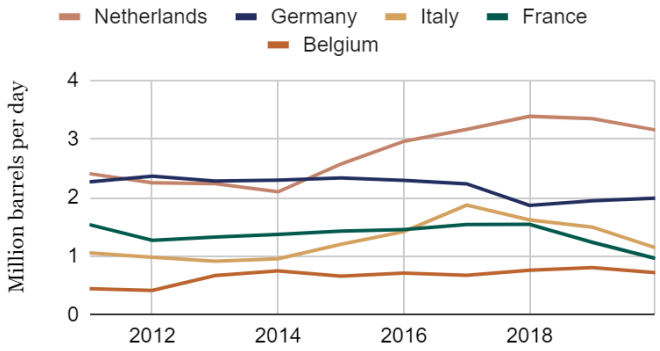
Figure 12. Refinery output of oil products in European countries since 2011.
Data from JODI, 2021



About half of all naphtha produced in Europe, or 5.9 mb/d, comes from ARRRA, as shown in Figure 13. This is the most highly industrialized and integrated (petro)chemical cluster in Europe, largely relying on naphtha as feedstock.[65] Figure 13 highlights the importance of the Netherlands in refining naphtha since 2014. In 2020, the Netherlands alone provided 3.15 mb/d. Germany, the second largest producer, accounted for 1.9 mb/d naphtha in 2020.

Figure 13. Naphtha production in European countries since 2011.
Data from JODI, 2021

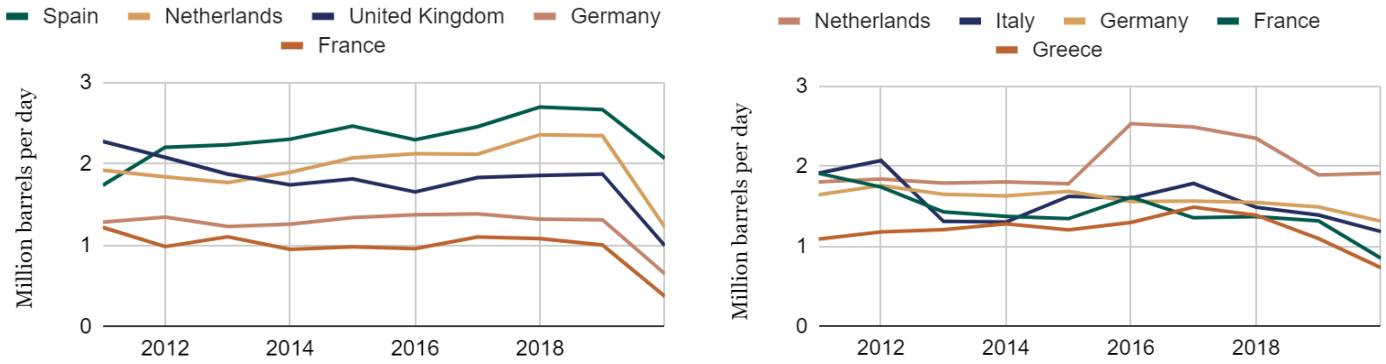




Spain is the largest European producer of kerosene, accounting for 2 mb/d in 2020 (see Figure 14). The Netherlands stands out as the second largest EU kerosene producer since 2015, with 2.3 mb/d of kerosene output in 2019. Domestic kerosene production can provide security of supply to Amsterdam Schiphol Airport, one of the main consumers of kerosene and one of the biggest airports of Europe. Europe's biggest bunkering port, Rotterdam, is a large consumer of fuel oil for ships. Dutch refineries produce large amounts of fuel oil, being the European leaders. The Netherlands provided 1.9 mb/d in 2019, as seen in Figure 14.

65 Meijering and van Leeuwen, "The Dynamic Development of Organic Chemistry in North-West Europe," 11.

Figure 14. Kerosene and fuel oil production in European countries since 2011. Data from JODI, 2021.



European production of gasoil/diesel, kerosene, and naphtha is not sufficient to fulfill domestic demand.[66] This makes the EU dependent on imports: gasoil comes from Russia and the US, while jet fuel from the Middle East and Asia-Pacific.[67] Tank storage is essential in balancing the supply and the demand of these refined products. Once imported, they are stored into tanks awaiting distribution.

When it comes to gasoline, the EU has a more advantageous position. European refineries have been oversupplying gasoline for decades. Germany, Italy and the UK are Europe's largest gasoline producers.[68] The Port of Amsterdam is the largest gasoline port in the world, playing a key role in international trade.[69] Once produced in European refineries, the surplus gasoline is stored and exported, primarily to North America and Asian countries.[70]

5.2. **Chemical industry**

One of the main advantages of the European chemical industry is the robust infrastructure connecting ports and storage facilities with petroleum refineries and petrochemical plants. This provides high efficiency in terms of transport times, costs, and infrastructure sharing. The ARRRA cluster (see Figure 15) generated a turnover of € 180 billion in 2015.[71] The cluster is responsible 46 % of all European sales of chemicals.

As shown in Figure 16, chemicals represent the fourth largest European manufacturing sector in terms of yearly turnover, topped only by food products, automotive and machinery. The industry has a yearly turnover of approximately € 553 billion.[72] The chemical industry is among the most important manufacturing sector in terms of value added as well, with 6.6 % of total added value in the EU+UK coming from chemicals.

66 Insights Global, "ARA Oil Tank Terminal Report 2020" (Netherlands, 2020).

67 Fuels Europe, "Statistical Report 2021," 26–32.

68 Data from JODI, 2021.

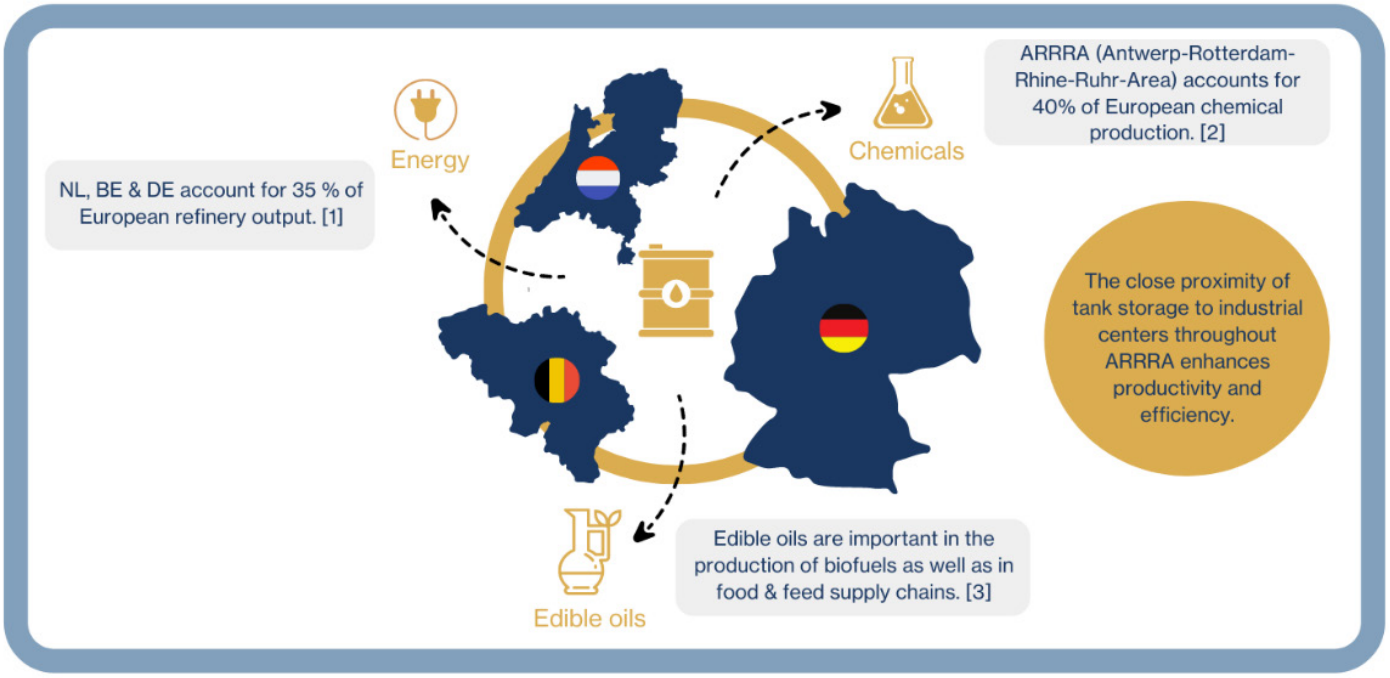
69 Port of Amsterdam, "Gasoline: The World's Largest Gasoline Port," June 8, 2020, https://www.portofamsterdam.com/en/business/cargo-flows/liquid-bulk/gasoline.

70 Insights Global, "ARA Oil Tank Terminal Report 2020."

71 "Our Region," Trilateral Chemical Region, accessed August 2, 2021, https://www.trilateral-chemical-region.eu/ueber-uns; "Refining and Chemicals."

72 CEFIC, 2021.

Figure 15. The role of tank storage in supporting regional industry in the ARRRA region



Sources:
[1] Data from JODI, 2021.
[2] "Our Region," Trilateral Chemical Region, accessed August 2, 2021, https://www.trilateral-chemical-region.eu/ueber-uns; "Refining and Chemicals."
[3] European Commission, "EU Agricultural Outlook for Markets and Income, 2019-2030," 2019, 26, https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/agricultural-outlook-2019-report_en.pdf.

European companies like Lyondell Basell and BASF bring millions worth of added value as well as employment to the European economy, and depend on the synergy between oil refineries, tank storage, infrastructural connections, and chemical production plants to remain profitable. Lyondell Basell is one of the largest plastics, chemicals, and refining companies in the world. Its Maasvlakte (co-owned with another European multinational, Covestro) and Moerdijk production sites have a combined yearly economic impact of $ 371 million.[73] They produce automotive exteriors, food packaging and high-pressure pipes.

BASF is the largest chemical producer in the world.[74] It originated in Germany, where it still has the largest and oldest integrated production site in the world.[75] The advantage of this location is the efficient interlinkage between production facilities, energy flows, logistics and infrastructure.[76] The second largest such 'Verbund' site is in Antwerp, Belgium.[77] The fact that the

73 Estimate includes yearly total for goods & services purchased and employee pay and benefits, excluding raw materials purchased. See LyondellBasell, "Maasvlakte Site," accessed August 18, 2021, https://www.lyondellbasell.com/globalassets/lyb-around-the-world/plant-sites/fact-sheets/factsheet-maasvlakte.pdf; LyondellBasell, "Moerdijk Site," accessed August 18, 2021, https://www.lyondellbasell.com/globalassets/lyb-around-the-world/plant-sites/fact-sheets/factsheet-moerdijk.pdf.

