

LONG-TERM PROSPECTS FOR NORTHWEST EUROPEAN REFINING

ASYMMETRIC CHANGE: A LOOMING GOVERNMENT
DILEMMA?

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TITLE

Long-term Prospects for Northwest European Refining

SUBTITLE

Asymmetric Change: A Looming Government Dilemma?

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NUMBER

2016 | 01

EDITOR

Deborah Sherwood

DESIGN

Studio Maartje de Sonnaville

COVER PHOTO

www.photostuip.nl

PUBLISHED BY

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LIST OF ABBREVIATIONS

Units

DWT	Deadweight tonnage
Mb/d	Million barrels per day
Kb/d	Thousand barrels per day
Mt/a	Million tons per annum
Kt/a	Thousand tons per annum

Pipelines

CEPS	Central Europe Pipeline System (Product)
NWO	Nort-West Oelleitung (Crude)
RRP	Rotterdam Rijn Pijpleiding (Crude/Product)
SPSE	Société du Pipeline Sud-Européen (Crude)
TAL	Transalpine Pipeline (Crude)

Other

ARA	Amsterdam-Rotterdam-Antwerp
COP	Conference of Parties
EIA	Energy Information Association
GHG	Greenhouse Gas
HFO	Heavy Fuel Oil
HHI	Herfindahl-Hirschman Index
IEA	International Energy Agency
IOC	International Oil Company
JV	Joint Venture
LNG	Liquid Natural Gas
LPG	Liquid Petroleum Gas
LTO	Light Tight Oil
NOC	National Oil Company
NWE	Northwest Europe
OECD	Organisation for Economic Co-operation and Development
OPEC	Organisation of the Petroleum Exporting Countries

PREFACE

This CIEP study on the northwest European (NWE) refining sector is part of our continuing research interest in the developments in the oil value chain. In 2008 we published our first study on oil refining, followed by CIEP studies in 2012 and 2013. Since the world of oil – and refining in particular – has changed dramatically, it was time that we revisited the northwest European refining sector.

This study could not have been completed without the support of the refining industry and experts in the field. Their generosity in discussing with us the set-up of the scenarios and their outcomes have resulted in a study that shows the interaction between the competitive pressure of dynamically evolving refining markets and the impact on the organisation of the sector in NWE. The developments also show the potential policy issues for NWE governments when shaping their energy policies. On the one hand, these policies are shaped by their efforts to move the energy economy towards a low-carbon profile, while on the other hand the asymmetry in timing of the transition of various energy markets may challenge their security of supply policies.

Last but not least, this study was in part made possible by a grant from Aramco Overseas Company. Neither Aramco Overseas Company nor the supporting institutions of CIEP are responsible for the content of this study. That responsibility rests solely with CIEP.

EXECUTIVE SUMMARY

This study was performed by *Clingendael International Energy Programme (CIEP)* to assess the post-2025 northwest European (NWE) refining sector on the back of increasing competition from non-European refining clusters (mainly in the Middle East) and the upcoming transition to a low-carbon economy. We foresee a potential return to the source refining model, in which NWE demand for petroleum products in the coming decades will be supplied by more oil product imports from outside Europe due to insufficient investments in the NWE refining sector. These developments may both affect NWE security of supply and bequeath society with a refining legacy of unprecedented proportions. Overall, this study can serve as a point of departure for further discussions on the implications of an imminent restructuring of the refining sector in NWE.

In this study, the NWE refining base is not assumed to be competitive in the long run vis-à-vis modern, mainly resource-based, non-NWE refining complexes, further complicating the investment case. Only refineries that offer strategic value to a supply chain, an industrial cluster or a company portfolio are considered to have the structural competitive advantages to be assured of the necessary upgrading investments to remain competitive vis-à-vis refined product imports. In order to better understand the pressures on the NWE refining industry, we have analysed individual NWE refineries according to one of the following archetypes: *Captive Demand*, *Petrochemical Integrated*, *Downstream Integrated* and *Surplus Coking*. We have constructed two scenarios: a 'must-run' refining scenario in which refineries derive their longer-term competitive position from their strategic added value in a cluster or market; and a 'closure-constrained' scenario in which refineries prolong their lease of life due to barriers to exit.

