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THE EUROPEAN REFINING SECTOR: A DIVERSITY OF MARKETS?

MICHIEL NIVARD AND MAURITS KREIJKES

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THE EUROPEAN REFINING SECTOR: A DIVERSITY OF MARKETS?

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LIST OF ABBREVIATIONS

Units

DWT	Deadweight tonnage
Mb/d	Million barrels per day
Kb/d	Thousand barrels per day
MTOE	Million Tonnes Oil Equivalent
Mt/a	Million tons per annum
Kt/a	Thousand tons per annum
MW	Mega Watt
% m/m	Mass Percentage

Pipelines

CEL	Central European Line (Crude)
CEPS	Central Europe Pipeline System (Product)
CLH	Compañía Logística de Hidrocarburos (Product)
NWO	Nort-West Oelleitung (Crude)
OCAP	Organic CO2 for Assimilation by Plants (CO2)
SPSE	Société du Pipeline Sud-Européen (Crude)
TAL	Transalpine Pipeline (Crude)

Other

ARRRA	Amsterdam-Rotterdam-Rhine-Ruhr-Antwerp
CDU	Crude Distillation Unit
CEE	Central Eastern Europe
ECA	Emission Control Area
ETS	Emissions Trading System
FCC	Fluid Catalytic Cracking
HC	Hydrocracking
HFO	Heavy Fuel Oil
IED	The Industrial Emissions Directive
IGCC	Integrated Gasification Combined Cycle
IMO	International Marine Organization
IOC	International Oil Company
JV	Joint Venture
LPG	Liquid Petroleum Gas
LTO	Light Tight Oil
MGO	Marine Gas Oil
NOC	National Oil Company
NWE	Northwest Europe
OECD	Organisation for Economic Co-operation and Development
SEE	Southeast Europe
TPA	Third Party Access
ULSD	Ultra-Light Sulphur Diesel

1 INTRODUCTION

Structural developments in the global refining market are challenging long-term competitiveness of the 85 operational refineries in the European Union (incl. Norway and Switzerland).[1] The emergence of modern, low-cost (including regulatory costs) refining centres in Asia, Russia and the Middle East and their ability to trade the various petroleum products globally are becoming an important competitive factor for refiners in the EU to take into account.[2] Apart from the new competition, the EU refining market suffers from maturing demand, the impending new product specifications for ocean going vessels and an ageing (but maintained) asset base.[3] Finding itself between a rock and a hard place, the 14.5 Mb/d of refining capacity in the EU as a whole, is increasingly competing with refined product imports from low-cost and sometimes also less strict environmentally regulated refining centres. This raises the question about what the broader implications might be for the EU refining sector of a potential increase in the share of imports for Europe's oil product supply mix in a medium-term outlook. In 2016, the *Clingendael International Energy Programme (CIEP)* addressed this same question with regard to the Northwest European (NWE) refining market. Based on this research, a more holistic approach to competition constraining factors in the sector was developed. The current study is a natural continuation of this analysis into the other refining regions in the EU.[4]

Analogous to the NWE refining study, an analysis has been done on the potential impact of more imported refined oil products to the EU. In the 2016 study, we separated integrated refineries (i.e. "must-run") from those that are less integrated (i.e. "exposed to competition"), with the former likely having a stronger ability to compete for markets with oil product imports. The wording in that study may have

1 Although the UK has voted to leave the European Union, the process is not expected to be finalised in the coming years and hence this study will focus on the current 28 European Member States. Also, in this analysis we included the non-Member States Norway (EER) and Switzerland (bilateral trade agreements) that are deeply integrated with the EU.

2 The bulk of downstream investments (both greenfield and upgrade) are directed to refining centres in the Middle East, Asia Pacific, Russia, and the US. Simultaneously, international shipping costs have declined with the emergence of larger, multiproduct tankers.

3 See, for example, EC JRC (2015) 'EU Petroleum Refining Fitness Check: Impact of EU Legislation on Sectoral Economic Performance' European Commission; McKinsey (2015) 'Profitability in a world of Overcapacity'; Bergh, Nivard & Kreijkes (2016) "Long-term Prospects for the Northwest European Refining Sector" CIEP; IEA (2016) – 'Oil Market Report'

4 This study is part of ongoing CIEP research on the refining sector and builds particularly on the Northwest European Refining study (2016). Bergh, Nivard & Kreijkes (2016) "Long-term Prospects for the Northwest European Refining Sector" CIEP

led to some confusion because all refineries in the sample group are necessarily exposed to competition. Nevertheless, we tried to argue that some refineries should be considered more resilient because they are part of a larger integrated cluster or are integrated in other downstream activities that underpin their business model. Some refineries, however, lack such forward or backward integration and rely solely on their operational excellence when competing with other refiners from inside or outside the EU.

In the course of this study (and in extending the geographical scope) we discovered that the check list or sensitivity we had developed for the NWE refining sector was not fully applicable to other EU regional markets, where other circumstances prevail. We therefore decided to look for the competitive strong points in European refining first, aiming to exclude the short-term gyrations in refining competitiveness. The current analysis couples the integration of refineries in wider economic value chains to the competitive long-term outlook of a refinery, distinguishing more 'resilient to competition' refining capacity from refineries that are more 'exposed to competition' with refined oil product import.[5]

In completing the holistic approach of the downstream oil sector, this study also looked at the most prominent barriers-to-exit that are present in the European downstream sector. In other words, what are the political and economic factors which may prevent a refinery from closing? These factors are important because exposed to competition implies that when operational excellence still puts a refinery behind imported fuels, the refinery might consider terminating its activities. Despite the recent rationalisation in the EU downstream sector, overcapacity is still present, indicating that other factors are at play in preventing EU refineries from closing. Are these factors the same across the EU or do they vary? Even though the implications of a larger share of the imported oil products transcend the interests of individual Member States, issues such as security of supply, economic footprint, secondary integration, and in particular government ownership and regulatory enforcement are largely national Member State affairs. These factors can complicate further rationalisation of refining capacity through (international) competition and may create alternative market circumstances.

5 For the 'resilient to competition' scenario the same underlying model is used as CIEP's must run scenario in the NWE refining study. See Bergh, Nivard & Kreijkes (2016) "Long-term Prospects for the Northwest European Refining Sector" CIEP.

This study may serve as a starting point for a wider discussion on future developments in the refining sector of the European Union by including both market developments *and* barriers-to-exit. To outline the medium-term EU refining sector outlook, this study identifies the strong points in EU refining on the one hand, and its experience with competition constraining factors on the other, resulting in a variety of market developments among EU regional markets. Legacy market structures and diverging government involvement in domestic refining markets among EU Member States have, so far, resulted in multiple coexisting refining regions to persist. Going forward to a medium-term timeframe, some of these regions are likely to remain competitive in the global market while other regions are very locally determined and/or subject to competition constraining factors. These asymmetric developments across the EU refining sector, exhibiting a variety of survival strategies that depend on local conditions and (local) government influences, might become more pronounced in the future.

First, Chapter 2 provides an overview of today's refining sector in the EU, including: operational refineries, relevant infrastructures, ownership structures, national demand and production profiles, and international trade flows. In Chapter 3, the integration of individual refineries in wider economic value chains is analysed, aiming to identify the more 'resilient to competition' refineries that are capable of withstanding competitive oil product import pressures. Lastly, Chapter 4 aims to include the various competition constraining factors present in the EU refining sector and is especially relevant for refining capacity that is more exposed to oil product imports.

2 OVERVIEW – REFINING SECTOR OF THE EUROPEAN UNION

Europe can be considered the cradle of modern-day refining. In 1854 one of the first refining operations started in present-day Poland, while the first large-scale refinery was built in Ploiesti, Romania.[6] Over the next century-and-a-half, a multitude of refineries have been built across the continent to satisfy the rising demand for petroleum products. Over time, borders, jurisdictions, and technologies have changed, incentivising the refining sector to continuously adapt and develop. Within the European Union this is presently manifested through the diversity of its refining base, displaying distinct capacities and product slates.

Today, the European Union has 85 operational refineries that have a combined throughput capacity of 14.5 Mb/d. Although this roughly matches total EU refined product demand (13.3 Mb/d) specific demand differs widely per oil product, country, and region, hence creating significant imbalances at the product level. To alleviate these mismatches, structural trade flows have emerged both within the Union and with non-European countries in order to satisfy national product shortages whilst finding export outlets for specific product surpluses. In order to facilitate these petroleum flows, European Member States and private companies have invested in petroleum infrastructure in the EU, creating a network of pipelines, (inland) waterways, storage facilities, ports, and rail/road connections.

2.1 CURRENT DOWNSTREAM ASSETS

The refining sector in the European Union is comprised of 85 refineries, spread across 22 Member States, Norway, and Switzerland (see Figure 2.1).[7,8] In total, the EU has a combined throughput capacity of over 14.5 Mb/d, accounting for roughly

6 Lukasiewicz from Poland is credited with being one of the first to experiment with crude oil refining and is said to have built the first modern oil distillery in Jaslo, mainly designed to produce kerosene. In the Romanian city of Ploiești the first larger scale refinery was built by the Mehedinteanu Brothers in 1857. See, for example, Alison Fleig, F. (2005). "Oil Empire: Visions of Prosperity in Austrian Galicia (Harvard Historical Studies)". Harvard University Press. ISBN 0-674-01887-7; or http://www.ropepca.ro/en/articole/oil-museum/59/

7 The six member-states without refining capacity are Cyprus, Estonia, Latvia, Luxembourg, Malta and Slovenia. This study defines a refinery as a crude processing facility containing a distillation tower (CDU), a minimum of 20 Kb/d of throughput capacity and a product slate extending mere specialty products. As such, smaller and/or specialty refineries were excluded from the overview. Annex B provides a description of a selection of the excluded petroleum processing facilities in the European Union.

8 See Annex A for an overview of all individual refineries that correspond to the numbers on the map of figure 2.1.

14.5% of global refining capacity in 2015.[9] Overall, the sector exhibits a wide variety in levels of configuration, integration, and production – with Nelson-Farrar complexity indices ranging from 1 to 15.8 and nameplate capacities between 40Kb/d and 425Kb/d. Europe's largest refineries (>250Kb/d) are located in the Netherlands, Poland, Germany, Belgium, Italy, UK and Spain.

Although it has shifted over the years, ownership of European refineries can broadly be divided into four categories: 1) International Oil Companies (IOCs); 2) National Oil Companies (NOCs); 3) Merchants; and 4) Joint Ventures (JVs). A concentration of IOCs can be seen in Northwest Europe, Italy, and Spain, although currently the refining capacity of oil majors has decreased as divestment campaigns have gained traction.[10] The entrance of trading houses in the refining sector shows less geographic concentration across Europe while acquiring smaller and flexible refineries. A typical merchant refiner aims to combine flexible refining activities with its existing oil trading portfolios hence benefitting from product outlets and arbitrage opportunities.[11] The presence of NOCs in the EU refining sector is shifting as Rosneft is consolidating its stake, while Tamoil and Kuwait Petroleum Corporation are exiting the European market. An interesting case is the share some European Member States hold in refineries active on the European market (see Chapter 4). An 'all of the above' ownership structure is also present on the European refining market with the presence of JV ownership structures combining NOCs, IOCs and/or merchants in one refinery.[12]

Throughout the continent an extensive network of pipelines and (inland) waterways enables the transportation of either crude oil or (intermediate) refined products between ports, refineries and (regional) demand centres.[13] Three major pipeline systems stand out, while some smaller, local networks serve crucial roles as well. First, north-western Europe operates an intricate network of pipelines, largely legacy

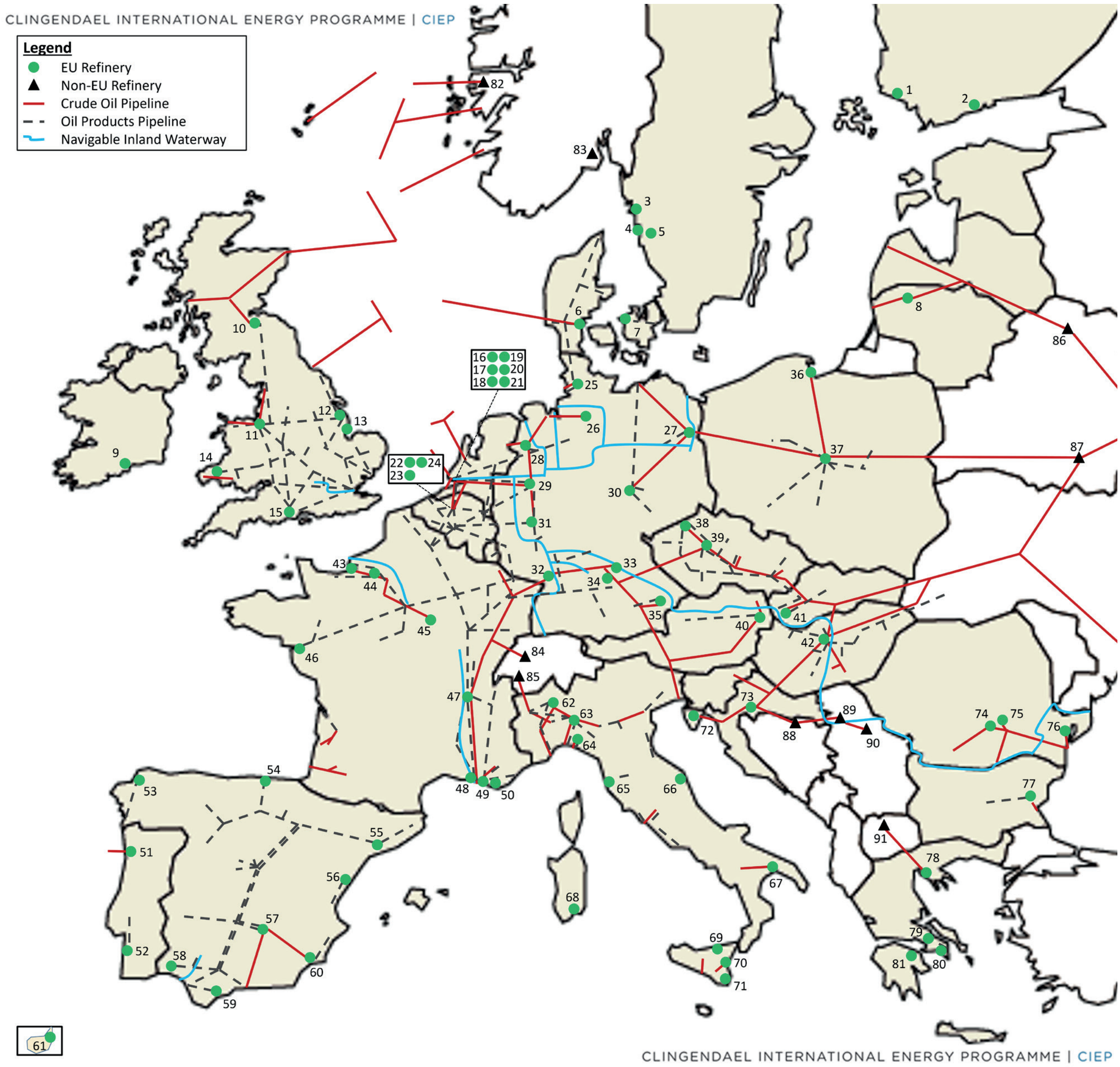
9 Based on data from: BP (2016) 'BP Statistical Review of World Energy – June 2016', and EC JRC (2015) 'EU Petroleum Refining Fitness Check: Impact of EU Legislation on Sectoral Economic Performance' European Commission.

10 In the recent decade oil majors like Shell (e.g. Heide, Litvinov, Göteborg, etc.), Total (e.g. Huelva, Rome, Schwedt), Exxon (e.g. Ingolstadt), and BP (e.g. Grangemouth, MiRO) have sold refining assets in (Western) Europe. See various company statements or CIEP (2016) 'A Genealogy of NWE Refining: A Decade of Refining in Northwest Europe'.

11 Examples of merchant refiners include Swiss oil trader Gunvor that has established a foothold in European refining via its stakes in the Antwerp, Ingolstadt, and Rotterdam refineries and Varo Energy which holds a stake in the Bayernoil refinery.

12 A textbook example of such a JV is the Bayernoil refinery in Bavaria which houses all three ownership forms. The ownership structure of the Bayernoil JV is as follows; 45% Varo Energy, 25% Rosneft, 20% ENI, and 10% BP.

13 Although the oil pipeline network is extensive, it is not nearly as dense as, for instance, the existing gas network in Europe. This results from the fact that oil, unlike gas, can also be transported economically by rail, truck or ship.



Nordics
1: Naantali (Neste)
2: Porvoo (Neste)
3: Lysekil (Preem)
4: Gothenburg (St1)
5: Gothenburg (Preem)
6: Fredericia (Dansk Olieselskab)
7: Kalundborg (Statoil)
8: Mažeikiai (PKN Orlen)

British Isles
9: Whitegate (Irving Oil)
10: Grangemouth (Petroineos)
11: Stanlow (Essar)
12: Humber (Phillips 66)
13: Lindsey (Total)
14: Pembroke (Valero)
15: Fawley (ExxonMobil)

ARA
16: Rotterdam (Shell)
17: Rotterdam (ExxonMobil)
18: Rotterdam (BP)
19: Rotterdam (Gunvor)
20: Rotterdam (Vitol)
21: Vlissingen (Total/Lukoil)
22: Antwerp (ExxonMobil)
23: Antwerp (Total)
24: Antwerp (Gunvor)

Germany
25: Heide (Klesch)
26: Holborn (Tamoil)
27: Schwedt (Rosneft)
28: Lingen (BP)
29: Gelsenkirchen (BP)
30: Leuna (Total)
31: Rhineland (Shell)
32: Karlsruhe (MiRO)
33: Neustadt/Vohburg (Bayernoil)
34: Ingolstadt (Gunvor)
35: Burghausen (OMV)

Visegrád + Austria
36: Gdańsk (LOTOS)
37: Płock (PKN Orlen)
38: Litvínov (Ceska)
39: Kralupy (Ceska)
40: Schwechat (OMV)
41: Bratislava (MOL)
42: Százhalombatta Duna (MOL)

France
43: Gonfreville (Total)
44: Port Jérôme (ExxonMobil)
45: Grandpuits (Total)
46: Donges (Total)
47: Feyzin (Total)
48: Fos-sur-Mer (ExxonMobil)
49: Lavéra (Petroineos)
50: La Mède (Total)

Iberia
51: Matosinhos (GALP)
52: Sines (GALP)
53: A Coruña (Repsol)
54: Somorrosto (Petronor)
55: Tarragona (Repsol)
56: Castellón (BP)
57: Puertollano (Repsol)
58: Rábida (CEPSA)
59: San Roque (CEPSA)
60: Cartagena (Repsol)
61: Tenerife (CEPSA)

Italy
62: Trecate (ExxonMobil)
63: Sannazzaro (ENI)
64: Busalla (Iplom)
65: Livorno (ENI)
66: Falconara (API)
67: Taranto (ENI)
68: Sarroch (Saras)
69: Milazzo (ENI/Q8)
70: Augusta (ExxonMobil)
71: ISAB (Lukoil)

SEE
72: Rijeka (INA)
73: Sisak (INA)
74: Petrobrazi (Petrom)
75: Petrotel (Lukoil)
76: Petromidia (Rompetrol)
77: Neftochim Burgas (Lukoil)
78: Thessaloniki (Helpe)
79: Aspropyrgos (Helpe)
80: Elefsina (Helpe)
81: Corinth (MOH)

Non-EU
82: Mongstad (Statoil)
83: Slagen (ExxonMobil)
84: Cressier (Varo)
85: Collombey (Tamoil)
86: Novopolotsk (Naftan)
87: Mozyr (Slavneft)
88: Bosanski (Zarubezhneft)
89: Novi Sad (NIS)
90: Pančevo (NIS)
91: Skopje (OKTA)

FIGURE 2.1: MAP OF THE REFINING SECTOR AND PETROLEUM INFRASTRUCTURE IN THE EUROPEAN UNION

assets from the 1950s-60s, transporting both crude oil and refined products.[14] Second, Spain has a domestic product pipeline system, arranged as a 'hub-and-spoke' network that covers all major ports, refineries, and demand centres.[15] Lastly, the vast Drushba pipeline network consists of a northern and southern branch, directly connecting the oil fields in Russia to refineries from eastern Germany to Hungary.[16]

Despite a multitude of inland waterways in Europe, only the Rhine and Danube rivers can accommodate barges to supply inland regions as fluctuating water levels restrict year-round supply, minimising the penetration rate of the European inland waterway system.[17] Countries that lack any pipeline network still largely depend on rail, road or coaster transport for their petroleum distribution. Although this is economically less efficient than pipeline transport, local market conditions may still prefer trucks over pipes – due to low population density, high greenfield pipeline costs, etc. Countries around the Baltic Sea are characterised by their low population density and scattered demand centres, hence, significant pipeline infrastructure is lacking in the Nordic Member States.