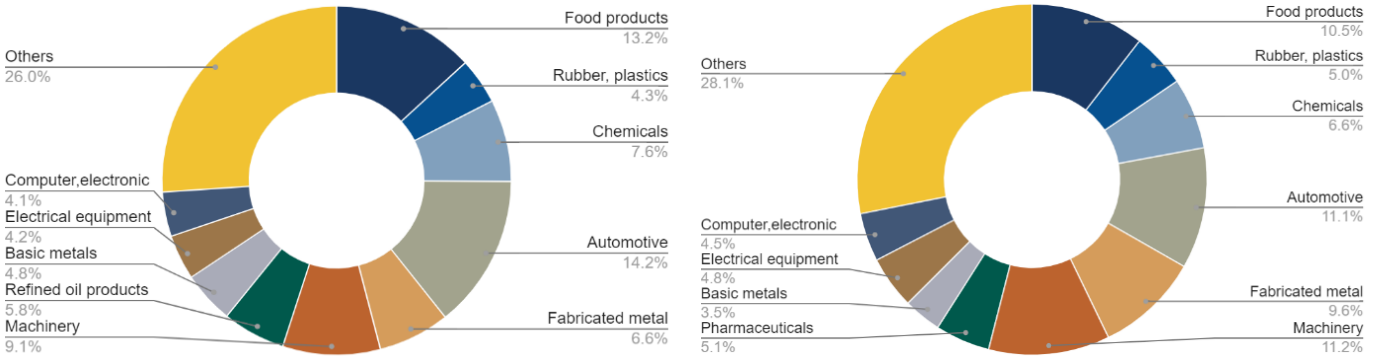
74 Joseph Chang, Nigel Davis, and Will Beacham, "The ICIS Top 100 Chemical Companies," *ICIS Chemical Business*, 2020.

75 BASF, "BASF Verbund," 2021, https://www.basf.com/global/en/investors/calendar-and-publications/factbook/basf-group/verbund.html.

76 BASF.

77 BASF; "BASF in Nederland," BASF, accessed October 22, 2021, https://www.basf.com/nl/nl/who-we-are/BASF-in-Nederland.html.

Figure 16. Top 10 manufacturing sectors in EU27+UK in terms of turnover (left). **Top 10 manufacturing sectors in EU27+UK in terms of value added at factor cost** (right). Data from CEFIC, 2021



largest chemical producer in the world reaps benefits from efficient integration of such facilities speaks to the added value of the ARRRA industrial cluster to the European economy.

Within ARRRA, Antwerp is the largest European chemical hub. Around 90 % of the 720 km of pipelines in the Port of Antwerp is used to transport chemicals and petrochemicals.[78] Production facilities are interconnected with refineries, steam crackers and port infrastructure, ensuring continuous supply of feedstock, raw materials and intermediary products. Figure 17 shows the pipeline network connecting Port of Antwerp with neighboring countries within the ARRRA cluster (Germany and the Netherlands) and beyond. Germany is one of the largest producers of chemicals in Europe, though the chemical hubs are located in close proximity to the Netherlands and Belgium, as a part of the ARRRA cluster. This means that chemicals are mainly stored in the Netherlands and Belgium, and less in Germany.

The large import and storage capacity of crude oil in European ports supports the chemical industry. Refineries receive crude oil supplies in a time and cost-effective manner, producing feedstock for the chemical industry. The products are easily transported to chemical sites through the well-developed pipeline networks and in-land transport possibilities via, for instance, the Rhine River. If the feedstock produced domestically is not sufficient to fulfill the chemical industry demand, chemical plants can get supplies directly from import terminals in ports. This is another advantage of the clustering of import and storage terminals with industry.

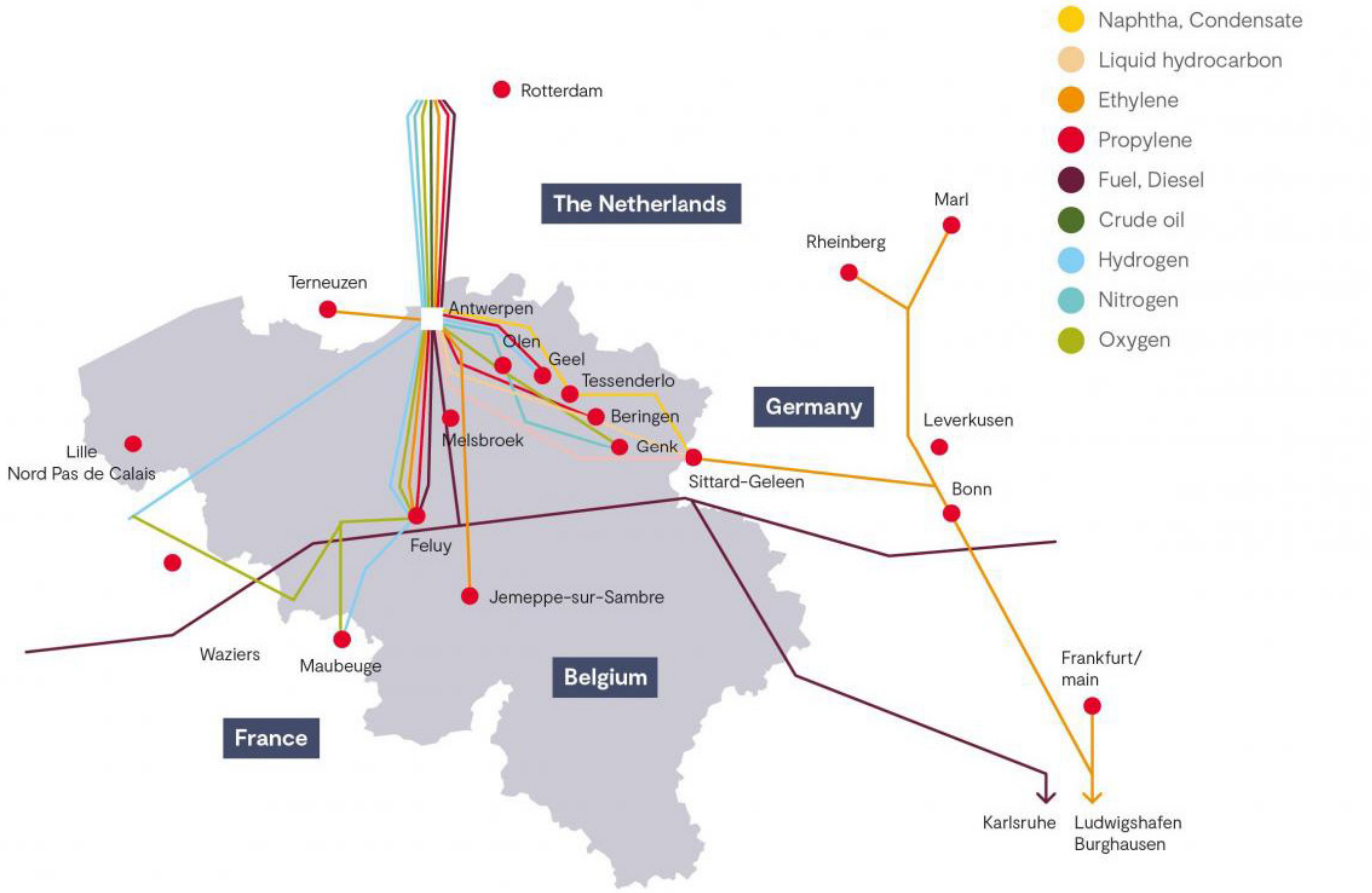
The importance of tank storage in supporting the European chemical industry becomes evident. Storing crude oil, oil products and chemicals provides flexibility and efficiency to the European industry. For instance, naphtha inventories, the most commonly used feedstock for aromatics or plastics, ensure security of supply for chemical production plants.[79] Supplies from diversified sources, i.e., imported from various countries or domestically produced, are stored in tanks, ensuring that sudden shocks in supply chains can be effectively overcome and potential damages to European industry can be minimized.

78 "Chemicals Hub," Port of Antwerp, accessed December 20, 2021, https://www.portofantwerp.com/en/chemicals-hub#integrated.

79 Meijering and van Leeuwen, "The Dynamic Development of Organic Chemistry in North-West Europe," 35.

80 "Chemicals Hub."

Figure 17. Pipeline network connecting Port of Antwerp to neighboring countries.
Figure from Port of Antwerp.[80]



5.3. **Edible oils and biofuels**

Policy support is a key factor impacting the future use of biofuels, and it varies as a result of sustainability concerns associated with conventional biofuels. These are based on oilseed, sugar, and starchy crops, which compete for agricultural land with food crops.[81] Land-use change and biodiversity issues have been associated with conventional biofuels. Advanced biofuels are based on technologies that mitigate sustainability issues but are still being tested and thus not yet commercially available. Whether the widespread production of advanced or conventional biofuels will ultimately be supported by European governments is yet unclear, but specialized tank storage would be necessary to facilitate such a development.

For oleochemical manufacturers, who source their stock from refineries, the largest refineries for edible oil in the EU are based in the Netherlands.[82] In Italy, some crude oil refineries have been transformed in biorefineries given the increasing demand. As seen in Figure 18, out of

81 IEA, "Energy Technology Perspectives 2020," 2020, 137–39.

82 Efeca, "Palm Oil in the Oleochemical Sector," August 2018, 4, https://efeca.com/wp-content/uploads/2019/12/Briefing-note-Oleochemicals_Efeca_09.08.18.pdf.

13 refineries, 11 are for crude oil and 2 have become biorefineries. While this is not sufficient to fulfil domestic demand, Italian production of biofuels has been increasing. Similarly, the production of biofuels in Spain has increased significantly over the last decade. Whereas before the Port of Barcelona was the only relevant player in this sector, facilities are increasingly prominent across Spain, for instance in the Port of Huelva. In the UK, biofuels will play an important role in the short and long term, especially for heavy transport. Since all imports/exports are taking place by shipping, which is one of the most difficult sectors to decarbonize, the UK will import biofuels to a much larger degree in the future.

Figure 18. The refining sector in Italy. In blue oil refineries, in green biorefineries. Figure from unem

6. Trade

Tank storage is an essential part of commodity trading. By holding inventories of liquid products, tank storage acts as a buffer in the physical market, contributing to price stability and reducing uncertainty. In certain countries the trading function is limited to imports and exports of liquid bulk. In others, however, trade has become a defining characteristics of their activity. The ARA (Amsterdam-Rotterdam-Antwerp) region, a highly interconnected network of ports, is widely recognized as a key player in the international oil market and an energy gateway into Northwestern Europe. ARA's dominant position was shaped and facilitated by its location on the North Sea coastline as well as by its well-developed port, storage, refining infrastructure, inland waterways as well as rail and road connections.

6.1. Crude oil

The Brent market in the North Sea is the global benchmark for over 75 % of globally traded oil.[83] Russian Urals' and West African crudes, among others, are priced based on the Brent benchmark. Other benchmarks include the West Texas Intermediate (WTI), Dubai and Oman. Like Brent, WTI is a highly liquid market but has decreased in importance since 2010 due to logistic and pipeline constraints. That is when Brent emerged as the most influential global benchmark.