The more extreme must-run scenario deems 12 out of 34 refineries 'must-run', operating around 3 Mb/d of crude distillation capacity, implying that the post-2025 NWE refining sector would only cover circa 40% of overall oil product demand. On average, these must-run refineries are larger and more complex compared to their so-called more 'exposed' NWE competitors and benefit from deeper integration, connections to a trading-hub, and/or specific captive demand. It is interesting to note that most must-run refineries are located in ARA, Rhine-Ruhr, and southern Germany, whereas foreseen refinery capacity reductions are concentrated in France, the UK and

northern Germany. IOCs are expected to retain ownership of 10 out of the 12 must-run refineries, representing over 80% of the remaining NWE refining capacity.

Although interviews with the industry have largely corroborated our analysis, it does remain a subjective exercise. Therefore, by lowering certain scenario thresholds, several refineries turned out to be very close to must-run status. Most of these second-tier candidates, however, are already included in the must-run scenario, albeit in another category. Nevertheless, some new second-tier candidates include the BP refinery in Rotterdam, the Exxon refinery in Fawley, the PCK refinery in Schwedt, and the Lukoil/Total Zeeland refinery.

Substantial barriers to exit, however, will prevent economically exposed refineries from being closed. Political intervention and the clean-up costs of refining sites are both limiting factors when assessing capacity reductions in NWE refining. An overview of historic refinery restructurings is used to construct two profiles that could potentially extend a refinery's lease-of-life: *Political Deals* and *Merchant Refining Deals*. Of the 22 so-called exposed refineries in the must-run scenario, 9 are expected to be closure-constrained because they are plausible candidates for political or merchant refining deals.

In total, 21 refineries are thought to overcome the threat of growing imports, as they either have strategic characteristics or face substantial barriers to exit. This leaves 13 refineries in NWE exposed to competitive non-NWE imports in their markets, with a significant risk of closure amounting to 2.6 Mb/d of potential capacity reduction. When combining this with the broader trend towards a low-carbon economy, a risk may arise of an asymmetric transition, in which the closure of refining capacity is not met with timely credible alternatives. This would pose a challenge to policy-makers interested in organising an orderly transition without exposing their markets to new security of supply issues.

In conclusion, this study identifies 13 refineries in NWE that are directly exposed to competition from non-European refining centres. Together with the expected global trend towards a low-carbon economy, these potential refinery closures might be ill-synchronised in the energy transition. As credible low-carbon alternatives will take time to materialise, substantial refinery closures might prove premature in certain parts of the market and their infrastructural developments. Considering the economic footprint and security of supply impacts, this study might kick-start a discussion on near future implications of unco-ordinated refinery restructurings due to market circumstances and government policy priorities demanding a different timing.

1 INTRODUCTION

Since the end of refining's golden age in 2008/2009, global crude oil and product trade flows have been facing a long-term transition.¹ Foreseen structural demand contraction in Europe, significant new export-oriented refining capacity in the Middle East, Russia and Asia, and changed US refining dynamics on the back of abundant light tight oil (LTO) supplies are upsetting existing regional market structures.² These developments combine to favour the source refining over the market refining model, depriving part of the northwest European (NWE) refining sector of much-needed investments.^{3,4}

At the same time, European policy-makers are preoccupied with the transition to a low-carbon economy.⁵ Accordingly, NWE refiners not only face growing competition from advanced source refineries but are also being squeezed by increasingly stringent policies designed to reduce emissions from burning fossil fuels.⁶ Coupled with high energy and labour costs, and a lack of direct access to feedstocks, the investment case for NWE refineries looks particularly weak in the context of this globalised refining industry. A failure to attract new investments may result in NWE refinery supply becoming increasingly uncompetitive vis-à-vis refined product imports. This raises questions about both structural competitive advantages and barriers to exit for NWE refineries. In other words, what role do structural competitive advantages and barriers to exit play in the post-2025 outlook for the NWE refining landscape?

1 Despite current high refining margins due to low oil prices, this study aims to go beyond the short-term flux of oil markets and attempts a long-term analysis of the structural developments of the NWE refining sector.