14 The NWE network includes the dense military (NATO) purpose CEPS pipelines transporting mainly jet fuel across several countries, the SPSE network connecting Marseille with southern Germany, the TAL pipeline system connecting southern Germany to the Italian port of Trieste, and the ARRA pipelines web that links the ports of Amsterdam, Rotterdam, and Antwerp to the Rhine-Ruhr industrial area. See, for example, Policy Department Economic and Scientific Policy (2009) 'Gas and Oil Pipelines in Europe' (IP/A/ITRE/NT/2009-13) or; van den Bergh, Nivard & Kreijkes (2016) 'Long-term Prospects for Northwest European Refining' CIEP.

15 The CLH network in Spain mainly transports refined products from the coastal refineries to the demand centres in Spain. See, for example, http://www.clh.es/section.cfm?id=2&side=134&lang=en

16 The Drushba (or 'Friendship') pipeline, with a total length surpassing 4000 km, is operated by state-owned Transneft and has an initial capacity of 2Mb/d supplying eastern Europe. See, for example, Figure 2.1 or; CIEP (2014) 'Russia – Europe: The Liquid Relationship Often Overlooked' Factsheet or; http://en.transneft.ru/.

17 There are more inland waterways throughout the NWE accommodating barges to supply inland regions, as described in van den Bergh, Nivard & Kreijkes (2016) 'Long-term Prospects for Northwest European Refining' CIEP.

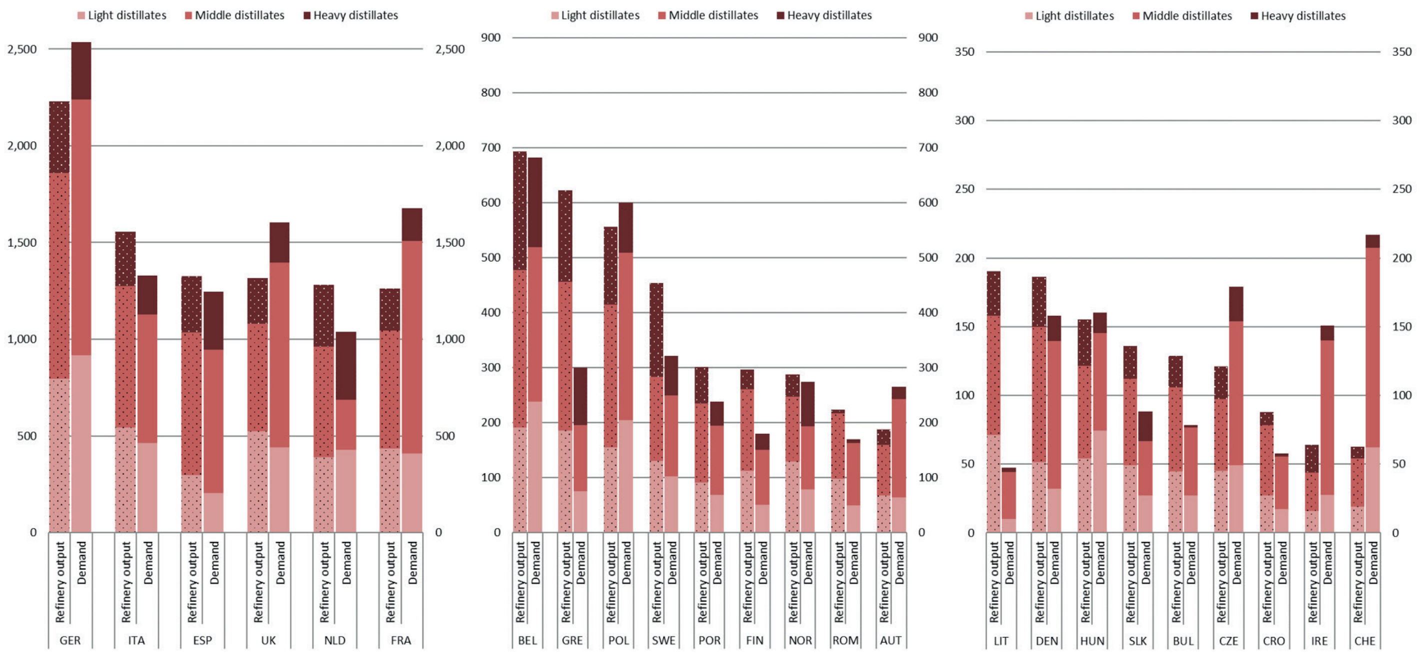


FIGURE 2.2: OIL PRODUCT DEMAND VS. REFINERY OUTPUT IN THE EU IN Kb/d[18]

Traditionally, these various modes of intra-European transport have facilitated the internal trade of crude oil and refined products within the Union, while also connecting inland regions with the global petroleum market. Although the 'single market' principle has theoretically eliminated internal trade restrictions, the absence of Third Party Access (TPA) on various crude/product pipelines, regions sheltered by natural barriers, and the ongoing existence of external tariffs on refined products, still prevents a complete barrier-free European oil market.[19] Petroleum trade flows that move internally in the European Union, predominantly take place between the Northern coastal Member States (see **Annex C**). These north-western countries house Europe's largest ports, in terms of throughput and storage capacity, and facilitating trade by pipeline and maritime transport. In addition, the pool of import/export partners seems to reduce significantly as countries lack necessary facilities for trade (e.g. world-scale ports).

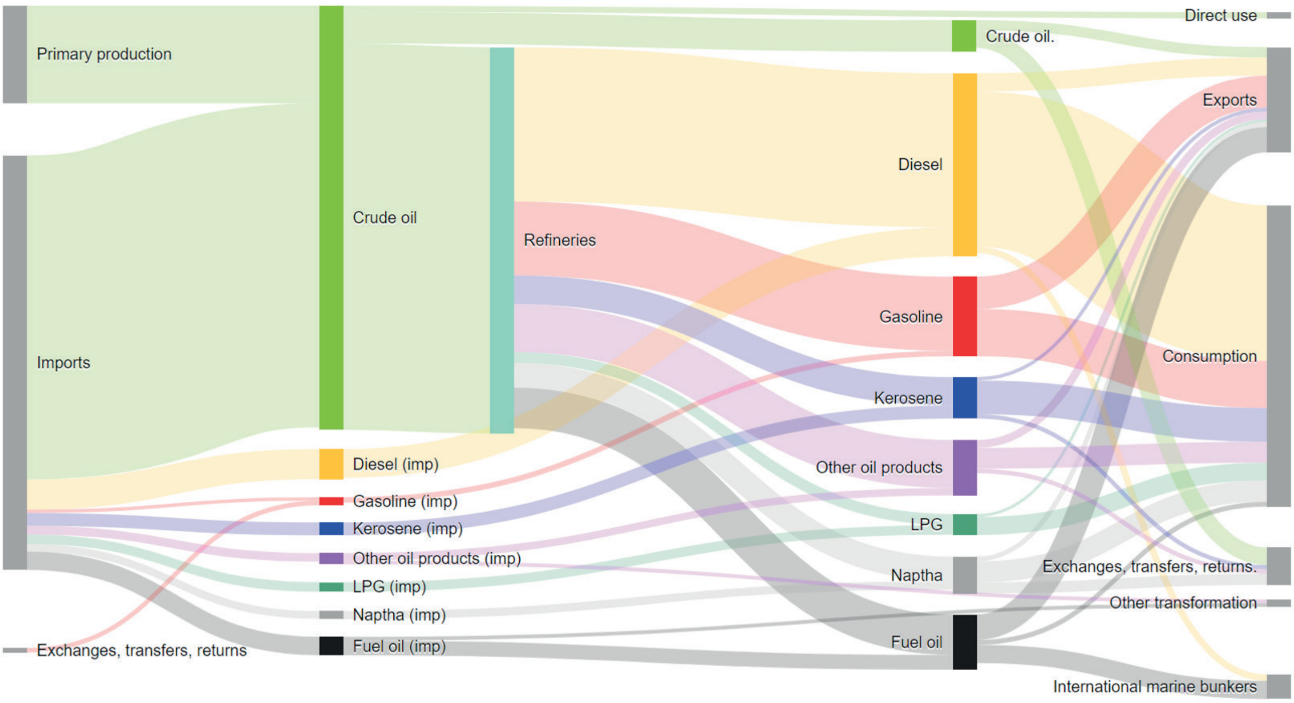
2.2 PETROLEUM FLOWS OF THE EUROPEAN UNION

Total European refining output (on a barrel-to-barrel-basis) is more or less balanced with total demand. However, zooming in on (national) refined products output reveals a more ambiguous picture. On a national basis, the demand mix for oil products differs significantly and rarely matches its domestic production profile (see

18 Based on Jodi data (Kb/d) using the year 2015, the demand and output capacity are yearly averages. Countries have been divided into three groups based on refining production levels: >1 Mb/d, 200-1000 Kb/d, 1-200 Kb/d.

19 Many European crude pipelines remain exempt from TPA obligations. The European Common Customs Tariff still upholds an import fee on specific refined products while the external tariff on crude oil is eliminated. See, for example, The European Commission (2013) 'Regulations – Commission Implementing Regulation (EU) No. 1001/2013'.

Figure 2.2).[20] Specific regulation (e.g. dieselisation, fuel oil policy) has affected European demand and pushed European refining slates to the limit – focussing heavily on middle distillates.[21] Additionally, national demand profiles may have diverging supply requirements – an outsized petrochemical industry requires longer naphtha supplies, while landlocked regions have lower HFO demand due to absence of marine bunkers. Uncertainty surrounding future marine bunker fuel demand is expected to rise due to new IMO regulations on sulphur contents (see Box 2.1).



refining.

FIGURE 2.3: SANKEY DIAGRAM OF OIL FLOWS IN THE EU PLUS NORWAY IN 2015 (SOURCE: EUROSTAT)[22]

22 Total refined product imports amount to 154 MTOE, refined product exports are 162 MTOE, and energy available for consumption is 514 MTOE. See Annex C for more details.

Box 2.1: IMO 2020 marine fuel regulation – a volatile future?

The International Marine Organisation (IMO) decided in October 2016 to significantly reduce the limit for sulphur content in marine fuels from January 2020 onwards.[23] Under the new global limit (including international waters) ships will have to use marine fuel with a sulphur content of no more than 0,5% m/m. Currently, for the EU the Emission Control Area (ECA) has a more stringent limit at 0.1% m/m of sulphur content.[24] Multiple pathways exist to reach the required sulphur content: 1) blending regular Heavy Fuel Oil (HFO) with Ultra Low Sulphur Diesel (ULSD) or gasoil, 2) consuming Marine Gas Oil (MGO) or LNG as marine fuel, 3) installing on-board scrubbers to remove pollutants from the ship's exhaust.[25]

The IEA estimates that this implementation would see a 2 million b/d of marine fuel demand switch from HFO to MGO. Others see an even bigger – 3 million b/d – switch from regular HFO to low sulphur HFO and/or distillates.[26] CE Delft foresees in its base case petroleum demand projections shifting away from regular HFO to low sulphur HFO and/or other distillates with a reduction of 192Mt/year (~3.4 million b/d) compared to 2012 figures.[27]

When considering the production of low sulphur marine fuels from a refiner's perspective multiple options come into play: 1) blending with gasoil or ULSD, which requires substantial distillate volumes, 2) changing feedstock to sweeter crude slates (lower sulphur content), 3) investing in additional desulphurisation processes, and 4) upgrading the bottom-of-the-barrel (an increase in HC-, FCC-, and coking units).[28, 29] The question is whether the global refining sector will be able to produce enough low sulphur marine fuels while also meeting the refined product demand of other sectors.

23 IMO (2016). "IMO sets 2020 date for ships to comply with low sulphur fuel oil requirement"; or http://www.imo.org/en/mediacentre/pressbriefings/pages/mepc-70-2020sulphur.aspx.

24 EIA (2016). "Tighter marine fuel sulfur limits will spark changes by both refiners and vessel operators"; or https://www.eia.gov/todayinenergy/detail.php?id=28952.

25 EIA (2016). "Tighter marine fuel sulfur limits will spark changes by both refiners and vessel operators"; https://www.eia.gov/todayinenergy/detail.php?id=28952; McQuilling Services (2017). Tankers Industry Note No.7: 2020 Bunker Regulation – "A Refined View".

26 The International Bunker Industry Association (IBIA) (2016). "Signals hinting at 2020 entry into force of 0.50% global sulphur cap"; or http://ibia.net/signals-hinting-at-2020-entry-into-force-of-0-50-global-sulphur-cap/.

27 CE Delft (2016). "Assessment of Fuel Oil Availability".

28 Refineries with deep conversion capabilities have a favorable position as the outlets for HFO may experience a substantial downturn.

29 S&P Global Platts (2016). "The IMO's 2020 global sulfur cap: What a 2020 sulfur-constrained world means for shipping lines, refineries and bunker suppliers", Shipping special report, October 2016; "Major changes in 2020 for the global refining industry", Oil special report, April 2017.

One thing can be said for sure, volatility in the international marine bunker market will rise. Without a first-mover advantage, the maritime and refining industry are both eyeing each other on what the ultimate outcome of the IMO regulation will be. Are scrubbers going to be installed on a massive scale, preserving HFO demand and acquitting European refiners to invest in upgrades? Is a switch to LNG expected, bequeathing refineries with HFO surpluses? Or will a potential price drop in gasoil make blending more economically attractive? And last but not least, how will compliance and enforcement on international waters of IMO regulation come into play? Without coordination on a combined maritime/refining approach, uncertainty is expected to reign.

As a result, significant trade flows are needed to counter the mismatch and satisfy (national) demand. Not only intra-European trade but especially trade flows with non-European refining centres are essential to manage product imbalances.[30] Given the specific infrastructure, European refinery configuration, and economic rationale, these product trade flows may very well increase in the medium-term future, especially as regulatory constraints are set to continue.[31]

For the European market as a whole, this has led to different trade flows per product, in general revealing overall deficits in middle distillates and surpluses in both gasoline and heavier parts of the barrel (see Figure 2.3).[32] Significant imports are needed to satisfy diesel, kerosene, and naphtha demand, while European refiners in general require ample export opportunities for their gasoline and fuel oil surpluses. Already over one fifth of total European petroleum imports consists of refined products indicating a significant market share of non-European refineries in European product markets. This share has steadily risen over the years and is not expected to dissipate.[33] Simultaneously, the importance of global export destinations for domestic European refineries that act as a much-needed outlet for excess products, further indicates the intertwinement of the EU's refining sector with the global market.

30 Flexibility for a refinery's product slate is limited to its unit configuration, the specific type of crude intake (varying in API gravity and sulphur content), and the underlying economics of production processes. Therefore, demand for some products in the EU is too high leaving the refining capacity unable to satisfy the need without creating huge surpluses in unwanted products. See, for example, Jones, D.S.J. & Treese, S.A. (2015). "Petroleum Products and a Refinery Configuration". S.A. Treese et al. (eds.), "Handbook of Petroleum Processing". ISBN:978-3-319-14528-0.

31 See, for example, the new IMO 2020 sulphur regulation. Europia (2011) 'Europia Contribution to EU Energy Pathways to 2050' or; http://www.imo.org/en/OurWork/environment/pollutionprevention/airpollution/pages/sulphur-oxides-(sox)-%E2%80%93-regulation-14.aspx

32 The Sankey diagram is based on Eurostat 2015 figures, for more details see Annex C.

33 In 2015, the share of refined products in the petroleum import mix of the EU reached 22%, up from 14% in the 1990s, according to Eurostat data.

3 RESILIENT TO COMPETITION CAPACITY – THE RHINE-DANUBE-LINE

With a maturing refined product demand in Europe, competition among domestic European refineries is mounting.[34] On top of this, new and modern refining capacity outside Europe is increasingly targeting the Old Continent, stimulated by lower production costs and decreasing shipping costs.[35] Substituting crude oil with refined products in Europe's import mix signals a return to the traditional source-refining model, undermining the competitive position of the EU refining sector as a whole.[36] Despite these structural developments, zooming in on individual European refineries reveals a different picture as some refineries are likely to withstand these competitive threats due to specific strategic characteristics. This chapter identifies 23 strong points in EU refining on the basis of their external integration, of which 84% are located along a line stretching from Rotterdam to Romania. This clustering of strong points, however, does not indicate one integrated market, since this area consists of several regions and largely remains exposed to international competition. However, refineries following this "Rhine-Danube-Line" are expected to be more resilient to competition due to their integration in local value chains. Further away from this "Rhine-Danube-Line", 62 refineries are likely to have a higher exposure to competition with refined product imports due to lower levels of competitive integration.

3.1 ASSUMPTIONS & METHODOLOGY

Two developments simultaneously imperil the EU refining sector which has already witnessed capacity retirement in recent years.[37] First, the demand for petroleum products in the EU has become stagnant, leaving an oversized EU refining sector

34 European demand for petroleum products seems to have reached maturity, and is likely to decline over the coming decades whilst maintaining a significant role in the total energy mix. Based on several outlooks: BP (2016), 'Energy Outlook'; IEA (2016), 'World Energy Outlook 2016'; Statoil (2016), 'Energy Perspectives 2016'.

35 Among others, the emergence of new multiproduct tankers has decreased overall shipping rates, allowing for a more economical maritime transport of petroleum products. See, for example, UNCTAD (2015) 'Review of Maritime Transport 2015' or; Fearnley Project Finance (2016) 'Shipping and Offshore Report 2015' or; TORM plc (2015) 'Paragraph 6.4.1. The Product Tanker Segment'.

36 Traditionally, refineries were located in the vicinity of a crude oil source. These source-refineries were replaced by market-refineries due to asymmetric location of product demand centres and crude long regions, the developments in maritime crude transport, the availability of capital, and technology in OECD countries. Today, we see a return to the source-refining model as most investments are concentrated in crude-long areas.