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

Brent oil has been produced in the British part of the North Sea since the 1970s, though over time its reserves have been depleted and the field is currently being decommissioned.[84] The pricing benchmark is now based on the Brent complex, i.e., a mixture of oil produced from separate fields.[85] It consists not only of the Brent Blend, but also of Forties Blend, Oseberg, Ekofisk and Troll crudes (referred to as BFOET).[86] The global trade of both physically delivered oil and financially settled derivatives is based on the Brent complex, managed by the Intercontinental Exchange (ICE). Brent has historically been recognized as a physical benchmark, although its contracts are financially settled. In other words, contracts are settled in cash at expiry and cargoes do not have to be delivered unless trading parties explicitly want this.[87]

High liquidity in physical oil cargoes is necessary for benchmarks to support and facilitate futures contracts and other types of derivatives.[88] Brent crude is waterborne, meaning that it can be easily shipped anywhere around the world.[89] This is an advantage over landlocked or regional crudes, and it makes Brent crude particularly attractive to physical traders. More than 600 related oil products within the Brent complex are traded on the physical market.[90] ICE Brent Futures contracts are in close synergy with the North Sea physical market, the two of which determine the global price of crude oil. Its waterborne characteristics mean that it can be delivered to refineries anywhere, but geographical proximity is advantageous in terms of delivery time and costs. In the Netherlands, significant oil trading stocks are available at all times to facilitate international trade rather than serve domestic end users.[91]

Tank storage can also be used in a strategic way within the financial market, to influence available supply and therefore pricing, leading to enormous gains. Futures markets determine the shape of the forward curve, and whether this is upward sloping (in contango) or downward sloping (backwardation). In turn, this has an impact on the levels of available inventories.[92] In case of a downward sloping curve, oil prices are expected to decrease in the future, meaning that traders remove oil from inventories in order to sell as much as possible in present time.

A contango situation implies that prices are expected to increase in the future, compared to current levels. 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 on the futures market at a larger price.[93] In contango, oil tends to be oversupplied and storage utilization rates tend to increase. While the international oil market is highly volatile and prices change constantly, there have been a few instances when the oil price plummeted. In 2014, as seen in Figure 19, the price fell from 111.8 dollars/barrel in June to 47.67 dollars/barrel within the span of six months. The crash was caused by a combination of factors, as many different variables can at all times influence the global availability and price of oil. In this case, a global oversupply in petroleum as a result of increasing US production of shale oil as well as Saudi Arabia's

84 Shell, "The Brent Story," accessed September 1, 2021, https://www.shell.co.uk/sustainability/decommissioning/brent-field-decommissioning/the-brent-story.html.

85 Bassam Fattouh, "An Anatomy of the Crude Oil Pricing System" (The Oxford Institute for Energy Studies, 2011), 37.

86 Wittner, "Brent: The World's Crude Benchmark."

87 This contrasts WTI, which requires physical delivery in Cushing.

88 Energy Intelligence, "Global Crude Benchmarks: Brent Sets the Standard," 2020, https://www.theice.com/why-the-world-needs-benchmarks-and-characteristics-of-benchmarks.

89 Wittner, "Brent: The World's Crude Benchmark."

90 Energy Intelligence, "Global Crude Benchmarks: Brent Sets the Standard."

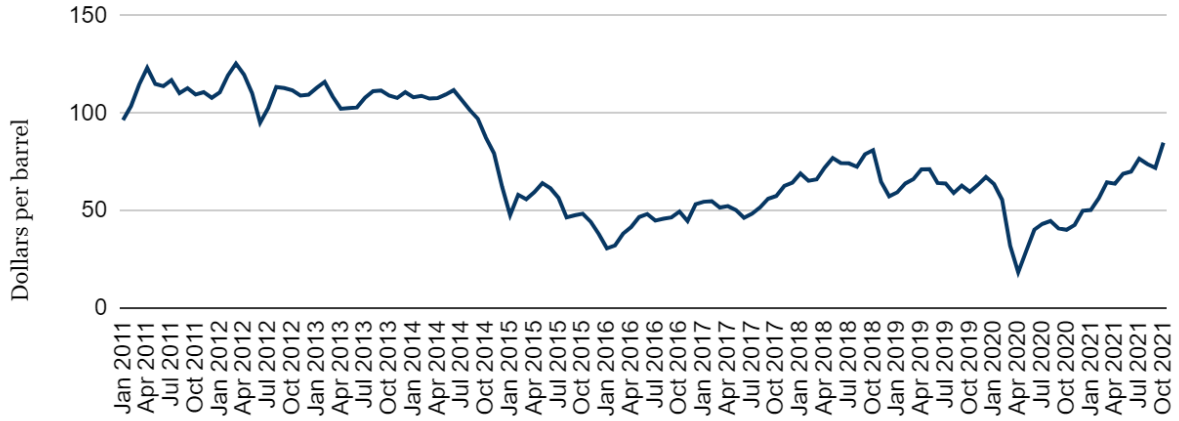
91 van der Lijn et al., "The Functioning and Implementation of Council Directive 2009/119/EC," 135.

92 For more information about commodity markets, see David Buchan and Charlie Errington, "Commodities Demystified" (Trafigura, 2019), https://www.commoditiesdemystified.info/pdf/CommoditiesDemystified-en.pdf#downloads.

93 Insights Global, "ARA Oil Tank Terminal Report 2020," 43.

Figure 19. Europe Brent spot price development, 2011-2020.

Data from EIA, 2021 and FRED Economic Data, 2021



unwillingness to reduce production in order to support prices, were the main reasons behind the price crash.[94] Consequent to this crisis, oil inventories increased in every quarter of 2015, reaching the highest levels that had been recorded since 1996.[95]

The COVID-19 pandemic was a particularly turbulent period of contango, showing the pivotal role of tank storage in international oil trade. The pandemic decreased oil prices to such an extent that trading companies started purchasing significant amounts of liquid bulk and storing it in expectation of a price increase. By April 2020, the Brent spot price fell to 18.38 dollars/barrel (see Figure 19). Its American counterpart, WTI, traded futures contracts for May delivery at negative levels for the first time in history, with -$37.63 per barrel (just before the closing of the contract).[96] Storage facilities in Northern Europe which had been empty until the beginning of the pandemic, suddenly became contracted at full capacity.[97] The largest American storage facility, US Strategic Petroleum Reserve, was filled by 89 % by April 2020.[98] Suppliers and traders around the world were struggling to find spare storage capacity, placing incredible pressure on the storage sector. In conclusion, spare storage capacity is a competitive advantage for countries that try to facilitate international trade and reap the benefits from large throughput in their ports.

94 Dave Mead and Porscha Stiger, "The 2014 Plunge in Import Petroleum Prices: What Happened?," Beyond the Numbers (US Bureau of Labor Statistics, 2015), 4.

95 EIA, "Crude Oil Prices Started 2015 Relatively Low, Ended the Year Lower," 2016, https://www.eia.gov/todayinenergy/detail.php?id=24432.

96 Myra P. Saefong, "Oil Prices Went Negative a Year Ago: Here's What Traders Have Learned since," MarketWatch, April 19, 2021, https://www.marketwatch.com/story/oil-prices-went-negative-a-year-ago-heres-what-traders-have-learned-since-11618863839.

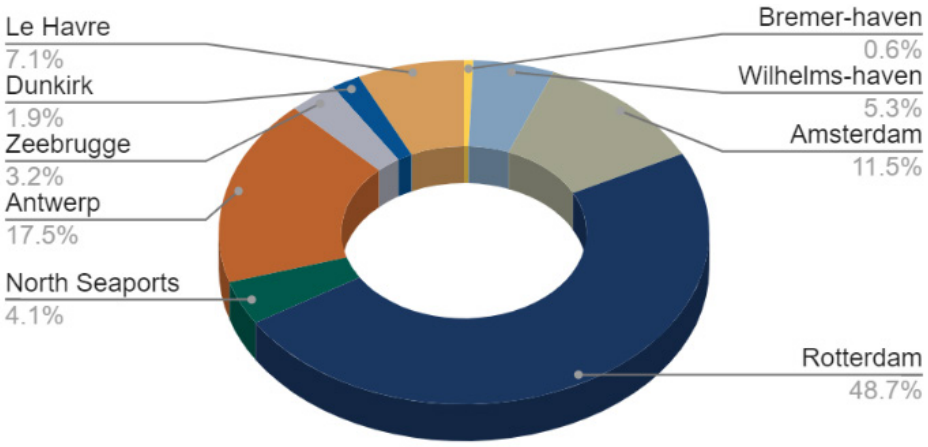
97 Martin Krastev, "The Bright Light amidst Today's Energy Uncertainty," *Tank Storage Magazine* (blog), April 29, 2020, https://www.tankstoragemag.com/2020/04/29/the-bright-light-amidst-todays-energy-uncertainty/.

98 Sam Meredith, "Oil Producers Scramble to Find 'creative' Storage Options after Historic Price Crash," CNBC, April 30, 2020, https://www.cnbc.com/2020/04/30/oil-and-coronavirus-producers-trying-to-find-creative-storage-options.html.

6.2. **Refined oil products**

Trade can take place anywhere in the world, but the places with the most favorable geographical location, low transport and handling costs, and integrated facilities, tend to be advantageous for traders. That is how Northwestern Europe (NWE) became a trading hub. A large part of products stored in the ARA region are intended for re-export, being an international trading hub for refined oil products.[99] They are stored, blended with other products and brought to the form desired by the customer, i.e., they are 'brought to spec'. This NWE spot market is active in both ocean-going cargoes and river barges. Together, the ports of Amsterdam, Rotterdam and Antwerp account for 75 % of all the liquid bulk throughput in the Hamburg-Le Havre region (Figure 20).[100] While the trading function in France is less prominent, Le Havre is the largest French port for import of liquid bulk.

Figure 20. Liquid bulk throughput in the Hamburg-Le Havre range.
Data from Port of Rotterdam, 2021



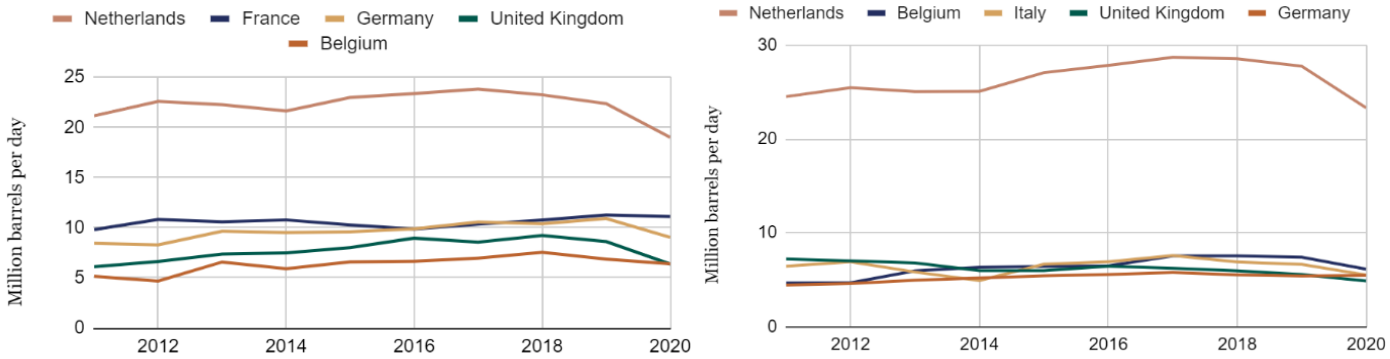
Compared to other European countries, the Netherlands both imports and exports significantly larger amounts of oil products. Figure 21 aggregates the trade flows of naphtha, kerosene, gasoil/diesel, fuel oil and gasoline in the largest oil trading countries of Europe. The Netherlands' position as a trading hub and the contribution it has to the EU's global economic influence becomes evident. In 2019, the Netherlands was a net exporter of oil products, exporting 27.7 mb/d and importing 23.3 mb/d. Gasoline is one of the main oil products traded through ARA, supported by the fact that the Port of Amsterdam is the largest gasoline trading port in the world.[101]

99 McKinsey, "Northwest Europe," accessed September 1, 2021, http://www.mckinseyenergyinsights.com/resources/refinery-reference-desk/northwest-europe/.