2 IEA (2015), "Oil: Medium-Term Market Report". International Energy Agency; Janssens, T. & Fitzgibbon, T. (2015), "Profitability in a world of overcapacity". McKinsey&Company; EC (2015), "EU petroleum refining fitness check"; Six, S. (2013), "US Refining Dynamics". Clingendael International Energy Programme; or Sen, A. (2013), "US tight oils: prospects and implications", OIES. Meijknecht et al. (2012), "A Cinderella story?", Clingendael International Energy Programme.

3 In this study we use a narrow definition of NWE, comprising the Benelux, Germany, France, and the UK. We do, however, believe that the general dynamics discussed for the NWE refining sector apply to the wider EU as well.

4 The source-refining model refers to refining that is closely integrated with crude oil production, as opposed to the market-refining model in which refineries are located close to demand centres instead.

5 See, for example, EC (2010), "Roadmap 2050: a practical guide to a prosperous, low-carbon Europe"; or <https://ec.europa.eu/energy/en/topics/energy-strategy/2050-energy-strategy>

6 For a detailed assessment of the impact on the EU refining industry from various environmental regulations in force between 2000 and 2012, see EC (2015), "EU petroleum refining fitness check".

For at least the next 25 years, oil is expected to meet the bulk of global and European energy demand in transportation.⁷ Consequently, a failure to attract refinery investments also risks a timing mismatch between reductions in NWE refining capacities and changing demand for oil products. During such a transition phase, NWE will still have to grapple with the external costs of a fossil-fuelled economy (GHG emissions, carbon leakage, stranded assets, etc.), while no longer enjoying the benefits of a thriving domestic refining sector (contribution to GDP, jobs, know-how, security of supply, etc.). Accordingly, this raises questions about the strategic implications of unco-ordinated NWE refinery closures before low-carbon alternatives have replaced NWE's oil product demand.

To reveal the structural competitive advantages of the NWE refining sector, this study aims to work out a 'what-if' scenario in which the traditional role of NWE's market refineries is no longer evident. To this end, Chapter 2 will focus on an extreme but plausible post-2025 scenario in which barriers to exit in the NWE refining sector are minimal and product imports replace all but must-run refineries. Subsequently, Chapter 3 aims to address the barriers to exit present in NWE refining and clarify their role in past refinery restructuring cases. In Chapter 4, we then build on our insights from past refinery restructurings to inform a closure-constrained post-2025 scenario in which barriers to exit are introduced to moderate must-run scenario conditions. Finally, in Chapter 5 we aim to kick-start a discussion around the strategic implications of a timing mismatch between changing demand for oil products and the reduction of NWE refinery capacity.

7 See, for example, IEA WEO (2015), "World energy outlook 2015 factsheet"; or UK Department of Energy and Climate Change (2014), "Review of the Refining and Fuel Import Sectors in the UK". Also, see various long-term energy outlooks by, for example, Exxon, Shell, BP, or OPEC. For example, Exxon expects oil to still serve close to 90% of world energy demand in transportation by 2040, and BP expects oil to still serve close to 90% of energy demand in transportation by 2035.

2 NWE MUST-RUN SCENARIO - THE 'LAST MEN STANDING'

In the aftermath of the great recession, refining investments have been overwhelmingly concentrated in crude long or high growth regions, starving the NWE refining sector of the capital required to stay competitive in a globally integrated market. If these lopsided investment patterns continue, and assuming refinery upgrading and closure decisions are purely a function of economic efficiency, a return to a source-refining model to supply NWE is extreme but plausible.⁸ To capture the long-term ramifications of such a transition, we focus on a post-2025 scenario in which product imports replace all but must-run refining capacity. Only refineries that offer strategic value to a supply chain or cluster are considered to have the structural competitive advantages to be assured of the upgrading investments needed to remain competitive vis-à-vis refined product imports.⁹ In other words, the must-run scenario aims to identify the 'last men standing' in NWE refining.¹⁰

In the following sections the must-run scenario is worked out in detail. In section 2.1, the assumptions and methodology underpinning the must-run scenario are set out. Section 2.2 describes the post-2025 NWE refining landscape under must-run conditions. Finally, section 2.3 gives a critical appraisal of the must-run model and discusses its limitations as well as assessing the sensitivity of its output.