37 In 2010 the European Union housed 104 refineries. Since 2008, approximately 2 Mb/d of refining capacity has been closed. See, for example, European Commission, November 17th 2010, "Commission Staff Working Paper on Refining and the Supply of Petroleum Products in the EU"; or van den Bergh, Nivard & Kreijkes (2016), "Long-term Prospects for Northwest European Refining"; or Exxon presentation at fifth refining forum (slide 7) or; Petrosyan, K. (2016) 'Presentation at Sixth EU Refining Forum' IEA or; BP (2016) 'BP Statistical Review of World Energy – June 2016'.

that suffers from decreasing utilisation rates and eroding margins.[38] Second, traditional export destinations for European refineries (i.e. Asia and the US) are becoming more self-sufficient while traditional crude suppliers (i.e. Middle East and Russia) are increasing their own refined product export capacities, both altering the global market to the detriment of European refiners.[39,40] These (new) non-European refineries often benefit from lower operational costs (mainly energy costs), higher utilisation rates, modern configurations, less stringent environmental regulation, and higher greenfield potential.[41] Combined with the decreasing cost of maritime transport, this results in a global refining market where any generic European refinery is effectively competing with a Middle Eastern, Asian, or Russian refinery.[42] As a result, the bulk of the global future investments will likely be directed towards higher growth and low cost regions outside the EU refining sector.[43] These new economic circumstances may result in Europe's refineries being denied much-needed upgrades.[44] In turn, the lower level of capital investments further widens the competitive gap vis-à-vis modern refining centres outside Europe, hampering overall competitiveness of the EU refining sector.[45] As a result, the European refined product market proves to be fertile ground for increasing imports of refined products to the European market (see Figure 3.1).

38 See, for example, IEA (2016) – 'World Energy Outlook 2016'; BP (2016) – 'Statistical Review of World Energy 2016'; IEA (2016) – 'Oil Market Report'.

39 In Asia, governments are increasingly stimulating their national refining capacity, encouraging investments and exports (even by smaller 'teapot' refineries). With the emergence of abundant LTO supplies in the US, traditional refining dynamics in the Atlantic basin are shifting, building pressure on European refiners as traditional gasoline outlets are evaporating. See, for example, Gaffney, Cline & Associates (2014) 'Exports or Imports – The Future of Asian Refining', or FT (2016) 'China's 'Teapot' Refineries pose Challenge to Majors', or Six (2013) 'US Refining Dynamics' CIEP, or OIES (2013) 'US Tight Oils: Prospects and Implications'.

40 The recent surge in new refining capacity in the Middle East is expected to continue as new refining projects are still in the pipeline. Simultaneously, Russia is upgrading its refining capacity aiming to stimulate the export of refined products. See, for example, World Refining Association (2015) 'The Future of the Middle East Downstream Sector' or; Oxford Institute for Energy Studies (2013) 'Refining Dynamics in the GCC and Implications for Trade Flows' or; EY (2014) 'Russia's Downstream Sector: Sights Set on Modernisation' or; PetroMarket (2016) 'Backward Russian Refineries: Shutdown or Upgrade?'.

41 See, for example, FuelsEurope (2015) 'FuelsEurope position on EU ETS reform', or; Exxon (2015) 'The State of European Refining Today'.

42 See, for example, Oil & Gas Journal (2016) 'Oil Tanker Freight-rate Volatility Increases' or, PWC (2016) 'Crude Oil Tank Market: A Strong Performer in 2015 and its Outlook' or, EIA (2016) 'Low tanker rates are enabling more long-distance crude oil and petroleum product trade' Today in Energy.

43 See, IEA (2016) 'Medium-term Oil Market Report – World Refining Capacity Additions' or, OPEC (2016) 'World Oil Outlook – Downstream Investment Requirements'.

44 Already, the bulk of refinery investments (both greenfield and upgrading) goes to regions that still experience demand growth like Asia, FSU, Middle East, and the US. Of the European refinery investments, a substantial part is not directed to the European Union but to Turkey. See, for example, IEA (2016) 'Medium-Term Oil Market Report 2016', or; http://www.starrafineri.com.tr/en/star-rafineri/about-us/8/.

45 The ageing refining sector in Europe may suffer from a 'handicap of a head start' as a significant portion of European refining capacity has been operational for decades, locked-in with older technology. Greenfield investments in non-EU regions can therefore incorporate the latest innovations, having higher efficiency returns.

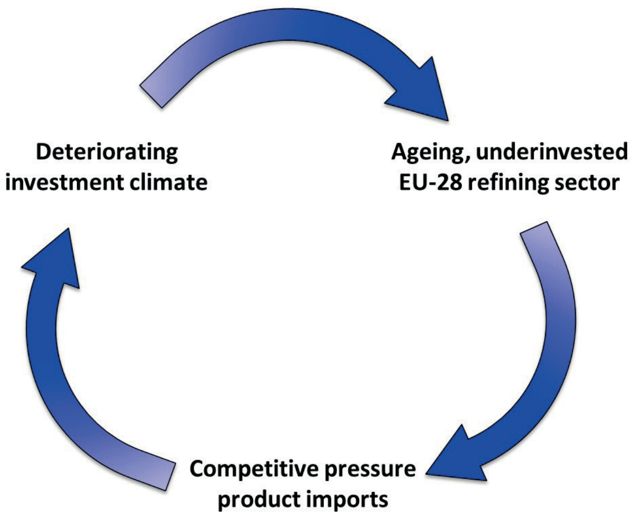


FIGURE 3.1: INTERNATIONAL PRESSURE ON THE EU REFINING SECTOR

Although the argument holds for the EU refining sector as a whole, individual refineries are still enjoying continued investments indicating a specific competitive edge.[46] Isolating these qualities would reveal which European refineries are most likely to weather the structural developments that imperil the entire refining sector in the European Union. In other words, what characteristics enhance the resilience of a refinery and hence ensure continued investments in that refinery despite the increasingly competitive outlook for the sector as a whole?

Conventional approaches centre their analysis around net cash margins and complexity rankings of individual refineries, but these internal characteristics often have a short-term and cash-centred focus, undervaluing critical structural criteria.[47,48] Instead, this study aims to incorporate the external integration in an economic cluster which is an essential part in the long-term existence of individual refineries. In

46 Case in point are some major investments in the ARA-cluster by Shell, Exxon, and Total but also upgrading investments in Spain and Poland indicates that individual refineries still receive significant capital investments. LOTOS (2007) "Program 10+" or, https://www.wsj.com/articles/exxon-mobil-to-plow-1-billion-into-belgian-refinery-1404286424 or, http://www.shell.com/media/news-and-media-releases/2015/shell-takes-fid-to-build-solvent-deasphalter-unit-at-pernis.html or, http://www.reuters.com/article/repsol-refinery-idUSMDT00473220080108.

47 Cash margins are highly dependent on the economic cycle and as such a poor indicator of long-term prospects. The Nelson-Farrar complexity index appraises a refinery by attributing values corresponding to their capital outlays, but again underappreciating structural indicators. An example is the Coryton refinery that, although it had the strongest internal indicators (i.e. complexity, cash margins) within the Petroplus portfolio, its weaker external characteristics (i.e. coastal location, proximity to excellent import facilities, and low integration) have likely led to its unexpected premature closure.

48 Although other internal measures like the operational flexibility, energy efficiency, operational performance, etc. are important indicators for continued investments, this study focusses on the external measures rather than internal. For limitations on the model, see Bergh, Nivard & Kreijkes (2016), 'Long-term Prospects for Northwest European Refining', CIEP.

other words, assessing the broader value chain(s) that depend on a refinery acknowledges the strategic position from which it can derive longer term competitiveness. For that purpose, an extreme but plausible scenario has been developed that analyses the refining sector on an individual refinery level, comparing them against four archetypical refineries.

The several types of strategic integration have been summarised by four archetypical refineries that are hypothetically well-suited to withstand long-term competitive threats (see Box 3.1). The 'Captive Demand', 'Petrochemicals Integrated', 'Upstream Integrated', and 'Surplus Coking' archetypes all constitute specific types of integration that have proven to grant long-term competitiveness for refineries. Although the assumptions may be extreme, and the assessment is necessarily subjective, detailed underlying codifications create a transparent model allowing for future feedback and adjustments.[49]

Each of the 85 European refineries is benchmarked against all four archetypes, measuring their compatibility with the underlying criteria.[50] This cross-check results in a separate group of refineries that are integrated in economic value chains and hence represent the strong points in European refining. This integrated refining capacity remains in competition with the global market but derives specific competitive benefits from its close integration with surrounding value chains and is hence expected to be more resilient to competition. On the other hand, (coastal) refineries that are characterised by low levels of integration (or even complete stand-alone refineries) and are situated in open local markets, are hence expected to have a lower potential to withstand the overall competitive threats in the medium term. In other words, the entire refining sector in the EU has an exposure to competition but some refining capacity is likely to have a higher vulnerability towards these competitive refined product imports – i.e. it has an increased exposure to competition.

49 The model was obtained via several meetings with refining experts and industry participants. For a detailed description of the underlying criteria and a sensitivity analysis of the 'must-run' model see van den Bergh, Nivard & Kreijkes (2016), 'Long-term Prospects for Northwest European Refining', CIEP.

50 Ibid.

Box 3.1: Scenario categories

(1) Captive Demand refineries are likely to derive strategic value from their integration in an inland demand region, providing competitive supply of locally refined products to a sheltered market. As long as infrastructure to facilitate refined product imports to this region is lacking or constrained, continued investments in these refineries are likely.[51] One crucial condition is the guaranteed direct pipeline supply of crude oil for the refinery, providing a secure supply of competitively priced feedstock.[52]

(2) Petrochemicals Integrated refineries have a potential to gain strategic value from the (chemical) cluster they serve. By offering secure and competitive feedstock supply, outlets for by-products, and reduced transport intensity, these refineries more effectively utilise raw material inputs, assets and working capital.[53] Even though petrochemical feedstocks represent only 10 to 15 per cent of a refinery's product slate, the strategic value of integration with a competitive (chemical) cluster is likely to provide sufficient rationale for continued (upgrading) investments.

(3) Upstream Integrated refineries are likely to benefit from their direct pipeline integration with a crude long region, generating buyers' power for a secure and premium source of crude oil. In fact, as long as the crude long region does not have export optionality and production is sustainable for the long term, these refineries are in a strong position to bargain for cheap feedstock supply, providing a strong case for continued investments.

(4) Surplus Coking refineries derive their strategic position from various policy initiatives that envision a gradual phase-out of heavy fuel oil (HFO) use in the EU and beyond.[54] Coking units use deep thermal conversion to upgrade bottom-of-the-barrel streams, avoiding the need to find outlets for HFO volumes.[55] Given the very limited availability of complex refineries with coking

51 Note that in the case of captive demand from a land-locked region not exposed to imports, it is critical that the refinery output matches local demand, because exports of surplus refined products may be as expensive as imports of deficit refined products.

52 A diversified feedstock supply is preferable as being restricted to a single crude supplier exposes the refinery to security of supply concerns. In that respect, central European countries may be more exposed to (geo-)political spikes in Russia as they are their major crude source.

53 See EPCA (2007), 'Supply Chain Collaboration and Competition in and between Europe's Chemical Clusters'.

54 For more details on changing HFO sulphur specifications see, for example, Concawe (2013), 'Oil refining in the EU in 2020, with perspectives in 2030'.

55 Residue gasification is another solution to upgrade bottom-of-the-barrel stream, but there is even less residue gasification capacity in the EU.

capacity in the EU, refineries with outsized (surplus) coking units can derive strategic value from their integration in (regional) HFO markets. New IMO regulations are only expected to increase the deficit in bottom-of-the-barrel conversion capabilities of European refineries.[56] Provided a surplus coking refinery maintains access to third party residue supplies, continued investment in these refineries is likely.

3.2 EU REFINING LANDSCAPE – A MEDIUM-TERM OUTLOOK

In total, the 85 refineries in the EU, Norway, and Switzerland are all subject to competitive threats. Imposing the first scenario conditions on the EU refining sector reveals 23 refineries – accounting for 4.8 Mb/d – that can be considered more 'resilient to competition' due to their specific competitive advantages derived from integration in local value chains (see Figure 3.2). Concentrated in Northwest Europe, 13 of these resilient to competition refineries (or 3.2 Mb/d) are mainly benefitting from complex chemical integration and substantial trading opportunities.[57] Outside NWE, 10 additional refineries (or 1.6 Mb/d) meet the scenario conditions. The bulk of this additional capacity is located in Central Eastern Europe where it benefits from a captive demand advantage.

Given the dispersed EU refining sector, the distribution of EU resilient to competition capacity is rather skewed, signalling less competitive refineries in southern and northern Europe whilst uncovering an area along the "Rhine-Danube-Line" where most refineries (for different reasons) are expected to be more resilient to competition. This shaded area holds 18 of the 23 resilient to competition refineries, aggregating up to 84% of total resilient to competition capacity within its breadth (see Figure 3.2).[58]

56 Significant reduction of SOx content for fuel oil use in the maritime sector towards 2020, including international waters, will significantly reduce the outlet for fuel oil in European ports. See: http://www.imo.org/en/OurWork/environment/pollutionprevention/airpollution/pages/sulphur-oxides-(sox)-%E2%80%93-regulation-14.aspx.

57 For more details on the 12 must-run refineries in NWE, see Van den Bergh, Nivard & Kreijkes (2016), 'Long-term Prospects for Northwest European Refining', CIEP. Switzerland was not part of the Northwest European scope but is now included in the NWE region.

58 The area along the "Rhine-Danube-Line" not only holds 84% of the strong points of the European refining sector, but is also home to a significant part of Europe's upstream industry (e.g. North Sea offshore, Schoonebeek, Vienna basin, Pannonian Basin). See, for example, Brunet R. (1989) 'Les Villes Europeennes', DATAR.

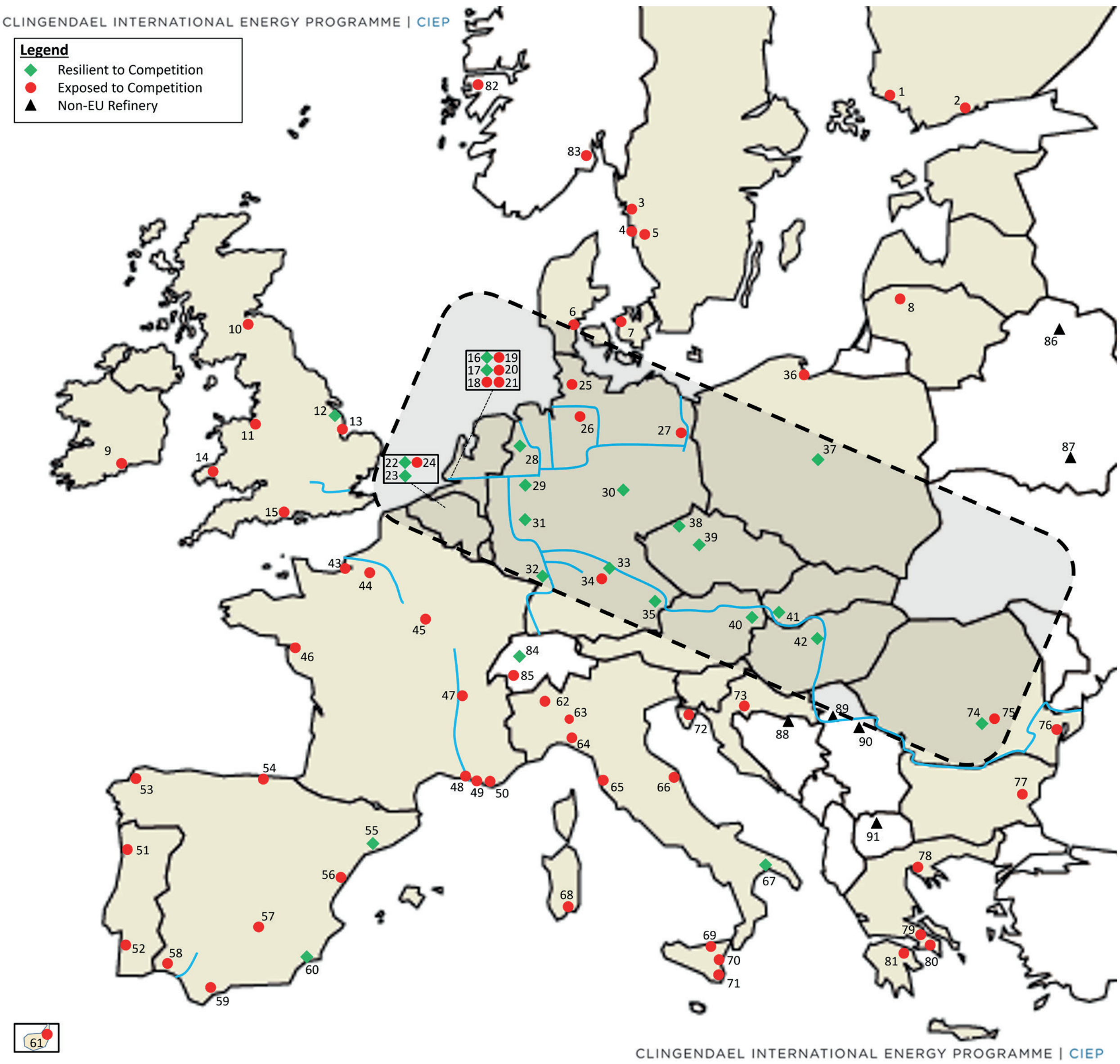


FIGURE 3.2: MAP OF RESILIENT TO COMPETITION REFINING CAPACITY IN THE EU ALONG THE "RHINE-DANUBE-LINE"

Starting from the highly complex ARRRA-cluster (Amsterdam-Rotterdam-Rhine-Ruhr-Antwerp), this area has a tail of captive demand refineries stretching from southern Germany into central Romania.[59] This leaves the Nordic and Mediterranean countries containing most of the remaining European refining capacity that is expected to have a higher exposure to direct competition of refined product imports.

59 The ARRRA-cluster refers to the Amsterdam-Rotterdam-Rhine-Ruhr-Antwerp cluster including the Germany industrial cluster with the traditional ARA-cluster. Rationale for the broader definition lays in the fact that the overall cluster enjoys a dense pipeline network and is characterised by large and complex refineries likely deriving competitive advantages from the deep integration. For an overview of the ARRRA pipelines see, for example, https://www.portofrotterdam.com/en/cargo-industry/refining-chemicals.

REGIONAL OVERVIEW

The more resilient to competition capacity is unevenly distributed across the EU with NWE and CEE countries housing the bulk of these refineries (see Figure 3.3). The NWE resilient to competition capacity can be divided into two regions; the complex and integrated ARA-cluster and the Southern German captive demand region.[60] Within CEE, the Visegrád and Austria have most of the resilient to competition refineries, where the main driver for resilient capacity concentration is the captive demand advantage that these refineries intrinsically enjoy. Infrastructural restrictions limit the penetration of refined product imports into central Europe, which is further amplified by the specific ownership structure of the existing pipeline network, minimising the likelihood of conversion into refined product pipeline whilst ensuring long-term crude supply to the specific region. The significant distance of CEE product demand to oil ports (> 250km) denies economically feasible transport of refined products via road or rail, further fortifying the captive demand positions of Visegrád and Austrian refineries.[61]

Under these conditions, northern European refining capacity is completely exposed to competition, indicating increased vulnerability for Scandinavian and Baltic refineries to competitive refined product imports, mainly driven by its coastal location, dispersed demand centres, and lack of significant chemical integration. These are the main drivers for the northern Member States to be left without significant competitive advantages for their local refineries. Declining petroleum demand, especially in the Scandinavian countries, deteriorates the future prospects of their respective domestic refining markets, strengthening the economic case for product imports.[62] Excellent port facilities and a solid track record with the transport of refined products by truck, rail, and coasters, further exacerbate the exposure of Northern refineries to refined product imports from outside the EU.[63]

60 For more details on the NWE must-run scenario outcome, see van den Bergh, Nivard & Kreijkes (2016), 'Long-term Prospects for Northwest European Refining', CIEP.