100 Port of Rotterdam, "Facts & Figures," 2020, 4, https://www.portofrotterdam.com/sites/default/files/2021-06/facts-and-figures-port-of-rotterdam.pdf.

101 Port of Amsterdam, "Gasoline."

Figure 21. European imports and exports of oil products.
Data from JODI, 2021.



Market imbalances are predictors of what type of role tank storage can take on. In other words, the quantity of products found in storage at any point in time is closely connected with markets and commodity prices. When there is a global surplus of oil, inventory levels will increase. In this case, storage capacity is essential to give the market the time to reduce the imbalance between physical supply and demand, as well as stabilize the price. When there is a surplus of refined oil products compared to the consumption levels in a certain region, this excess quantity can be easily exported elsewhere. Conversely, if there is a deficit of available products, more needs to be imported. The success of such operations, which are necessary functions of any economic system, depends on the availability of storage capacity.

6.3. **LNG**

The Dutch Title Transfer Facility (TTF) is now the most important gas trading hub in Europe, having overtaken the UK's National Balancing Point (NBP).[102] In 2020, over 70 % of European gas trade took place through TTF.[103] An increasing number of countries in the EU rely on the gas spot market to secure supplies, rather than on the traditional long-term contracts. The Netherlands in particular relies on the spot market, meaning that global market volatility could severely impact prices.[104]

Liquid natural gas (LNG) has certain logistical advantages over its gaseous form that have facilitated the creation of a global gas market. LNG is more easily transported and stored, its trade no longer requiring costly pipelines and long-term contracts between consumers and suppliers. Natural gas is now a globally traded commodity. The Netherlands' infrastructure facilitates its advantageous position as a physical market. The Gate terminal in the Port of Rotterdam and a well-developed transmission grid allow it to transport natural gas to the rest of Northwestern Europe. The country's extensive storage capacity, both underground and in above-ground tanks, reduces market uncertainty. The storage acts as a buffer in times when supply exceeds demand or vice versa, as well as in times of global volatility and conflict with an impact on supply.

102 Patrick Heather, "European Traded Gas Hubs: The Supremacy of TTF," Oxford Energy Comment, May 2020, 4.

103 IEA, "Gas Market Report, Q1-2021," 2021, https://www.iea.org/reports/gas-market-report-q1-2021.

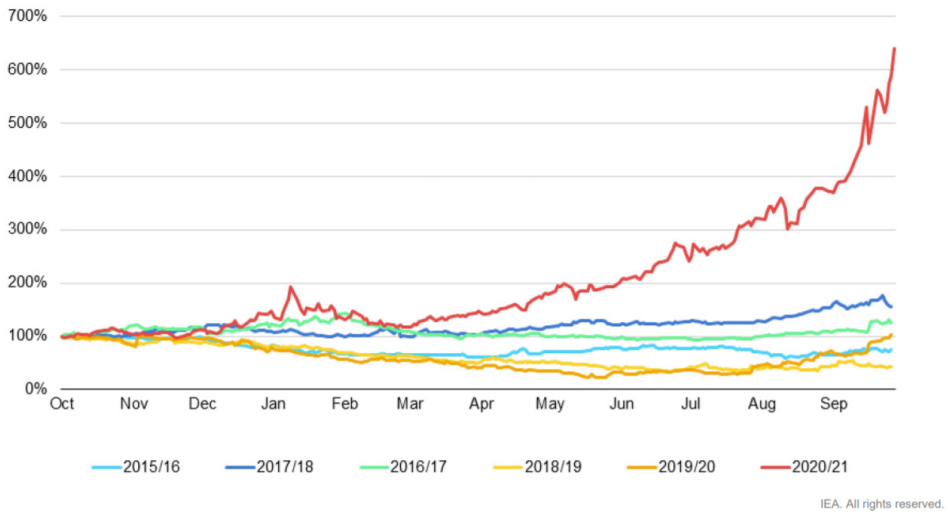
104 Simon Blakey et al., "The Swing in Dutch Gas: From Autonomy to Full Dependence," Strategic Report (IHS Markit, November 2018), 5, https://cdn.ihs.com/www/pdf/1118/IHS-Markit-The-Swing-Dutch-Gas.pdf.

For a long time, Europe has been seen as a 'market of last resort' by LNG suppliers.[105] European countries often absorbed surplus LNG volumes from the global market but were not the first choice of suppliers. This was partly due to Russia's monopoly over pipeline gas imports and thus its ability to decrease prices to such an extent that LNG prices would remain uncompetitive. Large underutilized gas and coal electricity generation capacity has also enabled Europe to act as the swing consumer for gas.[106] Increasing gas demand in China, Japan and South Korea and therefore higher prices, make the East Asian market a more attractive destination for LNG suppliers.

The continued dependence of the EU on natural gas imports places member states in a vulnerable position regarding price volatility and available supply. The aftermath of the COVID-19 pandemic is indicative of the uncertainty that characterizes international markets. After seeing record LNG price volatility in January 2021 and skyrocketing prices in Asia, as shown in Figure 22, the summer months led to the highest recorded gas prices in Europe. The very strong post-pandemic recovery together with high demand in Asia and a cold winter in 2021, led to the highest ever prices on the Dutch TTF, i.e., about € 90/ megawatt hour.[107] Low inventories and the constantly increasing price on the spot market led to high household prices across Europe in the second half of 2021. The high natural prices are strongly connected with electricity and CO_2 prices in the EU.

Gas storage is becoming ever more important in absorbing supply shocks and responding to rapid changes in demand. Spare storage capacity accommodates the sharp rises in imports during cold winters, ensuring that Europeans are able to heat their homes. Domestic inventories ensure that, in the case of a supply shock, the country can continue its socio-economic activities without any significant disturbance.

Figure 22. Annual evolution of natural gas TTF spot prices.
Figure from IEA, 2021



105 Luca Franza, "Outlook for LNG Imports into the EU to 2025," CIEP Paper, CIEP Perspectives on EU Gas Market Fundamentals (CIEP, 2016), 16, https://www.clingendaelenergy.com/inc/upload/files/CIEP_paper_2016_2D_LNG_web.pdf.

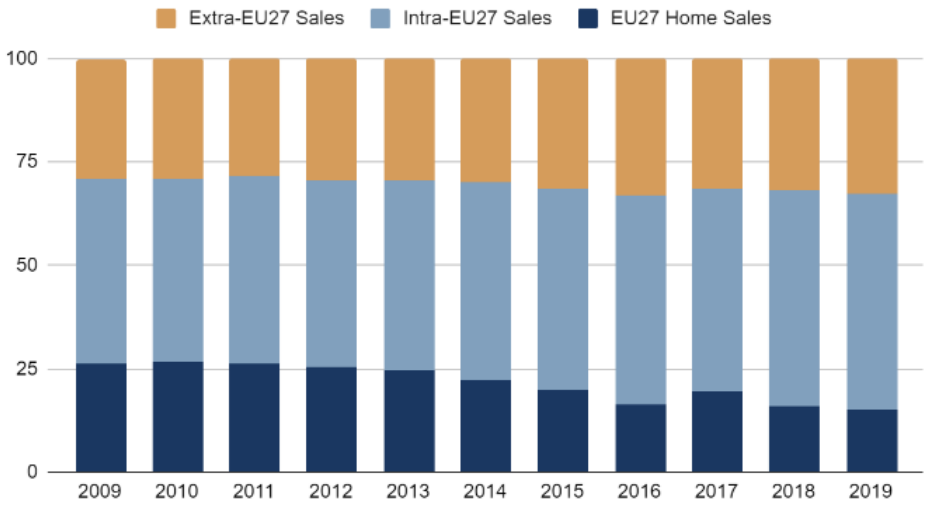
106 This is now changing due to the gradual demise of coal in Europe.

107 For more information, see Jilles van den Beukel and Lucia van Geuns, "De Afnemende Leveringszekerheid van Aardgas in Nederland" (HCSS, October 2021), https://hcss.nl/report/afnemende-leveringszekerheid-aardgas-nl/.

6.4. **Chemicals**

In 2019, the EU was the world's second largest chemical producer, with sales of € 543 billion, after China.[108] Within the EU, four countries account for almost 68 % of all chemical sales: Germany (28.8 %), France (14.2 %), Italy (13.3 %) and the Netherlands (11.5 %).[109] Figure 23 shows that approximately half of European sales take place intra-EU, between member states. Chemicals produced in the Port of Antwerp, the largest hub for chemicals in Europe, are transported though inland shipping, shortsea, road or rail, to consuming countries.[110] In 2019, 15 % of output was traded domestically, a decrease of 10 % since 2009. Contrastingly, intra-EU sales have grown significantly, showing the increasing degree of integration across member states (see Figure 23).

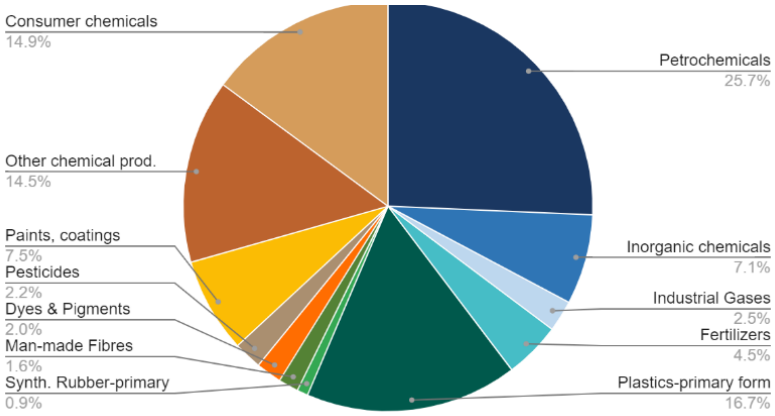
Figure 23. Chemical sales structure in EU27, 2009-2019.
Data from CEFIC, 2019



In terms of specific products traded by the EU, petrochemicals represent the largest category by far, with 25.7 % of total sales (see Figure 24). Petrochemicals come in liquid forms and are important products in need of storage. Consumer chemicals such as soaps, detergents, cosmetics, or perfumes, as well as paints & coatings, fertilizers, or pesticides, can also have liquid forms. Figure 24 shows the market share of each of these categories as a part of total European chemicals sales. The role of tank storage in international trade becomes evident when looking at the important role played by liquid chemicals in the EU.

108 European Commission, Chemicals Strategy for Sustainability Towards a Toxic-Free Environment, 2.
109 CEFIC, 2021.
110 "Chemicals Hub."