2.1 MUST-RUN SCENARIO - ASSUMPTIONS & METHODOLOGY

The must-run scenario is derived from three levels of abstraction. First, we introduce assumptions regarding NWE's position in the global refining sector. Second, we translate the assumptions about global refining to the regional context of the NWE refining sector. And third, we set out assumptions about the individual refinery level in NWE, employing four stylised refinery categories which each represent a set of must-run characteristics. At every level we aim to introduce extreme but plausible assumptions regarding the future development of the NWE refining sector.

8 Note that in Chapters 3 and 4 we will review and explicitly introduce barriers to exit in NWE refining, such as political intervention and environmental clean-up costs.

9 Internal factors (e.g. performance, energy efficiency, etc.) are rarely publicly available, and therefore we chose to focus on the strategic considerations in our model. In section 2.3 some of these limitations will be addressed.

10 The terminology 'last men standing' is derived from BP's 'last man standing', see for example, "BP full year 2014 results & investor update", February 3, 2015; and "Die zukünftige Raffinerieentwicklung in Europa Vortrag bei der GESTRATA-Hauptversammlung", November, 2012.

2.1.1 GLOBAL SCOPE

NWE's petroleum infrastructure is concentrated around the core Amsterdam-Rotterdam-Antwerp (ARA) region, encompassing a network of industrial complexes in the Benelux, Germany, France, and the UK. This is illustrated by the significant intra-NWE refined product trade balances shown in Figure 2.1. Domestic refineries play a crucial role in securing adequate oil product supplies in NWE, covering over 90% of overall oil demand in the region.¹¹ Nevertheless, strong growth in source-refining capacity and the increased use of product "super tankers" (including Aframax and even Suezmax sizes) undermine the competitive position of an ageing and fragmented NWE refining sector.^{12, 13}

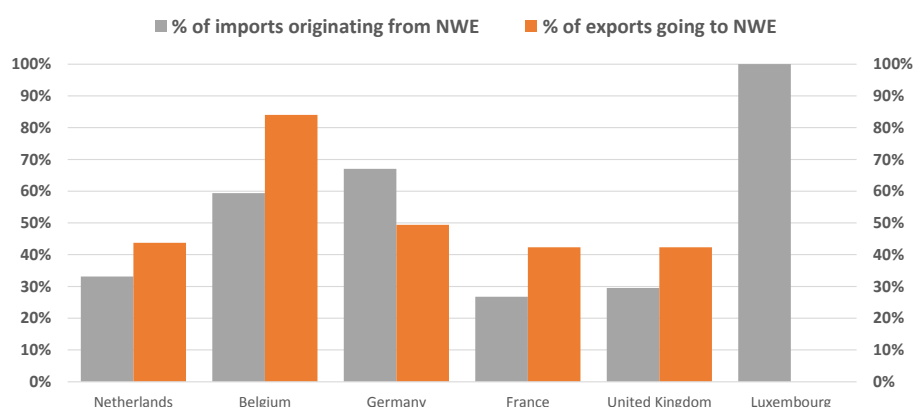


FIGURE 2.1: INTRA NWE REFINED PRODUCT TRADE (JAN-2014 TO MAR-2015)¹⁴

NWE refineries tend to be of a smaller scale than refineries in the rest of the world (see Figure 2.2). Only one refinery in NWE has more than 400 Kb/d of distillation capacity. In comparison, there are 10 refineries in Asia with over 400 Kb/d capacity, 8 in North America, and 5 in the Middle East.¹⁵ In order to maintain a competitive

¹¹ Based on Eurostat figures.

¹² McKinsey estimates that 25% of Western European capacity is margin negative and 40% is cash negative (taking into account turnaround and base/sustaining capital spending). See Janssens, T. & Fitzgibbon, T. (2015), "Profitability in a world of overcapacity", McKinsey & Company.

¹³ In contrast to crude 'super tankers' (ULCC or VLCC of ~200-500 DWT), oil product 'super tankers' (~100-150 DWT) can often carry multiple refined product types. See, for example, Reuters, April 9th 2015, "Refineries Revolution to Spur Use of Oil Products Supertankers". They include larger long-range 2 (LR2) and sometimes even Suezmax-sized tankers that have a DWT between 80K and 200K.