61 The nearest oil ports are Gdansk (> 400km to Warsaw), Omisalj (> 300km to Hungarian border), and Triest (> 300km to Graz).

62 Consumption of petroleum products is decreasing steadily over recent decades in the Scandinavian countries (-18% in Denmark, -14% in Finland, -30% in Sweden since the '80s) not in the least aided by stringent environmental regulation – 20% biofuel target in Finland, Swedish vehicle fleet fossil independent by 2030. See, for example, Swedish Energy Agency (2015) 'Energy in Sweden 2015' or, http://www.oil.fi/en or, European Biofuels (2016) 'Biofuels Factsheet – Biofuels in Finland' or, IEA (2014) 'Energy Supply Security – Denmark' or, https://ens.dk/en.

63 Both Sweden and Finland lack any form of petroleum pipeline network and are hence necessitated to supply their demand centres by road, rail or maritime. See, for example, Figure 2.1 for an overview of infrastructure; IEA (2014) 'Energy Supply Security 2014 – Sweden, Finland, Denmark'; and Eurostat data for transport-mode per country.

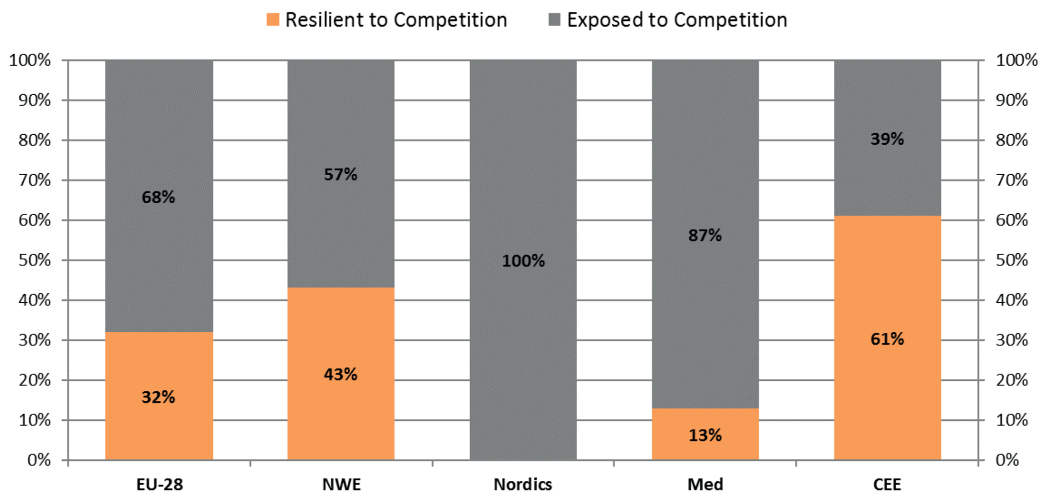


FIGURE 3.3: RESILIENT TO COMPETITION REFINING CAPACITY SHARE PER REGION

Moving south towards the Mediterranean (Med), only a handful of refineries have been identified that meet the scenario conditions. Again, due to the fact that the majority of Med refineries are located in coastal areas combined with low levels of up- and downstream integration, most of the southern refineries are expected to be increasingly exposed to competition. In addition, Spain has an excellent domestic product pipeline network connecting its ports to its inland demand centres, stimulating product imports but undermining its domestic refining sector.[64] Meanwhile, Italy has already witnessed significant downsizing of its refining capacity in recent years but the coastal exposure and sub-world scale chemical integration is not likely to provide competitive advantage in the medium term.[65] Three resilient to competition refineries in southern Europe are an exception on the basis of their surplus coking capacity, petrochemical- and upstream-integration. However, this leaves a significant share (87%) of Mediterranean refining capacity exposed to refined product import competition.

64 The Spanish refining sector is characterised by geographically dispersed refineries, covering every corner of the country, that are mutually connected by the CLH product pipeline system. Because the CLH pipeline system by law cannot have majority ownership of domestic refineries and it has a TPA guarantee, the Spanish market structure is very open to refined product imports. See, http://www.clh.es/section.cfm?id=2&side=134&lang=en or, IEA (2014) 'Energy Supply Security 2014 – Spain'.

65 As we assume refineries to be in global competition, the freed-up market share by recently closed refineries is not expected to be won by neighbouring Italian refineries but predominantly replaced by (cheaper) product imports. Some of the recently closed Italian refineries include: Gela, Porto Marghera (both ENI), Cremona (Tamoil), Rome (ERG/Total), and Mantova (MOL). See, for example, Unione Petrolifera (2016) 'Data Book 2016 – Energia e Petrolio'.

CATEGORICAL OVERVIEW

By and large, the captive demand category has the highest share of resilience in the EU refining sector (see Figure 3.4). Stretching eastwards from southern Germany towards central Romania, there is an inland region with 12 refineries that combine the benefits of stable local demand with low potential for refined product imports.[66] The fact that the product pipelines reaching this area – potentially supplying imported refined products – lack sufficient capacity and that road/rail transport is not economically viable further shelters these inland markets. Simultaneously, these captive demand refineries are ensured of continued crude supply, either by locked-in long-term supply contracts for Urals via the Drushba pipeline system or via shared ownership structures of crude pipelines (i.e. Adria, SPSE, and/or TAL pipeline systems) providing access to the global crude market – diversity of crude supply remains a critical issue as a single crude supplier may increase security of demand risks.[67,68]

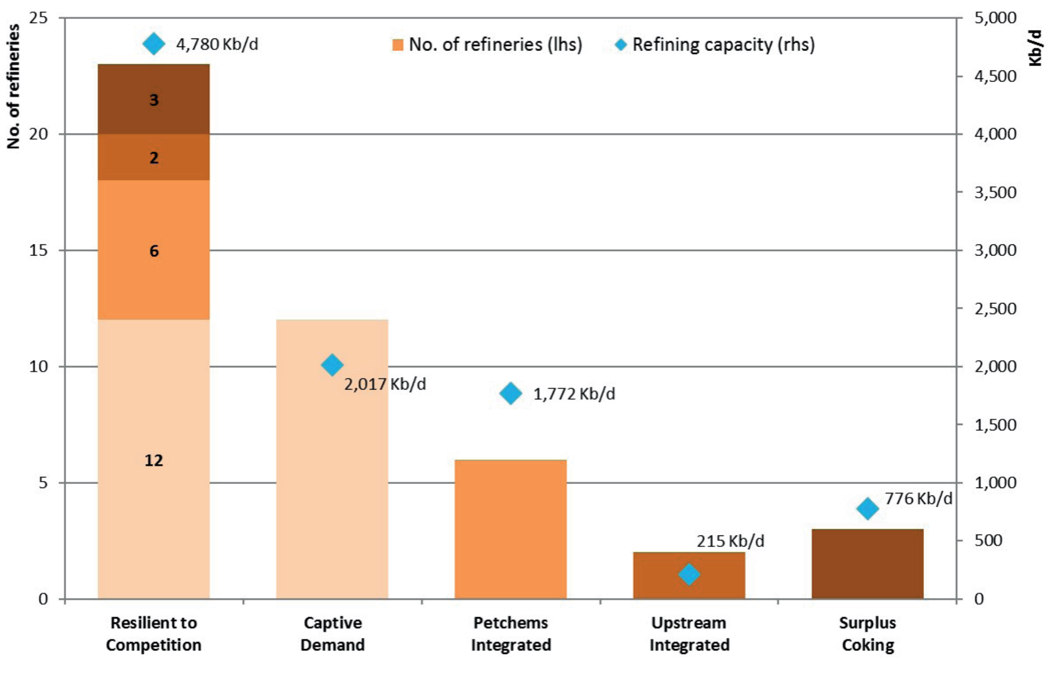


FIGURE 3.4: REFINING CAPACITY PER RESILIENT TO COMPETITION CATEGORY

66 Refined product demand forecasts for central European countries are likely to remain stable and correspond to the local refining capacity of domestic refineries (on a barrel of oil equivalent). See, for example, IEA (2014) 'Energy Supply Security 2014 – Austria, Czech Republic, Hungary, Slovakia' and, various company statements.

67 The inland resilient to competition refineries have joint ownership structures of the pipelines supplying crude oil, decreasing the likelihood of future conversion into a product pipeline. The exemption of third party access (TPA) in these existing pipelines further reduces the likelihood of future pipeline conversion. On the other hand, ensuring pipeline access is crucial for inland refineries since the pipelines provide essential feedstock.

68 See, for example, http://www.ogj.com/articles/2016/07/unipetrol-secures-long-term-crude-supplies-for-litvinov-refinery.html?cmpid=EnlDailyJuly52016&eid=311856375&bid=1451765 or; http://www.orlen.pl/EN/PressOffice/Pages/PKN-ORLEN-signs-an-annex-to-a-long-term-crude-oil-supply-contract-with-Rosneft-Oil-Company.aspx.

The low share of petrochemical integrated refineries outside NWE is largely driven by the sub-world-scale chemical clusters that fail to reach international benchmarks and have uncertain long-term viability.[69] As such, despite integration with a chemical cluster, most Mediterranean petrochemical refineries will not render a long-term competitive edge. A notable exception is the Spanish refinery in Tarragona (Repsol), which meets the pre-set requirements as it is integrated with a viable long-term cluster that offers a direct pipeline integration with two steam crackers with a combined nameplate capacity of nearly 1.2 Mt/a.[70]

Outside the North Sea basin, oil production in the EU is practically non-existent.[71] However, one of the largest onshore oil fields in Europe is located in southern Italy with a direct pipeline connection to ENI's Taranto refinery, ensuring a feedstock supply that may likely increase competitiveness as the refinery is the only outlet of this oil.[72,73] Two other oil basins that cannot be left unmentioned are the Austrian and Romanian onshore oil fields.[74] Both are directly connected to local refineries (e.g. Schwechat in Austria and Ploiesti in Romania) potentially providing a competitive edge. Nevertheless, the production of both fields is decreasing rapidly, significantly

69 Among others, one important benchmark used to identify the resilient to competition refineries is the long-term viability of the associated chemical cluster. Compared to international standards, clusters outside NWE are less competitive on a global scale. See, for example, CEFIC (2013) 'The European Chemical Industry: Facts and Figures 2013' or; KPMG (2010) 'The Future of European Chemical Industry' or; http://www.clusterobservatory.eu/index.html.

70 See, for example, Petrochemicals Europe (2014). "Facts and Figures"; Oil & Gas Journal (2014), "International Survey of Ethylene from Steam Crackers"; Association of Petrochemicals Producers in Europe (2011), "Refineries and Steam Crackers in EU-27"; https://www.repsol.com/es_es/tarragona/sobre-el-complejo/nuestra-historia/default.aspx; http://www.dow.com/iberica/es/about/iberica/sites/tarragona.htm.

71 Oil production in the EU is concentrated in the North Sea Basin but despite recent cost reductions and some new discoveries (e.g. John Sverdrup), overall North Sea production has been decreasing – at 1 Mb/d in 2016. See, for example, Eurostat data, or https://www.platts.com/latest-news/oil/london/outlook-2017-north-sea-oil-industry-hopes-gradually-26631429 or, BP (2016) 'Statistical Review of World Energy 2016'.

72 The Val d'Agri field in southern Italy is also referred to as the 'Texas of Italy' and has a production capacity of over 80,000 b/d. The extensive COVA (Centro Oli Val D'Agri) pipeline network transports the crude oil directly to the Taranto refinery, supplying close to 50% of its crude intake. Despite an Italian probe into ENI's Val d'Agri operations due to illicit waste disposal, the Val d'Agri production is expected to resume. See, for example, http://www.eniday.com/en/education_en/largest-oil-field-europe/ and http://www.bloomberg.com/news/articles/2016-04-04/eni-to-see-negligible-impact-from-halt-of-italian-oil-field.

73 Despite ENI's statement that the Sannazzaro refinery is their top-rated refinery, this analysis prefers Taranto's upstream integration over Sannazzaro's chemical integration. According to this analysis, the Milan-Genoa-Turin market that Sannazzaro supplies is not characterised as captive but has a potential of being supplied by refined product imports via the ports of Genoa and Venice.

74 The Vienna Basin in Austria was producing less than 20 Kt/a of crude oil in 2012 (down from 44 t/a in 1998). Only the Lower Austrian field production is directly connected to the Schwechat refinery. See, for example, RAG (2012) "75 Years of Successful Energy Production (Zisterhof)".

downplaying the upstream integration advantage in the long term.[75] Direct integration with offshore oil fields is regarded as less strategic since the producer is not bound to the local refinery but can arbitrate to the world market.[76]

With the emergence of stringent sulphur regulations, coking units have emerged throughout Europe to upgrade bottom-of-the-barrel residues. However, the variety in coking capacity and availability of excess heavy fuel oil in the European market shows a lopsided distribution. Beyond NWE, most coking units lack the capacity advantage of their NWE peers with the Cartagena refinery as a notable exception.[77] Bottom-of-the-barrel-residue stocks can be expected to grow in the Mediterranean basin – especially with new IMO regulations in place – increasing the need for alternative outlets for HFO in the region. Nevertheless, given the scenario criteria, there is only one resilient to competition surplus coking refinery in the wider EU-28.

75 Similarly, direct connections to offshore oil fields have been disregarded as alternative marketing options do exist. For example, the Fredericia refinery (until recently owned by Shell) in Denmark is directly connected to the North Sea offshore oil production via the DONG oil pipeline. However, once onshore, the crude can be marketed on the global market denying the Fredericia refinery a competitive advantage. See, for example, Danish Energy Agency (2014) 'Oil and Gas Production in Denmark' or; IEA (2014) 'Energy Supply Security 2014 – Denmark' or; http://www.shell.dk/aboutshell/our-business-tpkg/refinery/about-the-refinery.html.

76 Examples include the Mongstad integration with the Troll/John Sverdrup fields, BP Rotterdam with the North Sea fields, and/or Fredericia refinery with GORM-field.

77 The Cartagena (Repsol) refinery commissioned a new coking unit (60 Kb/d) in a large €3.15 billion upgrade programme; http://www.ogj.com/articles/2012/04/repsol-opens-cartagena-refinery-expansion.html.

4 COMPETITION CONSTRAINING FACTORS – EXPOSURE DOES NOT MEAN CLOSURE

Solely focussing on strategic aspects and specific integration of refineries, the previous scenario revealed a concentration of strong points in EU refining (i.e. along the "Rhine-Danube-Line") that are likely to remain competitive in the long run. The majority of refining capacity outside of this area – although highly exposed to product import competition – is likely to remain operational in the medium term.[78] The main reason is that additional 'competition constraining' factors, which are not directly affecting the long-term economic competitiveness of a refinery (and were thus left out of the earlier analysis), play a substantial role in the long-term operational European refining capacity.[79] Indicative is the fact that overcapacity in the European downstream sector has not necessarily led to massive rationalisation of refining capacity, although some closures have been seen over the last decade.[80]

The refining sector is, unlike other industries, subject to compelling barriers to exit, not in the least fuelled by significant clean-up costs induced by potential soil and/or groundwater contamination associated with the refining process in the past. No clear estimates exist on the cost for decontaminating a closing refining site, but the low number of completely closed refineries in the European market are a strong bellwether for the extent of the (financial) burden. It appears that converting a refinery (into a storage terminal, bio-refinery, specialty refinery, or even a mothballed site) is the preferred path for at-risk refiners since this offers the possibility to delay or mitigate future clean-up costs.[81]

Besides environmental concerns, (local) governments will also take an interest in the social, economic, and strategic impact of a potential reduction in (local) refining capacity. Factors under consideration in this analysis include: economic footprint,

78 Refining capacity in the EU that shows higher exposure to competition will likely experience stronger economic headwinds in the long-run. Considering the recent waves of capacity destruction in EU refining, a lack of investments will increasingly deteriorate the most at-risk capacity, and hence some closures cannot be ruled out.

79 This study builds on the CIEP analysis of the refining sector in Northwest Europe which used a so-called 'must-run' and 'closure-constrained' model. Although the must-run model is replicated here, the closure-constrained model provided too narrow of a view as alternative forces are present in the rest of the EU refining sector. Therefore, to incorporate these additional forces, without compromising with the NWE analysis, this report enhances the closure-constrained model by incorporating additional competition constraining factors.

80 Petrosyan, K. (2016) "Recent Developments in European Refining – IEA".

81 For more information on cost estimates for decommissioning a refining site and the different types of refinery conversions, see Bergh, Nivard & Kreijkes (2016) "Long-term Prospects for Northwest European Refining".

security of supply, secondary integration, government ownership, and regulatory enforcement. The level and type of involvement differs per Member State, timeframe, available set of instruments, and prevailing political preferences. Historic analysis of the sector proves that, indeed, there are several precedents for governmental involvement on the grounds of protecting public interests. Owners of struggling refineries will hence have to address public concerns, raising closure costs.

4.1 COMPETITION CONSTRAINING FACTORS – GOVERNMENT DRIVEN

The interplay between industry and (local) government in the case of an at-risk refinery reveals an interesting paradox in which strategic public interests may not necessarily coincide with strategic private company interests (see Figure 4.1). However, challenging market realities may prevent industry from contributing to necessary investments. In this 'shareholder vs. stakeholder' debate, the public function of a refinery may entail (local) governments to influence a decision concerning an at-risk refinery.