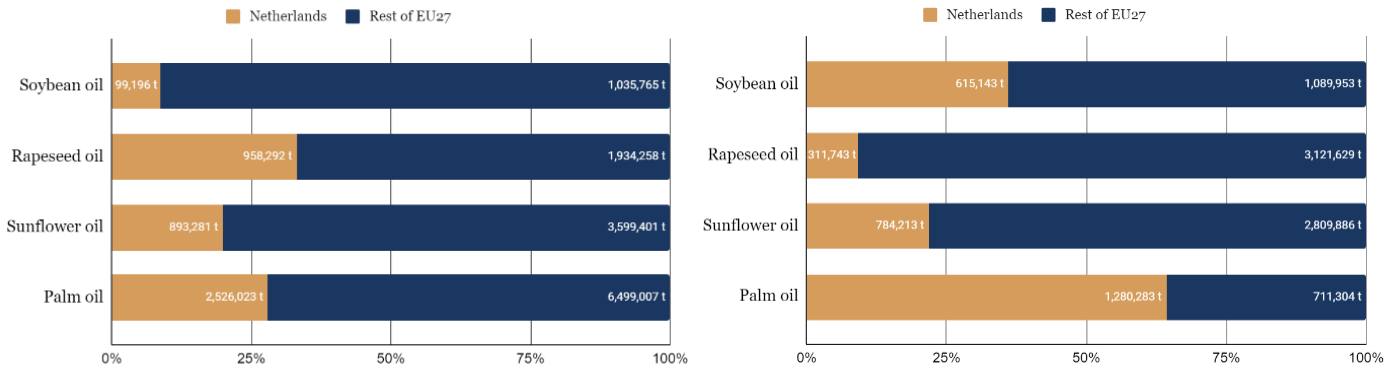
Figure 24. EU27 chemical sales in 2019, divided by product category. Data from CEFIC, 2021.



6.5. Edible oils and biofuels

Oils and fats are the largest agri-food sector in the Netherlands, with an import value of € 15 billion and an export value of € 12 billion in 2020.[111] While most vegetable oils and seeds are imported in Europe, certain countries, like the Netherlands fulfil a trade hub function. According to VERNOF[112], about 80 % of produced vegetable oils in the Netherlands are exported. [113] The Netherlands is a net exporter of soybean and palm oil and has a dominant position in European trade in all four categories displayed in Figure 25. Approximately 36 % of all European soybean oil exports come from the Netherlands, corresponding to about 615 000 tons.[114]

Figure 25. Imports (left) **and exports** (right) **of edible oils by the Netherlands and EU, measured in tons.** Data from MVO, 2021



111 "De oliën- en vettenketen," MVO, July 29, 2021, https://mvo.nl/organisatie/de-keten.

112 VERNOF stands for The Association of Dutch Producers of Edible Oils and Fats.

113 Vernof, "About VERNOF", 2020, https://www.vernof.com/home-en/.

114 Data from MVO, 2021.

When looking at palm oil, the situation becomes even more striking: the Netherlands accounts for 64.3 % of all European palm oil exports and 28 % of imports (see Figure 25). In other words, 1.28 million tons of palm oil were exported by the Netherlands in 2020, while 2.56 million were imported. While the Netherlands is not a net exporter of sunflower oil, the traded quantity has been sharply increasing since 2015, from about 424 000 tons to 784 000 in 2020. This represented almost 22 % of all EU27 sunflower oil exports in 2020. The Netherlands is therefore a key player in this industry and storage capacity is pivotal in supporting the country's advantageous position.

The biofuel market has been growing over the last decade, particularly since the 2009 European Renewable Energy Directive imposed mandatory blending quotas of biofuels into diesel and gasoline.[115] In 2020, the Netherlands exported approximately $ 4.6 billion of biodiesel. The latter's value for the Dutch economy has been increasing sharply since 2015, when the export value was three times lower than that of 2020.[116]

115 European Union, Directive 2009/28/EC on the promotion of the use of energy from renewable sources.

116 Data from UN Comtrade, 2021.

7. Strategic storage

Maintaining sufficient stocks of energy products is, apart from an economic necessity, a national security provision. In many countries, it is mandated by law that emergency oil stocks are held, ensuring a quick recovery in case of geopolitical, military or logistic disruptions in supply. Tank storage is an essential part of emergency response to crises.

7.1. Emergency stocks

The International Energy Agency (IEA) requires signatory states to maintain oil stocks equivalent to at least 90 days of net oil imports.[117] This measure was passed as a consequence of the 1973 oil crisis, which for the first time illustrated the gravity of a global oil shortage.[118] Despite increasing debate on the need for strategic stocks of other energy products, such as natural gas, none other than crude and refined oil are included in emergency stockholding requirements.

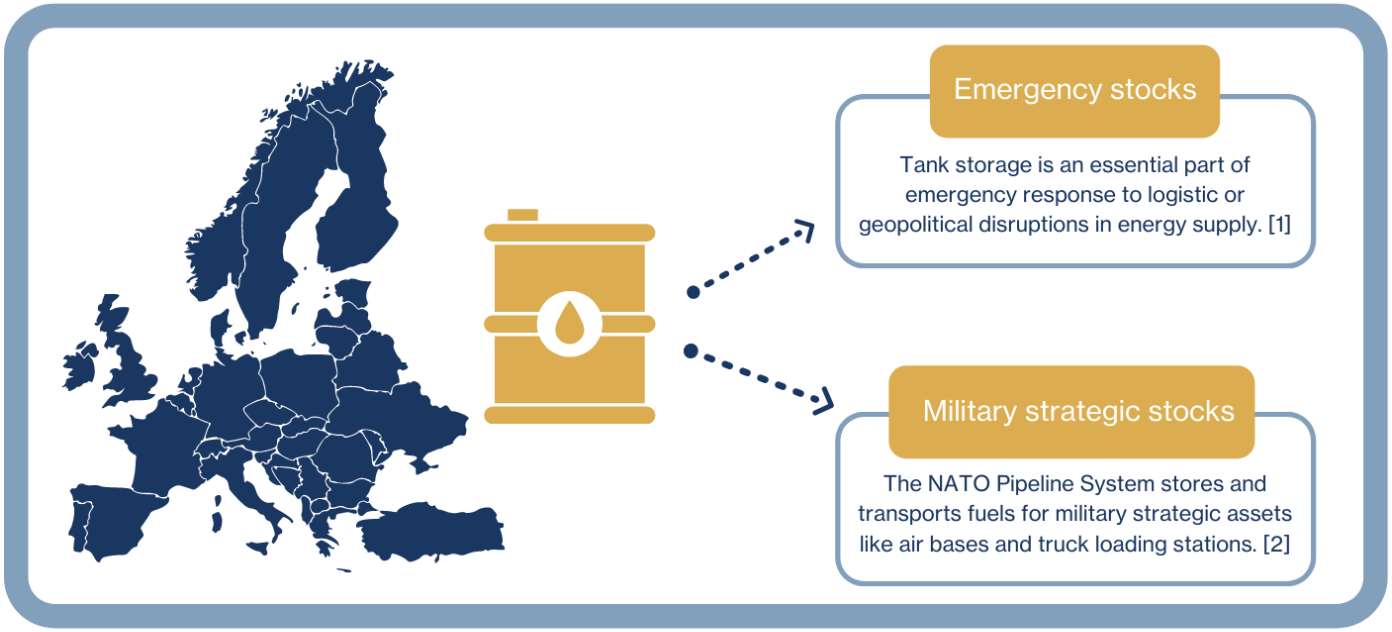
Three types of stockholding regimes are recognized by the IEA.[119] Government stocks are directly owned by the state and are financed by public budgets, like in the United States, Czech Republic, or Australia. Other countries, such as Belgium or Ireland, rely on separate agencies representing either the government or the industry to maintain sufficient oil inventories. Lastly, governments can impose measures on industrial actors such as importers, refiners, or wholesalers, to maintain minimum stocks.

117 IEA, "Oil Stocks of IEA Countries," August 12, 2021, https://www.iea.org/articles/oil-stocks-of-iea-countries.

118 IEA, "Oil Security," 2019, https://www.iea.org/areas-of-work/ensuring-energy-security/oil-security.

119 IEA.

Figure 26. The role of tank storage in emergency and military stockholding



Sources:
[1] European Union, "Council Directive 2009/119/EC Imposing an Obligation on Member States to Maintain Minimum Stocks of Crude Oil and/or Petroleum Products".
[2] NATO, "NATO Pipeline System," 2018, http://www.nato.int/cps/en/natohq/topics_56600.htm.

In most countries, there is a combination of different types of stockholding regimes. In 2009, the European Commission passed a directive requiring all member states to hold emergency stocks that are equivalent to either 90 days of average daily imports or 61 days of average daily inland consumption, including international aviation bunkers.[120] Out of these two options, countries need to choose the one yielding the larger quantity. The Netherlands, France and Spain demand both the industry and a separate agency to manage strategic stocks, i.e., COVA in the Netherlands, Sagess in France and *Corporación de Reservas Estratégicas de Productos Petroliferos* (CORES) in Spain. The stockholding obligations of COVA, the Dutch agency that manages strategic stocks, and industry differ both in terms of quantity and type of products. COVA manages approximately 80 % of inventories, although it does not own any storage facilities.[121] The remaining 20 % is held by industry and private actors, like refiners and traders.

In France, strategic reserves are stored in underground storage facilities, such as salt caverns, as well as in above ground storage sites. In the Netherlands, strategic storage is largely in above-ground tanks. These can be segregated tanks, i.e., tanks that cannot be used for any other purpose. Contrastingly, commingled storage refers to tanks also used for commercial operations. This is advantageous in the case of, for instance, jet fuel, which needs to be refreshed every few weeks to maintain its properties. This process is done automatically in commingled tanks when jet fuel is physically traded. The third way of storing is based on 'tickets', i.e., contracts that ensure the purchasing right of a guaranteed quantity of products.[122] In times of crisis, the stored oil is physically delivered under the conditions that had been agreed upon in the ticket. Companies can participate in both domestic and foreign tickets, in case bilateral governmental agreements are in place.

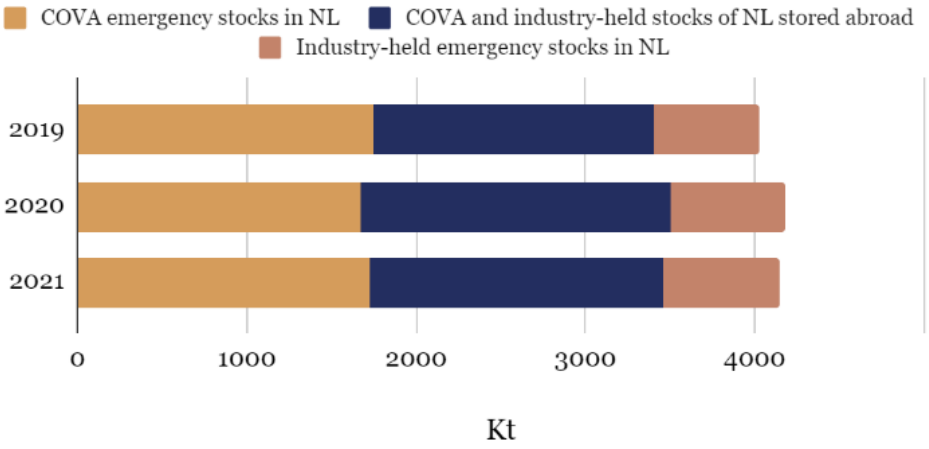
120 European Union, "Council Directive 2009/119/EC Imposing an Obligation on Member States to Maintain Minimum Stocks of Crude Oil and/or Petroleum Products".

121 van der Lijn et al., "The Functioning and Implementation of Council Directive 2009/119/EC," 135.

122 IEA, "Oil Stocks of IEA Countries."

The Dutch government is involved in 11 bilateral agreements with other EU member states, partly due to the country's significant storage capacity.[123] Similarly, the Netherlands stores a large part of its strategic stocks abroad, for example in salt caverns in Northern Germany.[124] Both COVA and industry can fulfill part of their stockholding obligation by storing products abroad. Between 1600 and 1900 kt of Dutch emergency stocks have been stored abroad since 2019, as indicated in Figure 27.