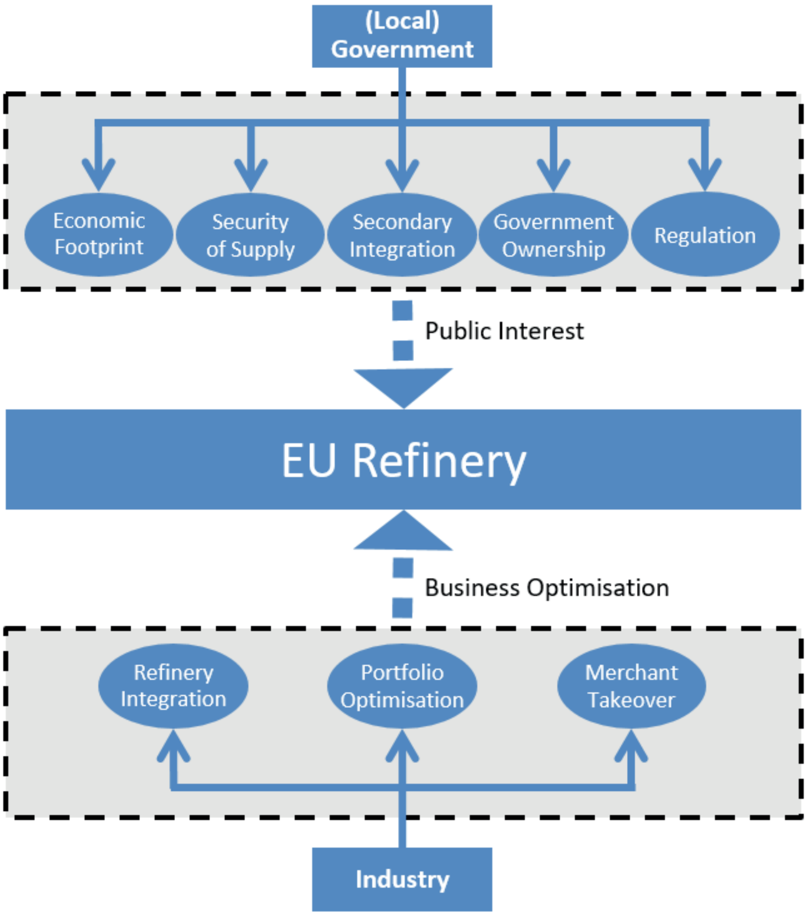


FIGURE 4.1: FORCES ON AN EU REFINERY

Governments seem to be the recurring theme in preventing a market exit in the current European refining industry as they have an incentive to protect the economic footprint, security of supply, and environmental obligations of a refinery. To ensure these are properly addressed, (local) governments can create and uphold barriers-to-exit (i.e. takeover approvals, environmental legislation, lease-of-life and/or regulatory enforcement) as a tool to influence the downstream sector of the European Union and ensure continued operational refining capacity. In short, due to legacy ownership governmental participation can still be witnessed today.

Consequently, the industry is likely to cherry-pick within the refining sector, especially there where (local) governments may influence continued refinery operation, hence co-shaping the medium-term refining sector outlook via merchant takeovers, portfolio optimisations and refinery integrations. Nevertheless, there may arise a conflict of interest among industry and government, insofar as asymmetric government influence in national refining markets risks disrupting market forces as the government becomes an indirect market player.

The driving factors that extend the lifetime of a refinery are more ambiguous compared to the previous scenario, which had an economic focus. Addressing differences of regulatory enforcement throughout the EU or describing the effects of security of supply issues regarding individual refineries may prove too subjective an exercise. Therefore, by providing cases from the European refining sector this section discusses some of the most prominent competition constraining factors that are likely to extend the European refining sector's lease-of-life. Hereby, it is important to note that not every refinery exhibits similar sensitivity to each constraining factor, and having multiple constraining factors does not mean that there is no risk of closure.[82]

- The **economic footprint** of a refinery to its local economy is mainly rooted in employment, investments and regional GDP creation. Although labour intensity of the refining sector compared to other manufacturing sectors is relatively low, the indirect labour effect can be significant (i.e. employment of (sub-)contractors, derivative industries, etc.)[83,84] Additionally, the presence of a refinery may likely

82 An example is the Greek refining sector that has multiple refineries that exhibit sensitivity to several competition constraining factors. Despite the push of IMF/EU/ECB for the Greek government to divest in their refining assets, no buyer has been found. See, for example: http://af.reuters.com/article/energyOilNews/idAFA8N0UD01420150128, and http://en.people.cn/90778/8042463.html.

83 According to the EU Petroleum Refining Fitness Check (2015), 119,000 direct jobs are associated with the refining sector in the EU. Nevertheless, the indirect job creation is substantially higher although difficult to assess. Estimations range from 8-11 times the number of direct jobs. In addition the sector accounts for over 0.9% of European GDP.

84 See, for example, European Competitiveness Report 2013; or EU Petroleum Refining Fitness Check (2015), P.65. or; http://www.rasmussen.edu/student-life/blogs/main/education-and-employment-a-comparison-by-industry/.

stimulate economic activity via its integration in local value chains, leading to negative externalities when eliminating the refinery for the overall competitiveness of the connected cluster. Lastly, the national trade-balance may deteriorate as domestic refining output is substituted by imports, causing substantial capital outflow.

Regional labour market characteristics vary across the European Union with an unemployment differential of 29% and long-term unemployment reaching up to 21%.[85] Combining these statistics with employment figures of a refinery indicates the different regional outlooks for re-employment of refinery workers. Although the share in the regional Greek labour market is relatively modest, the Helpe refineries in Athens (approx. 1200 employees) prove a case in point.[86] As regional unemployment (25%) and long-term unemployment (19%) are among the highest in the EU, this increases the likelihood of employment destruction in the case of a refinery closure. Comparing this to the Gothenburg cluster in western Sweden (i.e. unemployment 6.6% and long-term unemployment 1.2%) it reveals that the Greek labour market is more rigid compared to Sweden. Hence, it is likely that potential layoffs in such labour markets will have a stronger constraining effect in Greece, southern Italy, and in southern Spain.[87] Strong employment legislation in France boosted the effort of French union workers in protesting against intended refinery closures. Organised strikes in multiple French refineries ultimately led to a deal brokered between the French government and Total, ensuring the continued operation of five out of six refineries.[88]

- **Security of supply** is crucial for Europe's transport sector as it is likely to remain highly dependent on fossil fuels in the short to medium term due to the absence of credible and economic alternatives.[89] If the share of refined product imports is increased, this leaves the European economy exposed to foreign supply disruptions, re-questioning the value of the optionality of domestic refining capacity. Simultaneously, in a lower demand forecast, sinking below the 'self-sufficiency-ratio' can make economic sense because economies of scale are foregone, transferring the benefits to traders. The value that Member States

85 Eurostat data (2015) reveals unemployment highs of 31% in Andalusia (Spain) and lows of 2.5% in Niederbayern (Germany). Long-term unemployment is an indicator of labour market inflexibility with western Greece showing the highest levels: 21.7%.

86 See, for example, Elstat data (2015) or, Eurostat data (2015) or, IOBE (2014) 'The Refining Sector in Greece: Contribution to the Economy and Prospects'.

87 Spanish regions Murcia and Andalusia exhibit unemployment levels of 25-32% and long-term unemployment of 12-15%.

88 See for example, http://www.argusmedia.com/pages/NewsBody.aspx?id=726655&menu=yes or; www.nytimes.com/2010/02/23/business/global/23oil.html or; http://www.ft.com/cms/s/0/fe7ec610-2276-11df-a93d-00144feab49a.html?ft_site=falcon&desktop=true#axzz4for2c8qh.

89 IEA (2016) 'World Energy Outlook'.

attribute to their domestic refining sector will differ but it is likely to hinge on the share of petroleum in the energy supply mix, future demand predictions, the availability (and stability) of alternative suppliers, and dependency of strategic sectors. Additionally, the supply integration of a refinery with strategic sectors (e.g. military, hospital, airport) of a country will likely prove to be a constraining factor as well.[90]

In general, foreign takeover proposals of strategic industries have historically triggered national governments to design specific legislative firewalls aimed at preventing the loss of control over crucial assets. The Irish government, for example, obliged Phillips66 to keep the Whitegate refinery operational until mid-2016 despite the company's intention of selling the facility.[91] Finally, Irving Oil received approval to buy the refinery as they were able to ensure continued operation of the facility, citing the Irish government to claim a win for Irish long-term energy security.[92] In that sense, the recent friction during the buy-in of Chinese CEFC in Romania's Navodari (Petromidia) refinery, although driven by overdue debt payments, may also have involved some strategic considerations.[93] Countries with only one operational refinery may have stronger security of supply concerns especially if the diversity of imports is constrained due to lack of infrastructure.[94] For example, direct access to the global market makes Irish security of supply issues likely to be less pressing when compared to inland regions like Slovakia or Hungary.[95] Similarly, diversity of suppliers and (geo) political relations with those suppliers are likely to play a role as they can steer future supply stability.[96]

90 Backup fuel systems are mainly fuel-based and the European military has prioritised its energy security liability. See, for example, CRO Forum (2011) 'Power Blackout Risks – Risk Management Options' and; The Quaker Council for European Affairs (2010) 'Military Responses to Energy Security Problems'.

91 Phillips66 had an obligation to keep the Whitegate refinery operational despite intention to sell or convert the site, but as part of the deal was provided with a $200 million cash injection. See, for example, http://www.irishexaminer.com/business/whitegate-refinery-firm-gets-180m-injection-348825.html.

92 See, for example, http://irvingoil.com/newsroom/news_releases/irving_oil_welcomes_whitegate_to_the_team/ or; http://www.dccae.ie/news-and-media/en-ie/Pages/PressRelease/Sale%20of%20Whitegate%20Oil%20refinery%20by%20Phillips66%20to%20Irving%20Oil.aspx.

93 See http://www.ogj.com/articles/2016/12/chinese-firm-kazakhstan-form-jv-for-romanian-refining-assets.html.

94 EU Member States like Austria, Bulgaria, Hungary, Ireland, Lithuania, and Slovakia that have only one operational refinery are likely to have larger security of supply issues as substitution means imports. If they lack unrestricted access to global markets (e.g. Austria, Hungary, Slovakia) the strategic value of their refineries increases significantly.

95 Irish ports (e.g. Dublin, Whitegate, Cork, etc.) already handle 70-80% of refined product imports. Despite its access to the world market the Irish government has actively meddled in the sale of the Whitegate refinery with the intention of securing domestic refining capacity. See, for example, http://www.dccae.gov.ie/news-and-media/en-ie/Pages/PressRelease/Sale%20of%20Whitegate%20Oil%20refinery%20by%20Phillips66%20to%20Irving%20Oil.aspx or, http://www.ipia.ie/statistics/volumes-2014-2015/.

96 Even though Lithuania theoretically has a well-diversified supply mix (i.e. domestic Mazeikiai refinery, global market access via Butinge oil terminal, and Russian supplies) recent geopolitical tensions have put new weight on domestic refining optionality.

- **Secondary integration** of a refinery like on-site production of heat, electricity, and/or biofuels creates a foothold in the supply of other energy sources.[97] Even the production and capture of CO_2 associated with the refining process shows potential of becoming part of a valuable feedstock supply chain for industry and agriculture. These forms of secondary integration can act as a constraining factor if there is no readily available substitute and hence both refinery and consumer are locked-in.[98] Given the energy/carbon efficiency potential, secondary integration may prove to be the starting point for refineries to remain a crucial element in the energy transition. Refineries with crucial integration in alternative strategic value could be assessed by local governments on a wider basis than mere economics.

  Since 1972, the Swedish city of Gothenburg has installed a district heating network where it taps the excess heat from the two refineries (amongst other suppliers) to warm the local residential sector.[99] In the Danish industrial clusters of Fredericia and Kalundborg, a network of local industries and households benefit from the exchange of excess heat and waste water.[100] Electricity production on Sardinia by the Saras refinery and on Sicily by the Impianti refinery is yet another form of secondary integration. In both cases an IGCC plant, supplied with the refinery's syngas or heavy residues, produces electricity for its internal refining process but is also an important supplier of electricity for the local residential markets in Sardinia and Sicily.[101] Integration of the Pernis refinery

97 Instead of being wasted, generated 'excess' heat can be captured and distributed to the local residential and/or industrial sector, providing a cheap and secure source of heat. Similarly, refining production residues can be treated and used to fuel (on-site) power stations, generating electricity for self-consumption, and the local grid. Lastly, onsite biofuel production that uses waste materials as feedstock, can be used to blend with fossil fuels and sold as biodiesel.

98 For example, consider a refinery that produces on-site electricity as a by-product of its refining operations and hence supplies the local community. In this case it is both a lock-in for the community (as they will have trouble finding a substitute supplier) and for the refinery (as they might be forced to supply electricity unable to exit the market). Hence, a mutual dependency between supplier and consumer emerges.

99 In 1972, the local waste incinerator was coupled to the district heat network. In 1980 the (then Shell) refinery was coupled to the network, later joined by the Preem refinery in 1997. Today, the Gothenburg district heating network has a capacity of 3,500-5,000 GWh/a, of which 81% is generated by waste heat, approximately a third is supplied by the two refineries. See Göteborg Energi (2015) 'Gothenburg Energy: Waste Heat from Refinery' Celsius Smart Cities.

100 Multiple cities surrounding Fredericia share excess industrial heat including from the Fredericia refinery. The Symbiosis project in Kalundborg started with the wastewater and excess gas exchange originating from the Statoil refinery. See for example, TVIS (2014) "A Multicity District Heating Wholesaler", or http://www.symbiosis.dk/en.

101 With an installed capacity of 575 MW the Sarroch refinery accounts for 30% of the Sardinian electricity supply. Installed capacity of 540 MW at the Priolo power station that is integrated with the ISAB refinery makes up for significant share of electricity supply of Sicily. Both are an important factor in the regional energy security. See, for example, Saras (2016) 'Consolidated Financial Statement of Saras Group for the 2015 Fiscal Year' or; http://www.saras.it/saras/pages/inthefield/assets/powergeneration or; ISPI (2015) 'An Oversized Electricity System for Italy' or; Terna database http://www.terna.it/it-it/sistemaelettrico/dispacciamento/datiesercizio/rapportomensile.aspx or; http://rds.erg.it/en/2011/group-profile/erg-group/il-gruppo-erg.html or; http://www.erg.eu/en/our-energy/natural-gas/our-plant.

in Rotterdam with greenhouses in the region proves another form of secondary integration, as it allows for the monetisation of captured pure CO_2 that is delivered to the local agriculture sector.[102] In addition, the combination of Neste's fossil fuel and advanced bio-fuel production facilities at their Porvoo site provides Neste with a foothold in both fuel supply streams.[103,104] All these types of integration (or lock-ins) may lead to supply disruptions imperilling dependent sectors in a case of the market exit of a refinery.

- **Government Ownership** Despite a continued privatisation effort in the (western) European refining sector, governments of some Member States remain shareholders in their domestic refineries. Outside NWE, a total of 23 refineries have a European government as shareholder, although some refineries are located outside the corresponding shareholder's jurisdiction.[105] Nevertheless, this is largely an eastern European phenomenon as (most) western European governments do not own any significant shares in their refining capacity. The traditional strong position of IOCs in the west European refining sector combined with the liberalisation in the 1990s of the sector in Spain, France and Italy explain the different relationship with the government as stakeholder. A less diversified and politically more sensitive supply base combined with more recent liberalisation efforts are probably the main reasons for the tighter grip of eastern European States on their domestic refineries. In fact, recently the Hungarian State even increased government ownership, with the acquisition of 25.2% of the MOL Group in 2011 and the Croatian government intention to increase its share in the INA refineries.[106]

102 The OCAP pipeline system, formerly used for transporting crude, is delivering pure 300kton pure CO2 to the greenhouses since 2005. See, for example: http://www.vshanab.nl/nl/projecten/detail/ocap-co2-vocap-co2-van-shell-naar-tuindersan-shell-naar-tuinders.

103 See, for example, https://www.neste.com/na/en/customers/products/renewable-products/neste-renewable-diesel or; http://www.hydrocarbons-technology.com/projects/fortum/ or; https://www.aiche.org/chenected/2016/01/finlands-neste-worlds-first-21st-century-oil-company.

104 See, Neste (2016) 'Neste Renewable Diesel Handbook' or; Aatola, H. et al (2008) 'Hydrotreated Vegetable Oil (HVO) as a Renewable Diesel Fuel'.

105 As an example, the Polish government holds a stake in the PKN Orlen corporation which not only operates a refinery in Poland (Plock) but also in Lithuania and the Czech Republic. See http://www.orlen.pl/EN/Company/ORLENInEurope/Pages/default.aspx.

106 Triggered by the Russian foothold in the Hungarian downstream sector via Surgutneftgaz's 21.2% stake in the MOL Group, acquired from OMV, led the Hungarian government to secure the stake and ensure its long-term energy security. The Croatian government has expressed intention to buy-back MOL's stake in INA, charging the Russian bid was subject to fraud. See https://www.wsj.com/articles/SB10001424052702303654804576343530886058382 or http://www.reuters.com/article/croatia-ina-mol-idUSL5N1FM5O7.

At first glance, a stake of a national government in a refinery signals a stable long-term outlook as the refinery is likely to have robust political backing. For example, the Polish government is a major shareholder in its domestic refining sector (53.2% in Lotos and 27.5% in PKN Orlen).[107] Within the EU, Poland is one of the most ardent defenders of fossil fuels which suggests continued support for its domestic refineries. Also, its recurring effort to merge both oil companies into a national champion, that supposedly is more likely to withstand a hostile (foreign) takeover, indicates ongoing support of the Polish government.[108] Closer inspection reveals that practicalities are likely to play a role too. The location of government shares, specific statutory power, and prevalent public opinion are all important facets.[109] With each election governments are prone to shifting political ideologies that refocus emphasis (and capital) towards different policy areas. Hence, the Naantali and Porvoo refineries, despite being majority-owned by the Finnish state, are not necessarily a beacon of unquestioned political support. Squeezed by public opinion, the Finnish government has increasingly vowed support for renewable fuels in the energy mix, urging the Neste refineries to adopt bio-refining capacity.[110]

- **Regulation** within the EU regarding the production of refined oil products is getting increasingly stringent in order to mitigate the environmental impact from the production process and product emissions. Increasing concerns over (local) soil-, water-, and air-pollution have thus given rise to several European regulations (e.g. ETS, IED, etc.) affecting the European refining sector. Complying with these directives naturally translates into additional costs, raising the average cost base for Europe's refineries vis-à-vis other regions. However, publicly available data reveals that asymmetric emission profiles still exist among refineries in the European Union, potentially indicating a trade-off between emission mitigating

107 See, for example, http://inwestor.lotos.pl/en/965/lotos_group/shareholder_structure or; http://www.orlen.pl/EN/InvestorRelations/ShareholderServicesTools/ShareholdersStructure/Pages/default.aspx.

108 See https://www.bloomberg.com/news/articles/2016-01-11/poland-mulls-oil-and-gas-merger-push-to-avoid-hostile-takeovers.

109 Throughout Europe, government shares in refineries are known to be held by several ministerial departments, welfare funds, or investment funds. Also, some governments have claimed specific veto-powers or right of first refusal. See, for example, https://www.neste.com/fi/en/state-finland-proposing-amendments-its-ownership-policy-holding-shares-neste-could-decrease or; http://www.parpublica.pt/index.php/home/emp/carteira-de-participacoes or; http://molincroatia.com/mols-investment-in-ina/croatian-governments-rights-over-ina.

110 By 2030 the share of biofuels in transport fuel must reach 30% according to newly adopted Finnish legislation. This stimulates the adoption of bio-refining capacity in the country and Neste Oil has started production of biofuels. See, http://www.reuters.com/article/finland-energy-biofuels-idUSL8N1DP2F8.

investments and surrendering to higher compliance costs.[111,112] Moreover, environmental legislation covers the European Union as a whole, while its enforcement remains within the national jurisdiction. Hence, disparities within the regulatory enforcement could potentially translate into varying levels of compliance costs within the EU as the minimum harmonisation principle allows for more stringent translation (and hence enforcement) of EU directives and regulation.[113]

Although enforcement of regulation is crucial, a critical analysis is difficult due to its subjective nature and lack of (public) documentation. Nevertheless, comparative studies on the rule of law and transparency can be an indication for differences in national regulatory enforcement, despite a shared framework among EU Member States.[114,115] Given these secondary sources, it is likely that although there is a single European regulatory framework, the level of enforcement differs across Europe. The combination of uniform legislation with local enforcement, harbours the threat of creating an asymmetric regulatory burden within the European refining sector. The undesired effect is that more polluting refiners in the EU might continue to operate due to lenient enforcement, which seems contrary to the spirit of stricter environmental legislation on an EU level.[116]

111 Total emissions for European industry can be found in in the European Union Transaction Log in which industries submit their yearly emissions on a company-level. For some refineries, the allowances in allocation show a diverging pattern with the actual verified emissions, forcing them to buy extra allowances to comply with their obligation. See http://ec.europa.eu/environment/ets/napMgt.do?languageCode=en.

112 Emissions can vary due to energy efficiency measures, types of crude intake, the refinery's conversion complexity.

113 In order to speed up the adoption of EU law into national law, the minimum harmonisation principle allows some lenience in national interpretation. However, there are recent efforts to increase so-called maximum harmonisation principles being adopted in EU laws and directives.

114 See, for example, World Justice Project (2016) 'Rule of Law Index 2016: Regulatory Enforcement' or, Transparency International (2015) 'Corruption Perceptions Index 2015'. Accordingly, the Netherlands is second to only Norway when measuring for regulatory enforcement, whereas Croatia occupies a 61st place. In the global corruption index, Denmark (first) is the best ranked European Member State while Bulgaria (69th) scores significantly lower.

115 For example, contamination in some industrial regions of Sicily is so extreme that, for example, pollution levels of 1,2-dichloroethane exceed all the national and international legislated limits. This is a major concern for health effects (e.g. diseases and birth defects) in the region, accordingly the study states that decontamination of groundwater resources in the areas investigated is urgently needed, in addition to existing actions. See: WHO (2014). "Human Health in Areas with Industrial Contamination".

116 As less polluting refineries might experience higher regulatory costs than the more polluting competitors with less strict enforcement of regulation, there is a risk that the 'wrong' refineries are penalized.

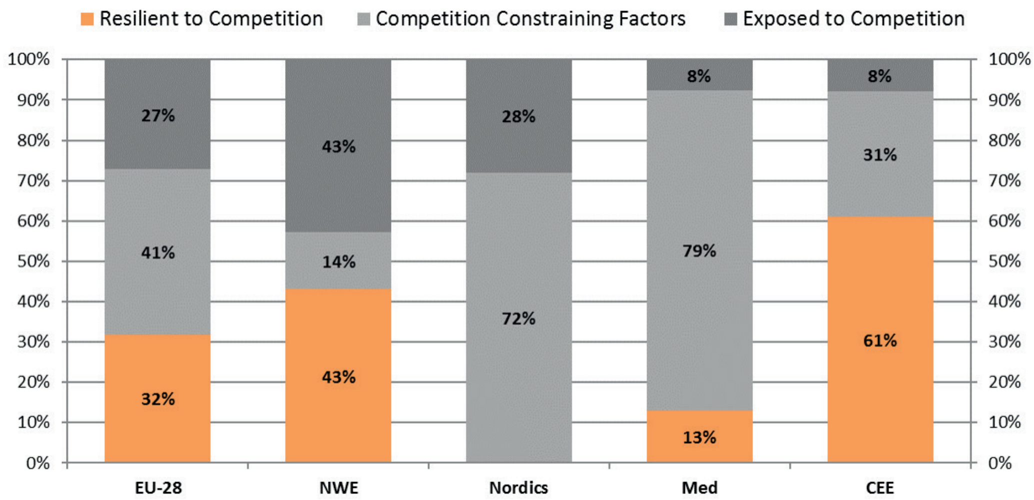


FIGURE 4.2: RESILIENT TO COMPETITION AND CONSTRAINED REFINING CAPACITY SHARE PER REGION[117]

Considering all competition constraining factors – and the role governments play – it becomes clear that among the group of refineries in the European Union that are expected to be exposed to competition, there is a lot of uncertainty concerning their barriers-to-exit (see Figure 4.2). In fact, some refineries have a higher sensitivity to specific constraining factors due to internal refinery characteristics or due to external particularities of their region/nation. This results in an asymmetric exposure of the European refining sector to competition constraining factors: secondary Integration (predominantly Scandinavia), economic footprint (predominantly Southern Europe), regulatory framework (predominantly South/East Europe), security of supply (scattered) see Figure 4.3 below.

117 Note that some refineries have multiple competition constraining factors. Furthermore, some refineries might be more 'constrained' than others. Even some Resilient to Competition refineries sometimes have competition constraining factors.

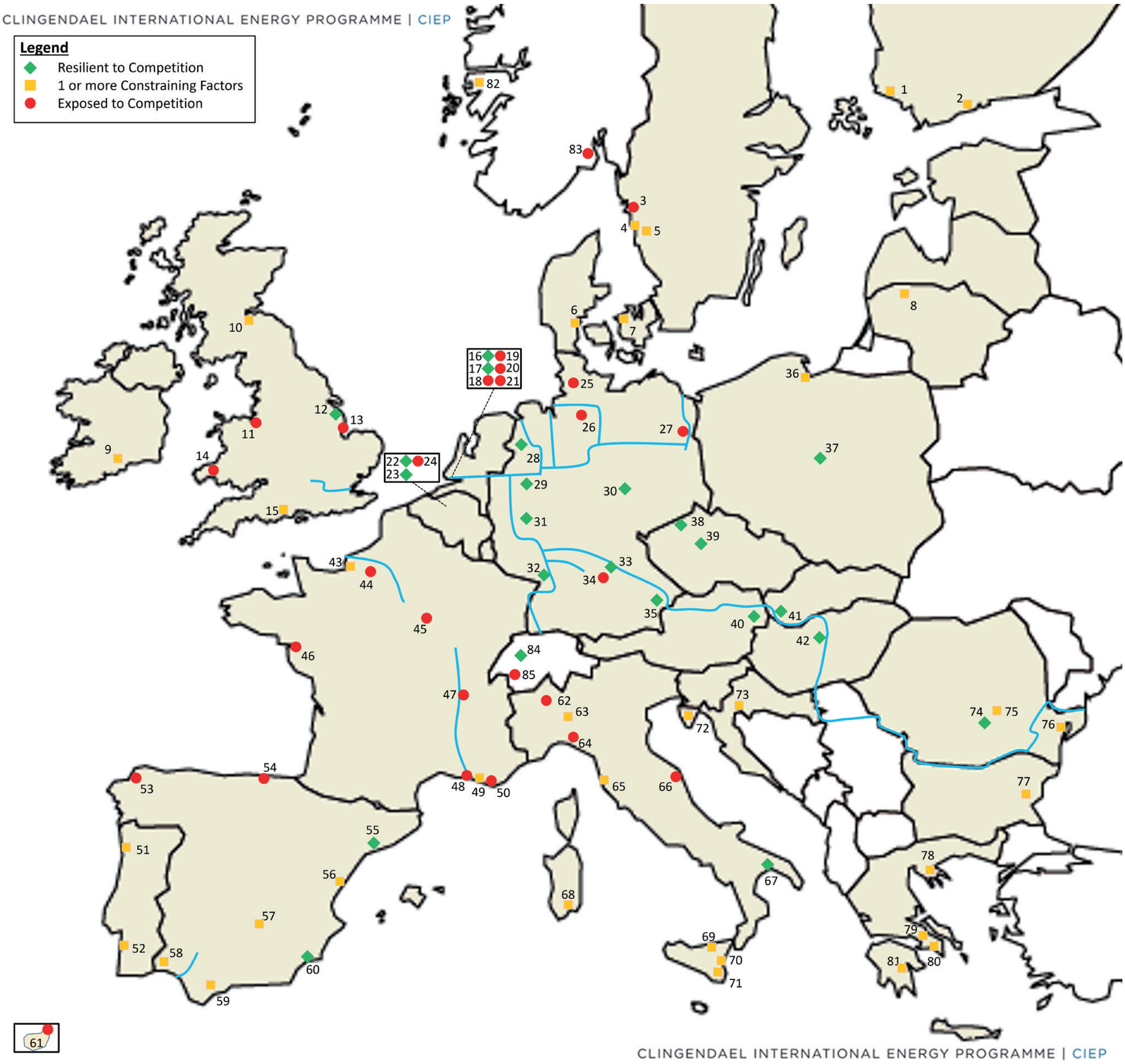


FIGURE 4.3: MAP OF RESILIENT TO COMPETITION REFINING CAPACITY AND REFINERIES THAT ARE SUBJECT TO CONSTRAINING FACTOR(S)

4.2 MARKET RESPONSE – INDUSTRY DRIVEN

The complex nature of an integrated oil value chain in general, and a refining operation in particular, leads to a multitude of business approaches.[118] The traditional integrated 'market-refining' approach – importing crude oil and refining it close to the demand centres – has become less dominant with the rise of producing countries as refiners. Over the last decade, a shift can be witnessed as specific market players are gaining a foothold in the refining market rejecting a fully integrated approach but rather focussing on separate segments in the value chain. With the waning of IOCs, the mix of owners in the EU refining market becomes more diverse, also including trading houses, NOCs, and (local) governments.

Refineries that are exposed to competition may therefore still harbour alternative economic opportunities triggering new business models to remain in the refining market. In general, three types of business restructuring that preserve overall refining capacity can be witnessed: 1) refinery integration, 2) portfolio optimisation, or 3) merchant takeover (see Figure 4.1). Hence, one company's exposed refinery could be the business opportunity of another, extending the lifetime of a refinery.

Continued refinery investments in order to remain competitive on the global market is an important measure for the medium-term outlook of the refining landscape (see Chapter 3). One of these investments includes refinery integration where two struggling refineries (located close together and sharing the same owner) could integrate into one 'mega'-refinery where the whole is greater than the sum of its parts. Refinery integrations have occurred in the European refining sector in the past decade, optimising the configuration and increasing efficiency gains of the 'mega'-refinery. ExxonMobil's Port Jerome & Gravenchon refineries, Bayernoil's Vohburg & Neustadt refineries, HELPE's Aspropyrgos & Elefsina refineries, and Shell's Godorf & Wesseling refineries are some examples of integration projects of the last decade. Plans to integrate the Finnish Porvoo and Naantali refineries operated by Neste are in the making.[119]

Focussing on just the refinery could prove too narrow an analysis as a refinery usually is part of a wider asset portfolio, integrated in the vertical value chain of an oil company, acting as an essential link to maximise profits for the entire corporation. For example, a refinery may serve as a secure outlet for crude oil production, as the refinery can

118 Apart from the traditional IOC/NOC operating a refinery within its integrated oil value chain, in recent decades there has been an emergence of independent or merchant refineries that operate on a more lenient basis aiming to reap the benefits of trading. Petroleum Intelligence Weekly (2016) 'US Refining's Merchant Model Yet to Go Global' June 27.

119 See, for example, Bayernoil (2014) 'A Refinery for Bavaria' or; Shell 'Geschichte der Shell Rheinland Raffinerie' or; http://www.ogj.com/articles/2015/08/neste-advances-integration-of-finnish-refineries.html.

maximise efficiency gains by optimising its configuration towards processing that specific type of crude.[120] It is not unlikely that integrated companies, like Lukoil and Statoil, will continue investing in their refineries in Bulgaria, Italy, the Netherlands, and Denmark as it could strengthen their wider asset portfolio.[121] Conversely, divestments in the refining sector can also be regarded as portfolio optimisation as it may refocus on those assets that are deemed most valuable within a company portfolio. In that respect, the recent IOC divestments (both wholly-owned and from JVs) in European refining prove a case in point as Shell alone has offloaded 11 European refineries from their books with the sale of its Fredericia refinery as a latest example.[122] In a different context, expanding the traditional 'downstream portfolio' by including integration of alternative energy streams – aiming to boost energy/carbon efficiency – proves to be another portfolio optimisation in the long-run.

Traditional oil traders could benefit from investing in refining assets as integrating refinery operations within their existing trading portfolio increases flexibility and crude outlets, allowing the overall business to become more responsive to local supply and demand fluctuations. In general, these traders will look for nimble and flexible refineries to maximise responsiveness whilst preferring significant on-site storage capacity that acts as a natural hedge against market downturn, as the refinery could be converted into a storage location if necessary. A merchant refinery takeover will furthermore be directed at operating in either a trading hub or a specific market, both being compatible with the trader's existing trading operations. Exposed refineries located near a trading hub thus provide investment opportunities benefitting from arbitrage opportunities present in a cluster, enhancing its refinery profitability.[123] A merchant takeover of refineries with inland market access is characterised by refining assets benefitting from a sheltered inland market allowing the merchant to monetise on arbitrage opportunities stemming from low import potential. The recent entrance of Gunvor, VARO, Dansk Olieselskab, or CEFC in the European refining sector show appetite of the traditional traders in the European refining sector.[124]

120 For example, the Rosneft-owned Schwedt refinery is a strategic outlet for its Urals crude production, providing a rationale for continued support of refining activities at the Schwedt site.

121 For an overview of Lukoil and Statoil activities, see, for example, Lukoil (2015) 'Annual Report – Always Moving Forward' or; http://www.statoil.com/en/ouroperations/explorationprod/pages/default.aspx.

122 Over the years, Shell has sold (its stake in) the Rome, Berre l'Etang, Petit Couronne, Reichstett, Heide, Gothenburg, Stanlow, Harburg, Kralupy, Litvinov, and Fredericia refineries. http://www.shell.com/media/news-and-media-releases/2016/shell-signs-agreement-to-sell-denmark-refining-business.html.

123 Amenities of a cluster giving a refinery arbitrage opportunities could be a deep port, storage potential, residue outlets, etc. Take for example Lukoil's ISAB refinery that, despite its coastal location, benefits from large storage capacity and supreme port facilities (600DWT) that serve Lukoil's portfolio diversification.

124 For more information on merchant takeover considerations and examples for northwest Europe see Bergh, Nivard & Kreijkes (2016), 'Long-term Prospects for Northwest European Refining' CIEP.

Overall, a change in the market structure can be witnessed in the refining sector in the EU. Not only are IOCs retrenching along the Rhine-Danube-Line and directing investments to complex, integrated facilities, some also seem to integrate in a wider palette of energy streams. Simultaneously, governments are witnessed influencing the refining sector in order to serve national interests. Furthermore, excellent infrastructure, an increasing level of refined products imports, and tightening market conditions all make the case for the entrance of trading houses into the refining market, requiring stronger focus on storage facilities. It is likely that the future refining sector in the EU will be characterised by these three ownership types, where especially the latter group is expected to increase its market share.

5 CONCLUSION

Faced with a declining market and increasing competitive product imports from modern source-refineries, the European refining sector is likely to encounter stiff competition in the medium term. With all EU refineries being exposed to (international) competition, some have become part of the mores of international markets, while others have remained largely part of a local habitat. With the expected longer-term decline in demand for refined products in the EU and the increasing competition from low cost refining export centres in the medium term, asymmetric paths of survival are expected, potentially resulting in changing value-propositions across the segmented refining sector in the European Union.

Building on the previous *CIEP* analysis of the Northwest European refining sector, this study looks beyond short-term indicators but rather focusses on structural factors.[125] Specifically, the integration in external value chains proves to be a strong indicator whether a refinery is more resilient in a competitive landscape in the long-run. The share of refineries in the EU that are indeed likely to benefit from such integration (e.g. petrochemical integration or a sheltered inland market) is especially substantial along the "Rhine-Danube Line". Outside this core area of strong points, the EU refining sector in the Mediterranean, Scandinavia, and the Balkans is expected to have a higher exposure to competition of product imports due to the large share of stand-alone and coastal refineries and scattered demand centres. In other words, the lack of a captured market, low levels of integration, and available import facilities create a realistic case for product imports into parts of the refining market of the European Union, exposing local refineries to increasingly fierce competition.

Merely looking at the competitive characteristics of refineries is not enough for an in-depth medium-term outlook of the refining sector since it risks neglecting the political-strategic interests in a refinery from the state- or local level. A refinery's contribution to the (regional) economic footprint, (national) security of supply, and (local) environmental conditions seriously incentivises governments to constrain a market exit – especially in the case of the last remaining refinery. Hence, in the NWE study, a more holistic approach was taken which included the public role of refineries and the subsequent involvement of national governments in co-shaping the refining sector.

125 See, Bergh, Nivard & Kreijkes (2016) "Long-term Prospects for the Northwest European Refining Sector" CIEP.

Therefore, refineries that have a higher exposure to competition are not necessarily expected to close as significant barriers-to-exit – rooted in (geo)political and other economic interests – are present in the form of competition constraining factors. Expanding the scope of the previous analysis to the rest of the European Union, however, required additional factors to be included which hitherto did not play a (major) role in NWE. Such a qualitative analysis reveals various types of factors constraining refineries from exiting the EU market: (local) economic footprint, security of supply, government ownership, regulation, and secondary integration. Across the European Union multiple cases per factor can be identified providing an indication of the significance of a refinery to (local) governments although their inclination to act upon their interests remains to be seen.

The expansion of the refining research to the entire European Union (incl. Norway and Switzerland) has revealed a variety of paths taken by refineries towards the medium-term future. Some refineries are seen to continue to invest hence aiming to stay ahead of the competitive curve and thus becoming more resilient to international competition. Others, however, will bet on their presence in sheltered markets, reducing their exposure to competition while dismissing their need to invest heavily in (environmental) upgrades. A third pathway includes refineries that are likely to highlight the public significance of their (continued) refining capacity hence appealing to governmental influence aimed at protecting the public interest. Although it is difficult to derive a general rule on the role of governments – as case-specific features combined with dissimilar (national) government intentions will lead to different outcomes – it remains a key part in assessing the medium-term prospects for EU refining.

The asymmetric development of a fragmented European refining market creates different incentives for EU refineries to adapt. Currently, a singular approach is lacking as some national governments have become market players in the European refining sector in their effort to protect national interests. The weight of refineries as a strategic asset depends on which Member State is involved, reflecting their strategic, economic, and environmental valuation. How some governments and companies will include EU environment policies into their efforts to maintain the local refining capacity operational becomes an increasingly crucial issue. Dissimilar approaches within the European Union in order to protect national interests hampers a market-based solution (i.e. industry players are directly competing with governments) thus resulting in regional solutions which leads to a segmented European refining market. This study may serve as a starting point for a wider discussion on future developments in the refining sector of the European Union.

Despite the energy transition and projected lower petroleum demand in the EU, refineries will occupy a key position in the EU's future energy mix for years to come.[126] Hence, strategic concerns over increasing import dependency on refined products remain valid if the EU is becoming strategically too import dependent. Nevertheless, it is also likely that the traditional value proposition of EU refineries may be subject to change when markets and government climate and energy policies evolve in the future. The energy transition will likely create future business opportunities for which refineries have a preferred position as an innovative hub for multiple energy streams and expertise in the conversion of molecules. Examples of EU refinery integration in heat networks and electricity supply chains indicate a diversification from hydrocarbon refining towards integration in (multiple) alternative energy value chains – potentially including biofuels, hydrogen, electricity, heat, and/or CO_2 in addition to their core business.[127] This transition will be pursued at different speeds depending on local potential, public opinion, and economic realities and opportunities.