Figure 27. Emergency stocks of the Netherlands, held on national territory and abroad. Data from Eurostat, 2021.



7.2. Military strategic stocks

The NATO Pipeline System stretches across Europe, with the purpose of ensuring continuous and sufficient fuel supplies for military strategic assets like air bases, pumping stations and truck loading stations.[125] There are several national pipeline systems, such as the Norwegian Pipeline System or the United Kingdom Government Pipeline and Storage System. Out of the two multinational pipeline networks, the Central European Pipeline System (CEPS) is the most extensive one of the Alliance.[126] Another multinational system operates in Denmark and Germany, called the Northern European Pipeline System (NEPS).

CEPS consists of ten military storage and distribution systems throughout Europe. It is used by five host countries (Belgium, France, Germany, Luxembourg, and the Netherlands) and one user state (the US). The US is the largest military client of CEPS, supplying fuel to its European military bases.[127] The system consists of approximately 5,300 km of pipeline and links 29 NATO depots and six depots for non-military use, as well as military air bases, major civilian

123 IEA, "The Netherlands 2020," Energy Policy Review, 2020, 222; van der Lijn et al., "The Functioning and Implementation of Council Directive 2009/119/EC," 137.

124 COVA, "Storage Policies," accessed September 3, 2021, https://www.cova.nl/storage-policies/?lang=en.

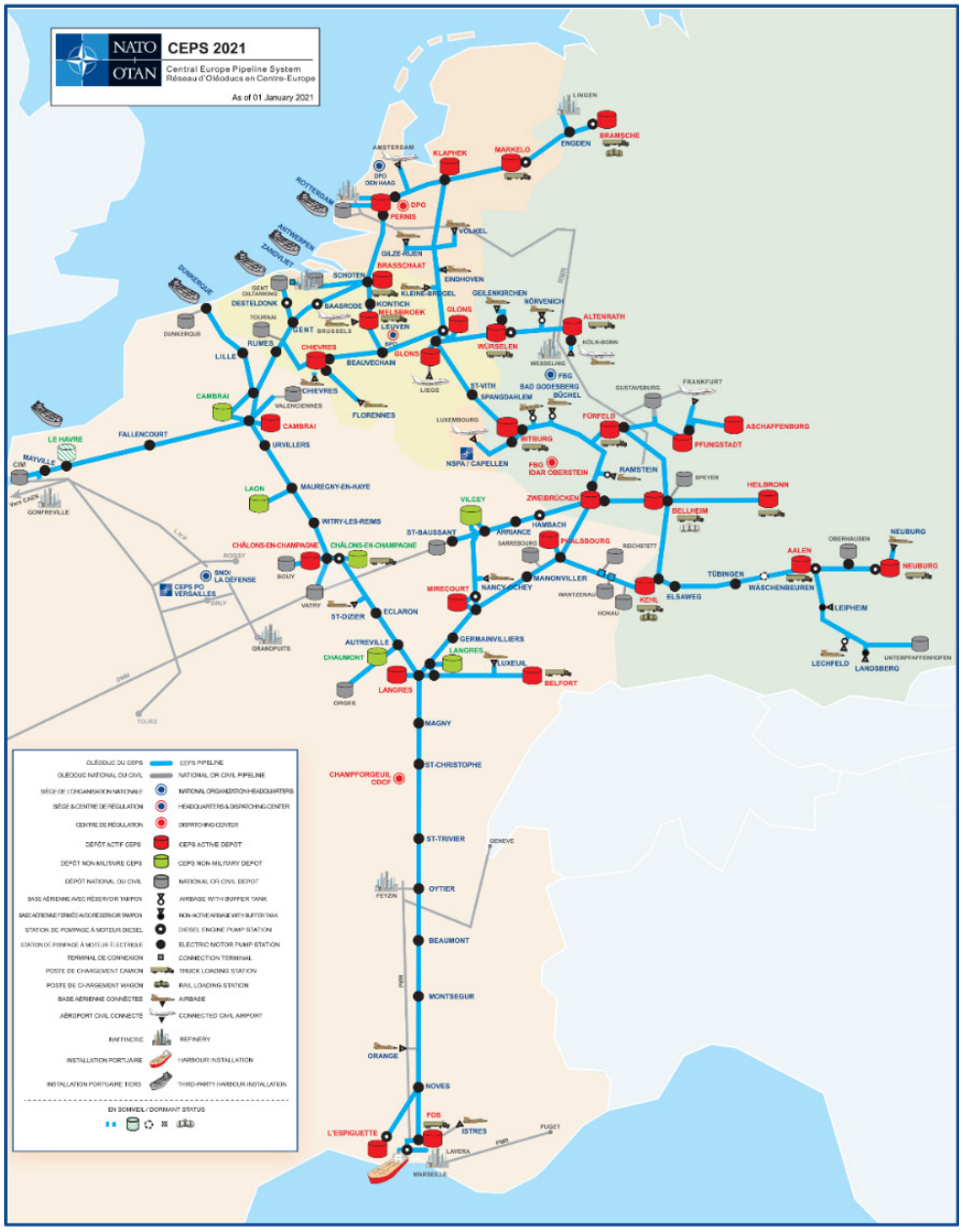
125 NATO, "NATO Pipeline System," 2018, http://www.nato.int/cps/en/natohq/topics_56600.htm.

126 NATO, "Central Europe Pipeline System (CEPS)," NATO, August 30, 2021, http://www.nato.int/cps/en/natohq/topics_49151.htm.

127 Ministerie van Defensie, "Defensie Pijpleiding Organisatie - Taken in Nederland" (Ministerie van Defensie, January 14, 2019), https://www.defensie.nl/onderwerpen/taken-in-nederland/defensie-pijpleidingen/defensie-pijpleiding-organisatie.

airports (incl. Schiphol, Brussels, and Frankfurt), key seaports (to the North Sea, the Atlantic Ocean and the Mediterranean Sea) and refineries throughout the European host countries. The CEPS transports 13 million m^3 of kerosene, diesel, gasoline and naphtha each year and has a net storage capacity of 1 million m^3.[128] Tank storage is therefore essential in supporting Europe's defense sector. Ensuring that storage, pipelines, refineries can be used for military purposes contributes to the EU's strategic autonomy goals. The ability to supply its military to a certain extent independently from the US, Russia or OPEC+ producers, places the EU in a strategically advantageous position.

Figure 28. Central European Pipeline System.
Figure from NATO, 2021



128 NATO, "NSPA | Central Europe Pipeline System," 2020, https://www.nspa.nato.int/about/ceps.

Mobile exercises, operations and missions by the NATO defense organizations predominantly rely on oil products, due to modern weapon systems and military deployments occurring in vulnerable environments with insecure energy supply lines.[129] In the Netherlands, about 35-40 % of total energy is consumed by non-operational activities, while the rest is used for ships (20 %), planes (30 %) and combat and road vehicles (12 %).[130] Following sustainability plans, the use of alternative resources (e.g. biofuels) to generate energy has been gradually increasing.[131] For defense vehicles, the Netherlands has implemented the EU's Renewable Energy Directive, which encloses the use of 20 % of biofuels with diesel.[132]

However, such a change cannot be undertaken unilaterally due to NATO standards that ensure far-reaching interoperability between the allies during missions. The Single Fuel Policy refers to the capability to store, transport, distribute kerosene through the entire NATO Pipeline System and use it for all land-based operations.[133] To support decarbonization, NATO members must jointly decide on new standards of blending biofuels with conventional ones.

Since the late 1950s, within the Dutch MoD, the *Defensie Pijpleiding Organisatie* (Defense Pipeline Organization, DPO) has been responsible for supplying and guarding the transportation of jet fuel to military and civilian airports in the Netherlands.[134] National agencies like DPO can be found in other European countries, for example the British *Oil and Pipelines Agency* (OPA)[135] and the French *Service National des Oléoducs Interalliés (SNOI)*[136]. At the moment, only 3 % of DPO's transport capacity is used for military purposes.[137] DPO is authorized to transport two types of fuel – kerosene and diesel. In addition to these two, SNOI also transports heating oil and gasoline. DPO mainly uses its pipeline network for commercial transport of kerosene to consumers like Schiphol Airport, the largest civilian consumer to date.[138] Similarly, SNOI contracts the current operation of the pipelines to a private company. Commercial contracts include a military clause, according to which the fuel is redirected for military use in case of an emergency.

Another example of a military network mainly used for commercial purposes is the United Kingdom Government Pipeline and Storage System. Almost all this network was sold to the Compañía Logística de Hidrocarburos (CLH, today rebranded as EXOLUM), a Spanish company that now operates these assets. The system, that consist of 2,000 km of pipelines and 16 depots connected to several refineries and import ports, plays a critical role on the supply of the most important English civil airports: Heathrow, Gatwick, Luton and Manchester, as well as the UK and US air bases in the United Kingdom (Figure 29).

129 Hendriks Vettehen, "Meer Inzet Met Minder Olie. Defensie En de Toekomstige Energiezekerheid.," *Militaire Spectator*, 2010, 381, https://www.militairespectator.nl/sites/default/files/uitgaven/inhoudsopgave/MS%207-8-2010%20Hendriks%20Vettehen%20Meer%20inzet%20met%20minder%20olie.pdf.

130 Hendriks Vettehen, "Varen, vliegen, verplaatsen en vooruitkijken," *Militaire Spectator* 178, no. 4 (2009): 205, https://irp-cdn.multiscreensite.com/9afbdf10/files/uploaded/Militaire%20Spectator%204-2009%20Hendriks%20Vettehen.pdf.

131 Ministerie van Defensie, 'Plan van aanpak Energietransitie Defensie - Nieuwe energie in de organisatie', (16 July 2020), https://www.rijksoverheid.nl/documenten/rapporten/2020/07/16/plan-van-aanpak-energietransitie-defensie.

132 Ministerie van Defensie, 10.

133 NATO, "Synthetic Fuels: Alternative to Petroleum-Based Fuels?," 2017, https://www.sto.nato.int/SitePages/newsitem.aspx?ID=3531.

134 Ministerie van Defensie, 'Defensie Pijpleiding Organisatie - Taken in Nederland' (14 January 2019), https://www.defensie.nl/onderwerpen/taken-in-nederland/defensie-pijpleidingen/defensie-pijpleiding-organisatie.

135 UK government, "The Oil and Pipelines Agency - About Us," GOV.UK, accessed December 30, 2021, https://www.gov.uk/government/organisations/oil-and-pipelines-agency/about.

136 "USI Member: SNOI-Service National Des Oléoducs Interalliés," accessed January 27, 2022, https://www.stockistes-usi.fr/en/members.php?id=61.

137 Interview with DPO, 2021.

138 Ministerie van Defensie, "Defensie Pijpleiding Organisatie - Taken in Nederland."

Figure 29. Pipeline network operated by Exolum in the UK, connecting storage terminals to airports. Figure from Exolum

Several truck- and train-loading stations also belong to the system and may be used when military demands increase in times of conflict. For example, CEPS contributed to NATO missions in the first Gulf War, the conflicts in Bosnia and Kosovo, the wars in Afghanistan and Iraq and current operations. During peacetime, commercial use of the CEPS is guaranteed through the Military Priority Clause in commercial agreements. Approximately 90 % of the pipeline capacity is used for civil transport, yet military forces are granted primacy of supply in special circumstances.[139] The transport network of fuels, which includes the pipelines, tank trucks and filling stations, also serves storage functions and can compensate for sharp, short-term instabilities in demand and supply without having to resort to the actual storage tanks.[140]

139 Ministerie van Defensie.

140 Florian Ausfelder et al., "Energy Storage as Part of a Secure Energy Supply," *ChemBioEng Reviews* 4, no. 3 (2017): 150, https://doi.org/10.1002/cben.201700004.