126 For more details on the outlook for Europe's energy mix, see: IEA (2016) World Energy Outlook.

127 See section 4.1 for more details on secondary business models currently present in the EU refining sector.

ANNEX A – INDIVIDUAL REFINERY COMMENTS

Refinery	N°	CDU Capacity	Status	Comments
Naantali (Neste)	1	50 Kb/d	1 Competition Constraining Factor	A small coastal based Finnish refinery that is exposed to product imports. The Finnish government, however, owns 50% of Neste which might be a constraining factor.
Porvoo (Neste)	2	200 Kb/d	2 Competition Constraining Factors	The largest of the two Finnish refineries with excellent port (260k DWT) and storage facilities that is exposed to product imports. The Finnish government, however, owns 50% of Neste which might be a constraining factor, urging to take up bio-refinery activities. As a result Porvoo already has secondary integration to other value chains producing multiple high-quality bio-fuels streams.
Lysekil (Preem)	3	210 Kb/d	Exposed to Competition	Sweden's largest refinery, coastal based with excellent port (500k DWT) and storage facilities that, despite its complexity and capability of producing sulphur-free fuels (Mk1), is exposed to product imports.
Gothenburg (St1)	4	69 Kb/d	1 Competition Constraining Factor	A small coastal refinery that is exposed to imports. Despite coastal exposure this refinery is constrained by its integration in a local heat-network in Gothenburg.
Gothenburg (Preem)	5	138 Kb/d	1 Competition Constraining Factor	A medium-sized coastal refinery that is exposed to imports. Despite coastal exposure this refinery is constrained by its integration in a local heat-network in Gothenburg.
Fredericia (Dansk Olieselskab)	6	70 Kb/d	1 Competition Constraining Factor	A small coastal refinery that is exposed to product imports, as its upstream integration has multiple outlets. This refinery is constrained by integration with a heat-network in the industrial and residential regions of Fredericia.
Kalundborg (Statoil)	7	110 Kb/d	1 Competition Constraining Factor	A small coastal refinery that, despite a direct product pipeline connection to Copenhagen, is exposed to product imports. This refinery is constrained by integration with a heat-network in the industrial and residential regions of Kalundborg.
Mažeikiai (PKN Orlen)	8	190 Kb/d	1 Competition Constraining Factor	A relatively large refinery that is exposed to product imports. Mažeikiai has a constraining factor as it is the country's only refinery and optionality of refining could prove important for domestic security of supply.
Whitegate (Irving Oil)	9	71 Kb/d	1 Competition Constraining Factor	A small coastal refinery that is exposed to product imports. Whitegate has a constraining factor as the Irish government marked this refinery as a strategic asset to the domestic security of supply.
Grangemouth (Petroineos)	10	210 Kb/d	2 Competition Constraining Factors	A relatively large coastal refinery with excellent port facilities (335k DWT) exposed to product imports. Used to be closely integrated with on-site naphtha steamcrackers, but since 2014 only gaseous feedstock configured steamcrackers are remaining on the Grangemouth site (with the aim to process imported ethane from the US). Constrained by security of supply issues as it is the last remaining refinery in Scotland, and by its economic footprint on account of its large employment base.
Stanlow (Essar)	11	296 Kb/d	Exposed to Competition	A large coastal refinery that in spite of some aromatics integration, is exposed to imports. Essar has also put the refinery up for sale.

Humber (Phillips 66)	12	233 Kb/d	Resilient to Competition	A large coastal refinery with surplus coking capacity. The gradual disappearance of HFO outlets and only two other refineries in NWE with surplus coking capacity to upgrade residual fuel oil streams makes this a strategic refinery configuration.
Lindsey (Total)	13	221 Kb/d	Exposed to Competition	A relatively large coastal refinery with a simple configuration that is exposed to imports. Total has decided to halve its refining capacity to 110 Kb/d by closing down one crude train.
Pembroke (Valero)	14	220 Kb/d	Exposed to Competition	A relatively large coastal refinery that in spite of some cracking capacity is exposed to imports.
Fawley (ExxonMobil)	15	274 Kb/d	1 Competition Constraining Factor	A coastal refinery that in spite of some petrochemicals integration is exposed to imports. It is worth noting that the chemical plant on the Fawley site already imports a significant portion of their feedstock requirements. Constrained as it is the UK's largest and one of its most advanced refineries serving the economically important greater London region and the Heathrow and Gatwick airports with direct pipeline connections, critical for security of supply.
Rotterdam (Shell)	16	425 Kb/d	Resilient to Competition + 1 Competition Constraining Factor	The refinery is petrochemicals integrated with the Moerdijk chemicals site, including a world scale steamcracker with significant feedstock flexibility. Steamcracker integration facilitates upgrading of refinery by-product streams (e.g. Hydrowax) and further processing of steamcracker backflows. The Moerdijk chemicals site is also an integral part of the competitive Antwerp-Rotterdam petrochemicals cluster. In addition this refinery has a constraining factor as it has two types of secondary integration; the exchange of heat with residential areas of Rotterdam and CO_2 delivery to greenhouses. Additionally the ARA-cluster provides significant trading opportunities.
Rotterdam (ExxonMobil)	17	201 Kb/d	Resilient to Competition	The refinery is petrochemicals integrated with ExxonMobil's world scale aromatics plant in Rotterdam Botlek, which is again an integral part of the competitive Antwerp-Rotterdam petrochemicals cluster. The refinery fulfils an especially important role as a source of sulphur-free naphtha and hydrogen for the aromatics plant. Excess refinery gas is, for example, used by the nearby Air Products plant to produce hydrogen, which is again supplied to the ExxonMobil aromatics plant. Additionally the ARA-cluster provides significant trading opportunities.
Rotterdam (BP)	18	377 Kb/d	Exposed to Competition	A large coastal refinery with a relatively simple configuration and limited downstream integration, which in spite of its size and considerable flexibility is exposed to imports. Nevertheless, the ARA-cluster provides significant trading opportunities.
Rotterdam (Gunvor)	19	88 Kb/d	Exposed to Competition	A small coastal refinery with a simple configuration that is exposed to imports. Nevertheless, the ARA-cluster provides significant trading opportunities.
Rotterdam (Vitol)	20	80 Kb/d	Exposed to Competition	A small coastal refinery with a simple configuration that is exposed to imports. Nevertheless, the ARA-cluster provides significant trading opportunities.
Vlissingen (Total/Lukoil)	21	149 Kb/d	Exposed to Competition	A medium-sized coastal refinery that in spite of its beneficial configuration (i.e., an outsized hydrocracker) and some downstream integration, is exposed to imports. Nevertheless, the ARA-cluster provides significant trading opportunities.
Antwerp (ExxonMobil)	22	323 Kb/d	Resilient to Competition	A large coastal refinery with surplus coking capacity. The gradual disappearance of HFO outlets and only two refineries in NWE with surplus coking capacity to upgrade residual fuel oil streams makes this a strategic refinery configuration. The refinery also benefits from access to excellent hydrogen supply from the Antwerp petrochemical cluster and is closely integrated with ExxonMobil's European solvents plant. Additionally the ARA-cluster provides significant trading opportunities.

Antwerp (Total)	23	350 Kb/d	Resilient to Competition	The refinery is closely petrochemicals integrated with Total's world scale steamcracker and aromatics production in Antwerp. The steamcracker has significant feedstock flexibility, and Total Antwerp's petrochemicals production is an integral part of the competitive Antwerp-Rotterdam petrochemicals cluster. Additionally the ARA-cluster provides significant trading opportunities.
Antwerp (Gunvor)	24	110 Kb/d	Exposed to Competition	Small coastal refinery, simple configuration that is exposed to imports. Nevertheless, the ARA-cluster provides significant trading opportunities.
Heide (Klesch)	25	91 Kb/d	Exposed to Competition	A small coastal refinery that in spite of some cracking capacity and petrochemicals integration is exposed to imports. Although significant crude supplies come from local Mittelplate field, upstream integration is limited as there are multiple outlets for the crude.
Holborn (Tamoil)	26	105 Kb/d	Exposed to Competition	A small coastal refinery with a simple configuration that is exposed to imports.
Schwedt (Rosneft/Shell/ Eni)	27	239 Kb/d	Exposed to Competition	A Rosneft-majority owned inland refinery that is connected to the Drushba pipeline system. Drushba crude has several alternative premium outlets and the Berlin demand region could potentially be supplied over the Oder inland waterway system or even via the upgraded Rostock-Berlin railway system.
Lingen (BP)	28	95 Kb/d	Resilient to Competition	The inland refinery is located in the midst of Germany's largest mainland oil fields and it has an upstream integration with a direct pipeline connection to the Dutch Schoonenbeek field. They supply around 1/3 of the refinery's crude requirements, and the refinery is connected to the NWO pipeline, for the remainder of its crude requirements. Its advanced configuration enables the processing of heavy local crude supply which provides additional benefits.
Gelsenkirchen (BP)	29	266 Kb/d	Resilient to Competition	The refinery is closely petrochemical integrated with world scale steamcracking capacity, and the site an integral part of the competitive Rhine-Ruhr petrochemicals cluster.
Leuna (Total)	30	227 Kb/d	Resilient to Competition	An inland refinery connected to the Drushba pipeline system. Drushba crude has several alternative premium outlets. The refinery is directly serving the Leipzig and southern Berlin regions (captive demand). The petrochemical feedstock pipeline has only limited capacity (~ 90 Kb/d) and there is a lack of inland waterways.
Rhineland (Shell)	31	344 Kb/d	Resilient to Competition	The large refinery is closely petrochemical integrated with world scale on-site steamcracking and aromatics capacity. The site is also an integral part of the competitive Rhine-Ruhr petrochemicals cluster.
Karlsruhe (MiRO: Shell/ ExxonMobil Rosneft/ Phillips 66)	32	322 Kb/d	Resilient to Competition + 1 Competition Constraining Factor	An inland refinery that is connected to the TAL and SPSE crude pipelines and serves a high (captive) demand region. The military CEPS offers only limited and interruptible capacity, and the upper Rhine often (40% of the days in 2013 and 2014) suffers from low water levels at the Rhine-Kaub bottleneck. In addition, the overlap between MiRO and SPSE ownership makes it likely that refined product transport through the SPSE pipeline will be restricted when the Feyzin refinery succumbs to competition from refined product import. In addition this refinery has a constraining factor due to secondary integration with surplus heat that is exchanged with the city of Karlsruhe.
Neustadt/ Vohburg (Bayernoil: Varo/ Rosneft/ ENI/BP)	33	218 Kb/d	Resilient to Competition	An inland refinery connected to the TAL crude pipeline and serving a high (captive) demand region, while the military purpose CEPS pipeline offers only limited and interruptible capacity. In addition it has some chemical integration as it supplies feedstock to the cracker at LyondellBasell’s Muenchsmuenster Site.

Ingolstadt (Gunvor)	34	110 Kb/d	Exposed to Competition	An inland refinery connected to the TAL crude pipeline and serving a high demand region, while the military purpose CEPS pipeline offers only limited and interruptible capacity. Nevertheless, the captive Bavarian market is likely to see a degree of excess refining capacity in the long run, in which case the Ingolstadt refinery is likely to be handicapped by its relative small-scale and simple configuration.
Burghausen (OMV)	35	78 Kb/d	Resilient to Competition	An inland refinery connected to the TAL crude pipeline directly serving the Munich region by an inland product pipeline, as well as the captive demand eastern Bavaria and western Austria regions. In addition this refinery has some onsite chemical integration.
Gdansk (LOTOS)	36	216 Kb/d	2 Competition Constraining Factors	This relatively large coastal refinery with its diverse crude supply, despite planned upgrades (Program 10+), lacks sufficient chemical integration and is located at a port (300k DWT) with excellent import facilities. This refinery has constraining factors as it is majority owned by the Polish government that marked this refinery as a strategic asset to the country's security of supply.
Płock (PKN Orlen)	37	355 Kb/d	Resilient to Competition + 1 Competition Constraining Factor	The large inland refinery has various crude sources with the (LOTOS owned) Pomeranian pipeline to the port of Gdansk and a crude connection with Drushba. Located in central Poland with product pipelines to Boronow, Rejowiec and Warsaw it serves a captive demand region. Combined with some chemical integration and government ownership this refinery has a constraining factor as well.
Litvínov (Ceska)	38	110 Kb/d	Resilient to Competition	A small inland refinery with some chemical integration which benefits from its diverse crude supply (Drushba and IKL). Continued crude supply combined with captive demand region will most likely prolong Litvínov's lifecycle.
Kralupy (Ceska)	39	65 Kb/d	Resilient to Competition	A smaller inland refinery close to Prague that benefits from its diverse crude supply (IKL and Drushba). Continued crude supply combined with captive demand region will most likely prolong Kralupy's lifecycle.
Schwechat (OMV)	40	195 Kb/d	Resilient to Competition + 1 Competition Constraining Factor	This relatively large inland refinery gets 10% of its crude from domestic production and the rest is secured via a crude pipeline connection from Trieste, resulting in an inland captive demand advantage. In addition this refinery is constrained by a significant ownership share of the Austrian government in OMV.
Bratislava (MOL)	41	124 Kb/d	Resilient to Competition	A small refinery with multiple supply sources for crude (Drushba and Adria) that benefits from its sheltered demand position against imports.
Százhalombatta Duna (MOL)	42	165 Kb/d	Resilient to Competition + 1 Competition Constraining Factor	The medium-sized inland Duna refinery has a diversified crude supply (Drushba, Adria and domestic) and a captive demand advantage. Its isolated location shields the refinery from any petroleum product import competition. In addition this refinery is constrained by security of supply issues as it is the last remaining refinery in Hungary.
Gonfreville (Total)	43	247 Kb/d	1 Competition Constraining Factor	A coastal refinery which is closely integrated with steamcracking and aromatics capacity, but both are sub world-scale. Accordingly, the refinery could, all else equal, be replaced by imports. This refinery is constrained by the factor of its economic footprint as it serves the Seine Valley cluster, the largest petrochemicals cluster in France, with its steam cracker and aromatics capacities that are critical to the base chemicals supply.
Port Jérôme (ExxonMobil)	44	248 Kb/d	Exposed to Competition	A coastal refinery which is closely integrated with on-site steamcracking and aromatics capacity, but both are sub world-scale. Accordingly, the refinery could, all else equal, be replaced by imports.
Grandpuits (Total)	45	101 Kb/d	Exposed to Competition	An inland refinery connected to a local crude supply from the "Bassin Parisien" and a direct crude pipeline connection which directly serves the Paris region. Local crude supply, however, covers only around 10% of the refinery's requirement, and the Paris region is also served by multiple product pipelines and the Seine inland waterway, meaning that the refinery is exposed to imports.
Donges (Total)	46	230 Kb/d	Exposed to Competition	A coastal refinery that in spite of its recent commitments to upgrade its desulphurisation capacity is exposed to imports.

Feyzin (Total)	47	117 Kb/d	Exposed to Competition	An inland refinery that is integrated with on-site steamcracking and aromatics capacity, but both are sub-world scale. The inland region is also served by multiple product pipelines and the Rhone inland waterway system. Accordingly, the refinery is exposed to imports.
Fos-sur-Mer (ExxonMobil)	48	136 Kb/d	Exposed to Competition	A coastal refinery that is closely integrated with the Berre steamcracker, but this steamcracker is sub-world scale. Accordingly, the refinery is exposed to imports.
Lavéra (Petroineos)	49	210 Kb/d	1 Competition Constraining Factor	A coastal refinery, closely integrated with onsite steamcracker and aromatics capacity, but both are sub-world scale. Hence, the refinery is exposed to imports. Constrained since it is integrated with France's largest hydrocracker, and serves the urban centres in the southwest of France making the Lavéra refinery critical to security of supply.
La Mède (Total)	50	158 Kb/d	Exposed to Competition	Total has already announced plans to convert the refinery site into a bio-refinery.
Matosinhos (GALP)	51	120 Kb/d	1 Competition Constraining Factor	A small coastal refinery with little industrial integration that is exposed to imports. Despite coastal exposure this refinery is constrained by a significant ownership share by the Portuguese government.
Sines (GALP)	52	220 Kb/d	1 Competition Constraining Factor	Largest Portuguese refinery, coastal based with large storage facilities that, despite recent investments and product pipeline connections to Lisbon, is exposed to imports. This refinery is constrained by a significant ownership share by the Portuguese government, if security of supply becomes an issue the national government might prefer Sines over Matosinhos.
A Coruña (Repsol)	53	120 Kb/d	Exposed to Competition	A small coastal refinery that is exposed to imports.
Somorrosto (Petronor)	54	220 Kb/d	Exposed to Competition	This relatively large and complex refinery with vast storage capacities located at a port and is exposed to imports.
Tarragona (Repsol)	55	186 Kb/d	Resilient to Competition + 1 Competition Constraining Factor	This relatively large and complex refinery has direct petrochemical integration with two steamcrackers with a joint world scale cracking capacity of 1.2 Mt/a. In addition this refinery is constrained by its economic footprint with a large employment base in the Catalonia region with high unemployment (>18%) and structural high unemployment (>10%) levels.
Castellón (BP)	56	110 Kb/d	1 Competition Constraining Factor	A non-integrated small coastal refinery that, despite some coking capacity, is exposed to imports. This refinery is constrained by its economic footprint with a large employment base in the Valencian region with high unemployment (>22%) and structural high unemployment (>11%) levels.
Puertollano (Repsol)	57	150 Kb/d	1 Competition Constraining Factor	A medium-sized inland refinery with direct connections to the excellent product pipeline infrastructure (CLH) that makes the refinery vulnerable as imported refined products can be transported with extreme ease, erasing any inland location advantage. This refinery is constrained by its economic footprint with a large employment base in the Castile de la Mancha region with high unemployment (>26%) and structural high unemployment (>13%) levels.
Rábida (CEPSA)	58	190 Kb/d	1 Competition Constraining Factor	A relatively large coastal based refinery that in spite of its capacity investments (2005) is exposed to imports. This refinery is constrained by its economic footprint with a large employment base in the Andalusia region with high unemployment (>31%) and structural high unemployment (15%) levels.
San Roque (CEPSA)	59	240 Kb/d	1 Competition Constraining Factor	The largest Spanish refinery, coastal based and enjoys abundant storage capacity and port facilities (350k DWT). Accordingly, the refinery is exposed to imports. This refinery is constrained by its economic footprint with a large employment base in the Andalusia region with high unemployment (>31%) and structural high unemployment (15%) levels.
Cartagena (Repsol)	60	220 Kb/d	Resilient to Competition + 1 Competition Constraining Factor	A relatively large and complex coastal based refinery with surplus coking capacity. The gradual disappearance of HFO outlets and being the only refinery in the Mediterranean with surplus coking capacity to upgrade residual fuel oil streams makes this a strategic refinery configuration. In addition this refinery is constrained by its economic footprint with a large employment base in the Murcia region with high unemployment (>24%) and structural high unemployment (12%) levels.

Tenerife (CEPSA)	61	90 Kb/d	Exposed to Competition	A small coastal refinery with a simple configuration that is exposed to imports. Its production has been idled since 2015.
Trecate (ExxonMobil)	62	126 Kb/d	Exposed to Competition	A small inland refinery that in spite of stable north Italian demand is exposed to imports as it is connected with a product pipeline to the Savona Port (316k DWT).
Sannazzaro (ENI)	63	200 Kb/d	1 Competition Constraining Factor	A relatively large and complex refinery that is connected to the CEL pipeline system, with both crude and product connections to the port of Genova that has excellent import facilities (500k DWT). Sannazzaro, despite serving an inland market, is exposed to imports as the Lombardia region has ample optionality for product imports. Despite exposure to imports this refinery is constrained by a significant ownership share by the Italian government. Recent fires make it difficult to assess the outlook for the refinery.
Busalla (Iplom)	64	40 Kb/d	Exposed to Competition	A small independent coastal refinery with a simple configuration that is exposed to imports.
Livorno (ENI)	65	105 Kb/d	1 Competition Constraining Factor	A small relatively simple coastal refinery that is exposed to imports. Despite exposure to imports this refinery is constrained by a significant ownership share by the Italian government. ENI has earmarked this refinery for storage terminal conversion.
Falconara (API)	66	83 Kb/d	Exposed to Competition	A small independent coastal refinery that, despite its regional market in the centre of Italy, is exposed to imports. This refinery has large storage capacity (1.5M cm) and is located at the port of Falconara (400k DWT).
Taranto (ENI)	67	120 Kb/d	Resilient to Competition + 1 Competition Constraining Factor	This small coastal based refinery has upstream integration with a direct crude pipeline to Centro Oli Val D'Agri (COVA), supplying close to 50% of its crude intake. This long-term viable but constrained oil field assures continued competitive feedstock supply to the Taranto refinery. In addition, this refinery is constrained by a significant ownership share of the Italian government.
Sarroch (Saras)	68	300 Kb/d	1 Competition Constraining Factor	This large coastal based refinery on the island of Sardinia lacks a substantial local demand and has no significant chemical integration. Accordingly, the refinery is exposed to imports. This refinery is constrained by secondary integration as it produces a significant amount of electricity, up to 30% of the Sardinian electricity supply.
Milazzo (ENI/Q8)	69	186 Kb/d	3 Competition Constraining Factors	A relatively large coastal based refinery on Sicily, lacking a substantial local market, having significant port facilities (420k DWT) and in direct competition with two other refineries on the island. Accordingly, the refinery is exposed to imports. However, Milazzo has three constraining factors as it is partially owned by the Italian government (15%), secondly this refinery is constrained by its economic footprint with a large employment base in the Sicily region with high unemployment (>21%) and structural high unemployment (14%) levels. Regulatory issues might be a constraining factor for the region.
Augusta (ExxonMobil)	70	176 Kb/d	2 Competition Constraining Factors	A relatively large coastal based refinery on Sicily, lacking a substantial inland market and in direct competition with two other refineries on the island. Accordingly, the refinery is exposed to imports. However, Augusta has two constraining factors as it has a significant economic footprint with a large employment base in the Sicily region with high unemployment (>21%) and structural high unemployment (14%) levels. Secondly, regulatory issues might be a constraining factor for the region.

ISAB (Lukoil)	71	320 Kb/d	3 Competition Constraining Factors	A large coastal based refinery on Sicily with some petrochemical integration, lacking a substantial inland market, having significant port facilities (600k DWT) and in direct competition with two other refineries on the island. Accordingly, the refinery is exposed to imports. However, the refinery has three constraining factors as it has a significant economic footprint with a large employment base in the Sicily region with high unemployment (>21%) and structural high unemployment (14%) levels. Secondly, the refinery has secondary integration with substantial electricity production capacity (540MW) making up for a significant share of electricity supply in Sicily. Thirdly, regulatory issues might be a constraining factor for the region.
Rijeka (INA)	72	90 Kb/d	3 Competition Constraining Factors	A small and complex coastal refinery that is exposed to imports as it is close to a large storage hub (Krk Island) and has excellent import facilities at the port of Omisalj (350k DWT). The Croatian government has a large share (44.8%) in INA and marked this refinery as a strategic asset to the country. Rijeka's employment base is significant as the Jadranska Hrvatska region copes with high unemployment (17%) and structural high unemployment (>10%) levels. In addition, regulatory issues might be a constraining factor for the region.
Sisak (INA)	73	44 Kb/d	3 Competition Constraining Factors	A small inland refinery with a simple configuration that is exposed to imports as it is close to a large storage hub (Krk Island) and has excellent import facilities at the port of Omisalj (350k DWT). The Croatian government has a large share (44.8%) in INA and marked this refinery as a strategic asset to the country. Sisak's employment base is significant as the Kontinentalna Hrvatska region copes with high unemployment (16%) and structural high unemployment (10%) levels. In addition, regulatory issues might be a constraining factor for the region.
Petrobrazi (Petrom: OMV/ Rompetrol)	74	90 Kb/d	Resilient to Competition + 2 Competition Constraining Factors	A small and complex refinery benefitting from both a captive demand market and some upstream integration. Recent upgrades have made domestic oil refining more profitable. The refinery has two constraining factors as the Romanian government has a large share (39.6%) in Petrom and marked this refinery as a strategic asset to the country. In addition, regulatory issues might be a constraining factor for the region.
Petrotel (Lukoil)	75	48 Kb/d	1 Competition Constraining Factor	Small and complex refinery that is not likely to benefit from the inland market due to competitive neighbours. Regulatory issues might be a constraining factor for the region.
Petromidia (Rompetrol)	76	100 Kb/d	2 Competition Constraining Factors	A small and complex coastal based refinery that is exposed to imports. The refinery has two constraining factors as the Romanian government has a large share (44.7%) in Rompetrol and marked this refinery as strategic asset to the country. In addition, regulatory issues might be a constraining factor for the region.
Neftochim Burgas (Lukoil)	77	196 Kb/d	2 Competition Constraining Factors	A relatively large and complex coastal based refinery that, despite recent upgrading investments, is exposed to imports. The refinery has two constraining factors as Burgas is the country's only refinery and optionality of refining might be important for its security of supply. In addition, regulatory issues might be a constraining factor for the region.
Thessaloniki (Helpe)	78	93 Kb/d	3 Competition Constraining Factors	A small coastal refinery with a simple configuration that is exposed to imports. Note that all Helpe refineries are for sale. Thessaloniki has three constraining factors as the Greek government has a large share (35.5%) in Helpe. Secondly, it has a significant economic footprint with a large employment base in the Central Macedonia region with high unemployment (26%) and structural high unemployment (>19%) levels. In addition, regulatory issues might be a constraining factor for the region.

Aspropyrgos (Helpe)	79	148 Kb/d	3 Competition Constraining Factors	A medium-sized more complex coastal refinery that, despite pipeline connection to Athens airport and demand centre together with recent upgrades integrating the Elefsina refinery, is exposed to imports. Note that all Helpe refineries are for sale. Aspropyrgos has three constraining factors as the Greek government has a large share (35.5%) in Helpe. Secondly, it has a significant economic footprint with a large employment base in the Attica region with high unemployment (>25%) and structural high unemployment (>19%) levels. In addition, regulatory issues might be a constraining factor for the region.
Elefsina (Helpe)	80	100 Kb/d	3 Competition Constraining Factors	A small more coastal refinery that, despite pipeline connection to Athens airport and demand centre together with recent upgrades integrating the Aspropyrgos refinery, is exposed to imports. Note that all Helpe refineries are for sale. Elefsina has three constraining factors as the Greek government has a large share (35.5%) in Helpe. Secondly, it has a significant economic footprint with a large employment base in the Attica region with high unemployment (>25%) and structural high unemployment (>19%) levels. In addition, regulatory issues might be a constraining factor for the region.
Corinth (MOH)	81	380 Kb/d	2 Competition Constraining Factors	Greece's largest refinery with a relatively simple configuration that is exposed to imports as it has the excellent Corinth port facilities (450k DWT). This refinery is constrained by its significant economic footprint with a large employment base in the Peloponnese region with high unemployment (>22%) and structural high unemployment (>17%) levels. In addition, regulatory issues might be a constraining factor for the region.
Mongstad (Statoil)	82	190 Kb/d	2 Competition Constraining Factors	A relatively large coastal based refinery that in spite of recent investments and some upstream integration to the Troll and Sverdrup oilfields is exposed to imports. The refinery has two constraining factors as the Norwegian government has a significant ownership share in Statoil. Secondly, the refinery has secondary integration with substantial electricity production capacity (280MW) from its CHP unit making up for a significant share of the region's electricity supply. CCS is applied to this CHP unit, plans are to strip CO_2 from the refinery's flue gasses from 2019 onwards, making it the world's largest technology center for CCS from flue gases.
Slagen (ExxonMobil)	83	122 Kb/d	Exposed to Competition	A small coastal refinery with a relatively simple configuration that in spite of recent investments and claimed efficiency improvements is exposed to imports as it is located at Tønsberg Port (250k DWT).
Cressier (Varo)	84	68 Kb/d	Resilient to Competition	A small inland refinery connected to the SPSE crude pipeline serving the captive market of Switzerland which has no other product source or pipeline. Resilient to competition given that the refinery's single crude source stays operational. Note that a wave of clients left SPSE and moved to TAL.
Collombey (Tamoil)	85	54 Kb/d	Exposed to Competition	A small inland refinery that is exposed to imports. Its production has been idled since 2015.

ANNEX B – SMALLER EU REFINERIES

In this study, refineries have been classified as a crude processing facility that operates a distillation column exceeding 20 Kb/d of nameplate capacity and produces a 'wider' range of products (i.e. excluding specialty refineries). Nevertheless, apart from this general refining base, Europe also houses some smaller and/or specialty refineries that were not taken into consideration in this study. To complete the overview, the following table lists a selection of some of the other refineries in the European Union (see Figure B.1).

Refinery	CDU Capacity	Category	Comments
Nynäshamn (Nynas)	17 kb/d	Specialty	Small refinery in the east of Sweden that is operated as a specialty bitumen facility.
Göteborg (Nynas)	8 kb/d	Specialty	Small refinery that is operated as a specialty bitumen facility.
Antwerp (Vitol)	850 t/a	Specialty	Refinery previously owned by Petroplus but since 2009 Vitol only operates the bitumen plant.
Harburg (Nynas)	330 t/a	Specialty	Refinery previously owned by Shell but since 2013 Nynas only operates the base oil plant.
Trzebinia (PKN Orlen)	4 kb/d	Teapot	Small, isolated refinery where PKN Orlen has started a conversion into a bio-refinery.
Jedlicze (PKN Orlen)	3 kb/d	Teapot	Small, isolated refinery in central Poland.
Tarragona (Repsol)		Specialty	Next to the large and advanced Tarragona refinery, Repsol also operates a smaller asphalt facility.
Ravenna (ALMA)	11 kb/d	Teapot	Small, independent refinery with a small production capacity.
Pardubice (Unipetrol)		Specialty	Small refinery in the Czech Republic that is transformed to a specialty refinery.
Vega (Rompetrol)		Teapot	Small refinery in central Romania.

FIGURE B.1 A SELECTION OF REFINERIES THAT ARE NOT INCLUDED IN THE OVERALL ANALYSIS.

ANNEX C – EUROPEAN PETROLEUM OVERVIEW

A Sankey diagram is used to visualise the petroleum balance, or petroleum overview, of the EU-28 and Norway (see Figure C.1). This visualisation is based on Eurostat statistics for the year 2015, the latest available.[128],[129] By further simplifying the model, excluding smaller energy flows, a more aggregate perspective appears.[130] The width of each flow represents the relative amount of energy in MTOE. The surplus of gasoline (49 MTOE net export) and deficit of diesel (20 MTOE net import) is a direct effect of the imbalance between Europe's transport fuel mix (dieselisation policy) and its (economically) restricted refinery production slate. Similarly, the shortage in kerosene production is mitigated by net imports (16 MTOE) whereas excess fuel oil is exported or shipped to international marine bunkers. LPG, naphtha, and other products balances are all slightly short.

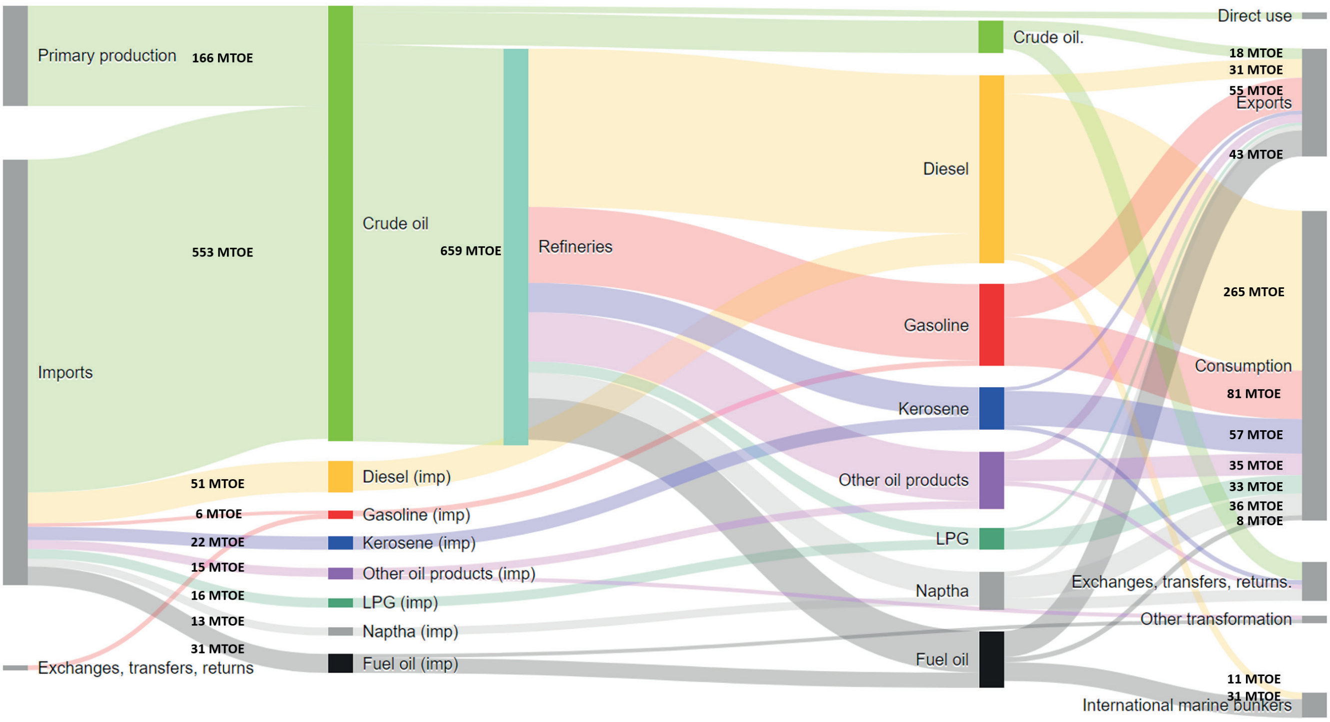


FIGURE C.1: EUROPEAN PETROLEUM OVERVIEW

128 Eurostat has statistics on the size of energy flows by all energy carriers throughout each process (conversion, consumption, etc.) of the EU. See for example: http://ec.europa.eu/eurostat/data/database.

129 The visualisation is modelled by programming in R, using the programme RStudio.

130 Energy flows with a non-significant amount (<5000 KTOE per annum) are omitted in the visualisations. The total amount of KTOEs still add up, excluded flows are incorporated in the calculations.

The Sankey diagram should be read from left-to-right. Two major flows of energy carriers are entering the energy system, with energy imports and primary energy production on the left. Within the energy system, primary energy carriers (raw material such as crude) are converted into secondary energy carriers (e.g. refined oil product, cokes, etc.) within European refineries.[131] At the other end of the Sankey diagram, flows of energy are leaving the system, with exports and the consumption of energy. International marine bunkers are neither considered export nor consumption as these products (mostly fueloil) are consumed on international waters for shipping, the HFO is used as fuel, not being part of the cargo. Direct use is a special category where crude oil and/or NGL are consumed outside refineries. Another special category is the flow of exchanges, transfers and returns on the left hand side of the Sankey, which refers to the inter-product transfers, products transfers and returns from the petrochemical industry.

Petroleum trade flows that move internally in the European Union, predominantly take place between the Northern coastal Member States (see Figure C.2).[132] These Northern countries house Europe's largest ports, in terms of throughput and storage capacity, facilitating trade by pipeline and maritime transport.[133] At the other end of the spectrum, countries located in a land-locked region, CEE in particular, tend to have substantially smaller petroleum product trade flows within the EU. In addition the pool of import/export partners seems to reduce significantly as countries lack excellent facilities for trade (e.g. world-scale ports).

131 See, for example: http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy.

132 The flows in Figure C.2 represent the sum of petroleum products using a cut-off of 1 Million tonnes. The Sankey diagram is based on Eurostat 2015 annual oil export figures.

133 Top of the list are ports in the Benelux, UK, Scandinavia and Mediterranean area. McCarthy, M. 2014. "Rotterdam Is Europe's Largest Port by Far", See: https://www.statista.com/chart/2046/eu28-cargo-ports/ or; Eurostat (2016). "Maritime ports freight and passenger statistics" See: http://ec.europa.eu/eurostat/statistics-explained/index.php/Maritime_ports_freight_and_passenger_statistics.

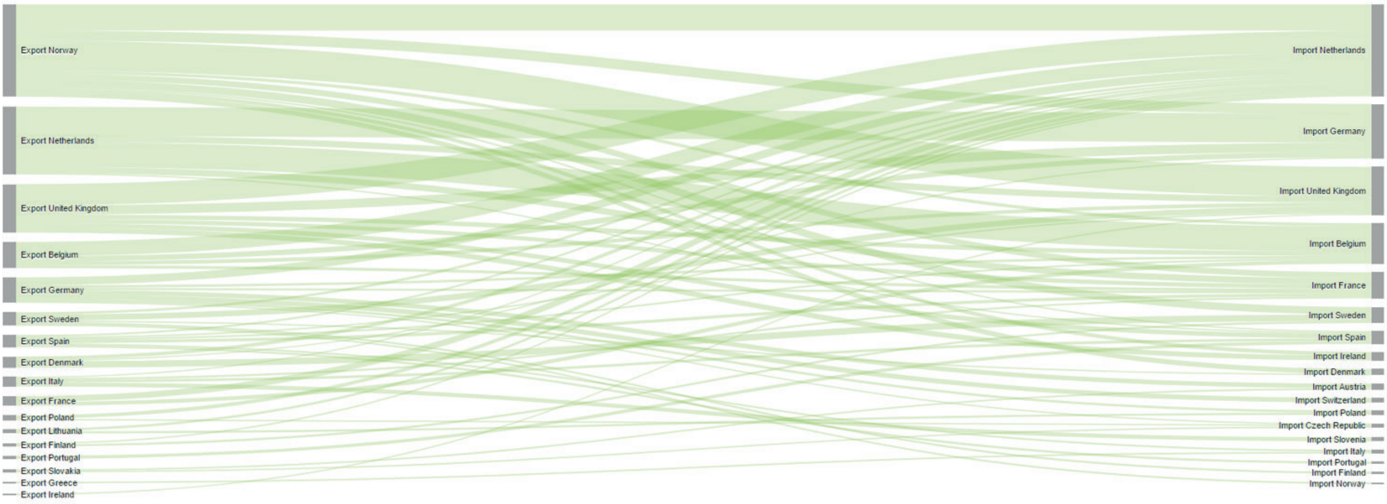


FIGURE C.2: PETROLEUM TRADE FLOWS WITHIN EUROPE (>1MTONNE)

The share of petroleum product imports from non-EU countries over the last decades has gradually increased from 14% to 21%.[134] This volume has been rising, not in the least stimulated by the excellent import facilities present in Europe. Ports like Amsterdam, Antwerp, Göteborg, La Havre, Marseille, Omalsj, Rotterdam, Trieste and Wilhelmshaven that allow large, multiproduct tankers in combination with large storage terminals and pipelines create an excellent network throughout the European Union.

134 Based on Eurostat data from the 1990s towards the year 2015.

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