8. Conclusion and Recommendations

8.1. Conclusion

The tank storage sector is a key component of the European economy, one that until now has been relatively unknown to the public. The tank storage sector supports a complex network of actors, from domestic industry players to residential users and international traders. Tank storage companies fulfill four broad tasks in the European economy, which were detailed throughout this paper.

1. **The tank storage sector supports the European industry:** Clusters of import terminals, storage facilities, oil refineries and (petro)chemical factories remain internationally competitive by being connected through hundreds of kilometers of pipelines, sharing infrastructure, electricity, and heat. Tank storage is an essential part of industrial supply chains.

2. **The tank storage sector facilitates logistics for domestic consumption**: The products they store provide electricity, heat and fuels to European citizens' homes, offices, and cars; as well as to our ports, airports and defense sector. The liquid bulk stored in tanks is used as feedstock to produce goods like pharmaceuticals, detergents, paint, candles and plastics.

3. **The tank storage sector strengthens Europe's international trading hub status:** International trade of liquid bulk partly relies on sufficient available storage capacity. Storage acts as a buffer in the international energy market. European countries with well-developed ports and infrastructure (including transportation modalities, storage and processing facilities) play an important role as trade hubs for the entire world.

4. **The tank storage sector safeguards emergency stocks:** Maintaining sufficient reserves of energy products is, apart from an economic necessity, a national security requirement. In European countries, it is mandated by law that emergency oil stocks are held, ensuring a quick recovery in case of geopolitical logistic disruptions in supply. Tank storage is an essential part of emergency response to crises.

In the mid-term, up to 2030-2035, the sector needs to balance two parallel energy systems. On the one hand, companies can help ensure that European demand for oil and gas products is fulfilled and that social and economic functions can continue uninterrupted. On the other hand, they need to start developing new business models based on a different infrastructure for novel products. This takes place in a highly uncertain environment, where investors are reticent to support conventional energy businesses, but policymakers have not yet offered a clear pathway as to how such companies should change. Whether ammonia or methanol will be the most advantageous hydrogen carrier, is unclear. When technologies will be available to support the decarbonization of the aviation or maritime industries, is also unclear. For now, tank storage companies manage enormous amounts of liquid bulk that continue to be needed in Europe and abroad. Some of them are simultaneously investing in new infrastructure for hydrogen production or carbon capture and storage. This theme is the central focus of the third paper "European tank storage in the global supply chains: Outlook to 2030" in the HCSS/VOTOB/FETSA series.

On the long-term uncertainty dominates. By 2050-2060, even the hard-to-abate sectors are expected to be decarbonized. The economy, industry and society will be powered by new energy carriers, as fossil fuels are eliminated. Yet comprehensive scenarios are developed and constantly updated. Uncertainty can be mapped to a certain extent, especially when developments depend on the very sectors that will be affected the most. Tank storage companies, like all other players in energy supply chains, can both influence and be influenced by the newly emerging system. Challenges and opportunities on the long-term are discussed in the fourth HCSS/VOTOB/FETSA paper "The European tank storage sector: 2050 and beyond".

8.2. **Recommendations**

Today, the European tank storage sector finds itself in an advantageous international position, one that has been consolidated throughout decades. Maintaining this position in the new energy system requires large investments, strategic decision-making and close cooperation with key stakeholders. Technological developments and innovative business approaches could be opportunities for tank storage to re-design its position in the European economy. Four recommendations can be derived for tank storage companies on the short-term:

1. **Proactivity and long-term planning**. The tank storage sector has a large role in shaping the next decades. Storage companies should become proactive players, taking initiative in showing how they can be part of the solution to the energy transition. Strategic decision-making accounting for long-term developments as well as ambitious goals are necessary. Companies should appoint staff members and representatives to ensure the right course of action is followed over time. Focusing on innovation and resilience will show the commitment of storage companies to achieve the transition and facilitate dialogue with investors and other stakeholders.

2. **Transparency**. The tank storage sector is largely unknown to policymakers and the public despite its pivotal role in today's economy. For that reason, uncertainty and reluctance tend to dominate the public discourse when it comes to tank storage. Open and transparent communication about current activities and long-term sustainable plans would encourage close cooperation and reduce uncertainty about the sector.

3. **Leveraging existing capabilities.** On the short-term, storage companies should emphasize ways in which their experience and know-how can support transition efforts. An example is blending sustainable with conventional fuels, which is one of the first steps leading to the transition. Storage companies are already blending biofuels with diesel or gasoline, synthetic kerosene with conventional kerosene. Such existing capabilities can contribute to current efforts as well as support in finding new innovative solutions.

4. **Cooperation.** Working with partners along value chains, as well as policymakers and legislators is essential in determining what the next decades could look like. Tank storage companies are part of a complex ecosystem. While their own proactivity is key, they cannot unilaterally influence the entire system. Storage companies are part of regional industrial clusters and international value chains. Together with key stakeholders, the tank storage sector should develop a concrete plan, outlining ambitions and dividing responsibilities. Such a roadmap would create a sustainable business case for supply chain players, create predictability and facilitate investments.

References

Ausfelder, Florian, Christian Beilmann, Martin Bertau, Sigmar Bräuninger, Angelika Heinzel, Renate Hoer, Wolfram Koch, et al. "Energy Storage as Part of a Secure Energy Supply." *ChemBioEng Reviews* 4, no. 3 (2017): 144–210. https://doi.org/10.1002/cben.201700004.

BASF. "BASF Verbund," 2021. https://www.basf.com/global/en/investors/calendar-and-publications/factbook/basf-group/verbund.html.

BASF. "BASF in Nederland." Accessed October 22, 2021. https://www.basf.com/nl/nl/who-we-are/BASF-in-Nederland.html.

Beukel, Jilles van den, and Lucia van Geuns. "De Afnemende Leveringszekerheid van Aardgas in Nederland." HCSS, October 2021. https://hcss.nl/report/afnemende-leveringszekerheid-aardgas-nl/.

U.S. Department of Energy. "Biofuel Basics." Accessed April 7, 2021. https://www.energy.gov/eere/bioenergy/biofuel-basics.

Blakey, Simon, Shankari Srinivasan, Laurent Ruseckas, Zoe Grainge, and Frederick Ritter. "The Swing in Dutch Gas: From Autonomy to Full Dependence." Strategic Report. IHS Markit, November 2018. https://cdn.ihs.com/www/pdf/1118/IHS-Markit-The-Swing-Dutch-Gas.pdf.

Buchan, David, and Charlie Errington. "Commodities Demystified." Trafigura, 2019. https://www.commoditiesdemystified.info/pdf/CommoditiesDemystified-en.pdf#downloads.

Chang, Joseph, Nigel Davis, and Will Beacham. "The ICIS Top 100 Chemical Companies." *ICIS Chemical Business*, 2020.

Port of Antwerp. "Chemicals Hub." Accessed December 20, 2021. https://www.portofantwerp.com/en/chemicals-hub#integrated.

COVA. "Storage Policies." Accessed September 3, 2021. https://www.cova.nl/storage-policies/?lang=en.

MVO. "De oliën- en vettenketen," July 29, 2021. https://mvo.nl/organisatie/de-keten.

ECSPP. "Chemmed Cluster Tarragona - Chemical Park - Spain." Accessed December 22, 2021. https://chemicalparks.eu/parks/chemmed-cluster-tarragona.

Efeca. "Palm Oil in the Oleochemical Sector," August 2018. https://efeca.com/wp-content/uploads/2019/12/Briefing-note-Oleochemicals_Efeca_09.08.18.pdf.

EIA. "Crude Oil Prices Started 2015 Relatively Low, Ended the Year Lower," 2016. https://www.eia.gov/todayinenergy/detail.php?id=24432.

Energy Intelligence. "Global Crude Benchmarks: Brent Sets the Standard," 2020. https://www.theice.com/why-the-world-needs-benchmarks-and-characteristics-of-benchmarks.

European Commission. "EU Taxonomy for Sustainable Activities." Accessed January 27, 2022. https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en.

European Commission. "Amendment Renewable Energy Directive 2030," 2021. https://ec.europa.eu/info/sites/default/files/amendment-renewable-energy-directive-2030-climate-target-with-annexes_en.pdf.

———. Chemicals Strategy for Sustainability Towards a Toxic-Free Environment, COM(2020) 667 § (2020). https://eur-lex.europa.eu/resource.html?uri=cellar:f815479a-0f01-11eb-bc07-01aa75ed71a1.0003.02/DOC_1&format=PDF.

———. "Cleaner Air in 2020: Sulphur Cap for Ships," January 3, 2020. https://ec.europa.eu/commission/presscorner/detail/en/IP_19_6837.

———. "EU Agricultural Outlook for Markets and Income, 2019-2030," 2019. https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/agricultural-outlook-2019-report_en.pdf.

———. "Seveso - Major Accident Hazards - Environment - European Commission." Accessed December 22, 2021. https://ec.europa.eu/environment/seveso/index.htm.

———. "Seveso Legislation - Industry - Environment - European Commission." Accessed December 22, 2021. https://ec.europa.eu/environment/seveso/legislation.htm.

European Parliament Directorate General for Parliamentary Research Services. *On the Path to 'strategic Autonomy': The EU in an Evolving Geopolitical Environment.* LU: Publications Office, 2020. https://data.europa.eu/doi/10.2861/60568.

European Union. Council Directive 2009/119/EC imposing an obligation on Member States to maintain minimum stocks of crude oil and/or petroleum products (n.d.).

———. Directive 2009/28/EC on the promotion of the use of energy from renewable sources. Accessed September 23, 2021. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0028.

Eurostat. "Energy Consumption in Households," 2021. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households.

———. "Oil and Petroleum Products - a Statistical Overview," 2020. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Oil_and_petroleum_products_-_a_statistical_overview.

Exolum. "Who We Are." Exolum. Accessed December 22, 2021. https://exolum.com/en/about-exolum/who-we-are/.

Fattouh, Bassam. "An Anatomy of the Crude Oil Pricing System." The Oxford Institute for Energy Studies, 2011.

Fediol. "Applications (Vegetable Oils and Fats)," 2020. https://www.fediol.eu/web/applications/1011306087/list1187970105/f1.html.

———. "Vegetable Oils Production, Imports, Exports and Consumption - Consumption of Vegetable Oils and Fats," 2020. https://www.fediol.eu/data/oils%20evol.pdf.

FETSA. "Tank Terminals in Europe - Key Figures," 2018.

———. "Tank Terminals in Europe - Key Figures," 2020.

Franza, Luca. "Outlook for LNG Imports into the EU to 2025." CIEP Paper. CIEP Perspectives on EU Gas Market Fundamentals. CIEP, 2016. https://www.clingendaelenergy.com/inc/upload/files/CIEP_paper_2016_2D_LNG_web.pdf.

Fuels Europe. "Statistical Report 2021," 2021. https://www.fuelseurope.eu/wp-content/uploads/SR_FuelsEurope-_2021.pdf.

Heather, Patrick. "European Traded Gas Hubs: The Supremacy of TTF." Oxford Energy Comment, May 2020.

Honore, Anouk. "Decarbonization and Industrial Demand for Gas in Europe:" Oxford Institute for Energy Studies, May 2019. https://doi.org/10.26889/9781784671396.

IEA. "Energy Technology Perspectives 2020," 2020.

———. "Gas Market Report, Q1-2021," 2021. https://www.iea.org/reports/gas-market-report-q1-2021.

———. "Oil Security," 2019. https://www.iea.org/areas-of-work/ensuring-energy-security/oil-security.

———. "Oil Stocks of IEA Countries," August 12, 2021. https://www.iea.org/articles/oil-stocks-of-iea-countries.

———. "Spain 2021: Energy Policy Review," 2021. https://iea.blob.core.windows.net/assets/2f405ae0-4617-4e16-884c-7956d1945f64/Spain2021.pdf.

———. "The Netherlands 2020." Energy Policy Review, 2020.

Insights Global. "ARA Oil Tank Terminal Report 2020." Netherlands, 2020.

USI. "Key Figures of the USI." Accessed October 5, 2021. https://www.stockistes-usi.fr/en/union-of-tank-storage-operators.php#presentation.

King & Spalding. "LNG in Europe 2018: An Overview of LNG Import Terminals in Europe," 2018. https://www.kslaw.com/attachments/000/006/010/original/LNG_in_Europe_2018_-_An_Overview_of_LNG_Import_Terminals_in_Europe.pdf?1530031152.

Krastev, Martin. "The Bright Light amidst Today's Energy Uncertainty." *Tank Storage Magazine* (blog), April 29, 2020. https://www.tankstoragemag.com/2020/04/29/the-bright-light-amidst-todays-energy-uncertainty/.

Lijn, Nick van der, Ron Williams, Jurgen Vermeulen, and Alipio Ferreira. "The Functioning and Implementation of Council Directive 2009/119/EC." Trinomics, 2016. https://ec.europa.eu/energy/sites/default/files/documents/Final%20Report%20Trinomics%20-%20August%202016.pdf.

LyondellBasell. "Maasvlakte Site." Accessed August 18, 2021. https://www.lyondellbasell.com/globalassets/lyb-around-the-world/plant-sites/fact-sheets/factsheet-maasvlakte.pdf.

———. "Moerdijk Site." Accessed August 18, 2021. https://www.lyondellbasell.com/globalassets/lyb-around-the-world/plant-sites/fact-sheets/factsheet-moerdijk.pdf.

McKinsey. "Northwest Europe." Accessed September 1, 2021. http://www.mckinseyenergyinsights.com/resources/refinery-reference-desk/northwest-europe/.

Mead, Dave, and Porscha Stiger. "The 2014 Plunge in Import Petroleum Prices: What Happened?" Beyond the Numbers. US Bureau of Labor Statistics, 2015.

Meijering, Jasper, and Jabbe van Leeuwen. "The Dynamic Development of Organic Chemistry in North-West Europe." Cracking the Clean Molecule. The Hague, The Netherlands: CIEP, 2021. https://www.clingendaelenergy.com/publications/publication/the-dynamic-development-of-organic-chemistry-in-north-west-europe.

Meredith, Sam. "Oil Producers Scramble to Find 'creative' Storage Options after Historic Price Crash." CNBC, April 30, 2020. https://www.cnbc.com/2020/04/30/oil-and-coronavirus-producers-trying-to-find-creative-storage-options.html.

Ministerie van Defensie. "Defensie Pijpleiding Organisatie - Taken in Nederland." Ministerie van Defensie, January 14, 2019. https://www.defensie.nl/onderwerpen/taken-in-nederland/defensie-pijpleidingen/defensie-pijpleiding-organisatie.

———. "Plan van aanpak Energietransitie Defensie - Nieuwe energie in de organisatie - Rapport - Rijksoverheid.nl." Rapport. Ministerie van Algemene Zaken, July 16, 2020. https://www.rijksoverheid.nl/documenten/rapporten/2020/07/16/plan-van-aanpak-energietransitie-defensie.

Ministerie van Economische Zaken en Klimaat. "Meer informatie over ondergrondse opslag De Marssteden (Enschede)." Vraag en antwoord. Ministerie van Economische Zaken, March 7, 2019. https://www.sodm.nl/documenten/vragen-en-antwoorden/documenten/vragen-en-antwoorden/meer-informatie-over-ondergrondse-opslag-de-marssteden-enschede.

NATO. "Central Europe Pipeline System (CEPS)." NATO, August 30, 2021. http://www.nato.int/cps/en/natohq/topics_49151.htm.

———. "NATO Pipeline System." NATO, March 9, 2017. https://www.nato.int/cps/en/natohq/topics_56600.htm.

———. "NATO Pipeline System," 2018. http://www.nato.int/cps/en/natohq/topics_56600.htm.

———. "NSPA | Central Europe Pipeline System," 2020. https://www.nspa.nato.int/about/ceps.

———. "Synthetic Fuels: Alternative to Petroleum-Based Fuels?," 2017. https://www.sto.nato.int/SitePages/newsitem.aspx?ID=3531.

Oliveira, C, and K.M. Schure. "Decarbonisation Options for the Dutch Refinery Sector." The Hague: TNO, PBL, 2020.

OPEC. "World Oil Outlook 2045," 2021.

Trilateral Chemical Region. "Our Region." Accessed August 2, 2021. https://www.trilateral-chemical-region.eu/ueber-uns.

Pern. "About Us." Accessed January 19, 2022. https://pern.pl/en/about-us/.

Poliport. "About." Accessed January 19, 2022. https://www.poliport.com/en/about.html.

Port of Amsterdam. "Gasoline: The World's Largest Gasoline Port," June 8, 2020. https://www.portofamsterdam.com/en/business/cargo-flows/liquid-bulk/gasoline.

———. "Kerosene: Facilities for Storage and Transport." Accessed August 18, 2021. https://www.portofamsterdam.com/en/business/cargo-flows/liquid-bulk/kerosene.

Chemical Parks in Europe. "Port Of Antwerp - Chemical Park." Accessed December 20, 2021. https://chemicalparks.eu/parks/port-of-antwerp.

Port of Rotterdam. "Facts & Figures," 2020. https://www.portofrotterdam.com/sites/default/files/2021-06/facts-and-figures-port-of-rotterdam.pdf.

The White House. "President Biden Announces Release from the Strategic Petroleum Reserve As Part of Ongoing Efforts to Lower Prices and Address Lack of Supply Around the World," November 23, 2021. https://www.whitehouse.gov/briefing-room/statements-releases/2021/11/23/president-biden-announces-release-from-the-strategic-petroleum-reserve-as-part-of-ongoing-efforts-to-lower-prices-and-address-lack-of-supply-around-the-world/.

FETSA. "Priorities | FETSA." Accessed October 13, 2021. https://fetsa.eu/priorities/.

Concawe. "Refinery Sites in Europe." Accessed October 6, 2021. https://www.concawe.eu/refineries-map/.

Port of Rotterdam. "Refining and Chemicals." Accessed August 16, 2021. https://www.portofrotterdam.com/en/setting/industry-port/refining-and-chemicals.

Port of Rotterdam. "Rotterdam Bunker Port." Accessed August 18, 2021. https://www.portofrotterdam.com/en/logistics/cargo/liquid-bulk/rotterdam-bunker-port.

Saefong, Myra P. "Oil Prices Went Negative a Year Ago: Here's What Traders Have Learned since." MarketWatch, April 19, 2021. https://www.marketwatch.com/story/oil-prices-went-negative-a-year-ago-heres-what-traders-have-learned-since-11618863839.

Scandinavian Tank Storage. "Company Presentation," 2022. https://scandinaviantankstorage.com/wp-content/uploads/2021/12/STS-CP2022.pdf.

Schiphol Group. "Key Figures 2019," 2020.

Shell. "The Brent Story." Accessed September 1, 2021. https://www.shell.co.uk/sustainability/decommissioning/brent-field-decommissioning/the-brent-story.html.

Solventaş. "About Us." Accessed January 19, 2022. https://www.solventas.com.tr/en/solventasa-ilk-bakis.php.

Energy.gov. "Strategic Petroleum Reserve." Accessed September 8, 2021. https://www.energy.gov/fe/services/petroleum-reserves/strategic-petroleum-reserve/spr-storage-sites.

UK government. "The Oil and Pipelines Agency - About Us." GOV.UK. Accessed December 30, 2021. https://www.gov.uk/government/organisations/oil-and-pipelines-agency/about.

UK pia. "Statistical Review 2018," 2018. https://www.ukpia.com/media/1008/ukpia-statistical-review-2018.pdf.

UKOOG. "Natural Gas Uses." UKOOG - Onshore extraction. Accessed January 24, 2022. https://www.ukoog.org.uk/onshore-extraction/uses.

"USI Member: SNOI-Service National Des Oléoducs Interalliés." Accessed January 27, 2022. https://www.stockistes-usi.fr/en/members.php?id=61.

Van Den Bergh, Robbert, Michiel Nivard, and Maurits Kreijkes. "Long-Term Prospects for Northwest European Refining." The Hague, Netherlands: CIEP, 2016. https://www.clingendaelenergy.com/publications/publication/long-term-prospects-for-northwest-european-refining.

Vernof. "About VERNOF." VERNOF, 2020. https://www.vernof.com/home-en/.

Vettehen, Hendriks. "Meer Inzet Met Minder Olie. Defensie En de Toekomstige Energiezekerheid." *Militaire Spectator*, 2010. https://www.militairespectator.nl/sites/default/files/uitgaven/inhoudsopgave/MS%207-8-2010%20Hendriks%20Vettehen%20Meer%20inzet%20met%20minder%20olie.pdf.

———. "Varen, vliegen, verplaatsen en vooruitkijken." *Militaire Spectator* 178, no. 4 (2009). https://irp-cdn.multiscreensite.com/9afbdf10/files/uploaded/Militaire%20Spectator%204-2009%20Hendriks%20Vettehen.pdf.

Vopak. "Roadshow Presentation 2008." 2008. https://www.vopak.com/system/files/roadshow_presentation_q3_2008.pdf.

Insights Global. "Who Are the Biggest Players in the Tank Terminal Market?," December 5, 2019. https://www.insights-global.com/who-are-the-biggest-players-in-the-tank-terminal-market/.

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

Appendix 1 – National associations and member companies within FETSA

Belgium	BATO (Belgian Association of Storage Companies)
France	USI (Union de Stockistes Industriels)
Germany	UTV (Unabhängiger Tanklagerverband E.V.)
Italy	Unione Energie per la Mobilità
The Netherlands	VOTOB (Vereniging van Nederlandse Tankopslagbedrijven)
Spain	ATliq (Asociación de Terminales de Líquidos)
United Kingdom	TSA (Tank Storage Association)
Poland	Pern
Sweden	Scandinavian Tank Storage
Turkey	Solventas
	Poliport

The Hague Centre
for Strategic Studies

HCSS
Lange Voorhout 1
2514 EA Hague

Follow us on social media:
@hcssnl

The Hague Centre for Strategic Studies
Email: info@hcss.nl
Website: www.hcss.nl