¹⁴ Based on Eurostat figures.

¹⁵ IEA (2015), Presentation to the Fifth Meeting of the EU Refining Forum, "Recent Developments in EU Refining and in the Supply and Trade of Petroleum Products".

position in a globalised refining industry, NWE refiners will need to make significant upgrading investments, which comes on top of the investments required to comply with Europe’s strict environmental regulations.¹⁶ The tightening of sulphur specifications for bunker fuels is of special concern to NWE refiners. Additional capital-intensive, bottom-of-the-barrel upgrading investments may be one of the solutions with which to cope with more stringent regulations.¹⁷

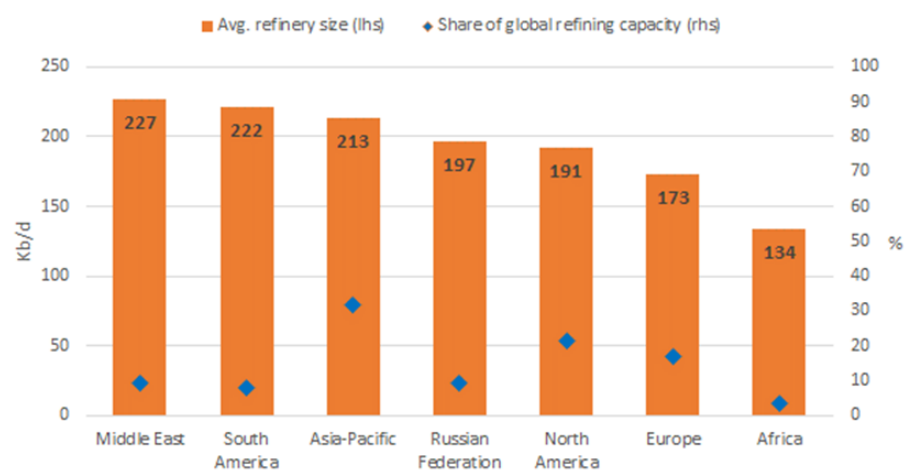


FIGURE 2.2: AVERAGE REFINERY SIZE BY REGION¹⁸

However, several developments conspire to limit investment in NWE market refineries. Structurally declining regional petroleum demand, high energy and labour cost, a lack of access to cheap and secure feedstocks, and an EU policy framework hostile to fossil fuels all work to undermine the long-term investment case for NWE refineries. Instead, a globalised oil industry favours investment in export-oriented source refineries or high-growth regions.¹⁹ Accordingly, the must-run scenario assumes that with the exception of strategic refining capacity, refinery investments will continue to be made outside NWE.

16 Concawe has estimated that by 2020 \$51 billion in investment will be required for the compliance and upgrading of European refineries. This compares to a mere \$4-5 billion of estimated annual profits for the total European refinery industry. See Concawe (April 2013), “Oil refining in the EU in 2020, with perspectives to 2030”; and Fuels Europe, M. Bénézit (Sept 2013), “The current state of EU refining”.

17 Bottom of the barrel refers to the residue that remains after atmospheric and vacuum distillation of crude oil. If not further upgraded through deep thermal or hydrocracking, this residue is blended into the heavy fuel oil pool. Alternatively, the shipping industry could invest in on-board scrubbers.

18 Figure based on BP Statistical Review (2015).

19 See, for example, IEA (2015), “Recent Developments in EU Refining and in the Supply and Trade of Petroleum Products”; EC (2015), “EU petroleum refining fitness check”, Chapter 5; House of Commons ECC (2013), “UK oil refining; Third Report of Session 2013–14”; Purvin and Gertz (2013), “The Role and future of the UK refining sector”; or Meijknecht, J. et al. (2012), “A Cinderella Story?”.

The transition to a source-refining model is already well underway (see Figure 2.3). The decline of NWE refining capacity following the great recession has been more than offset by an increase in Middle Eastern and Russian refining capacity. The dramatic increase in Chinese and Indian refining capacity, on the other hand, is mainly meant to serve domestic markets. However, capacity additions are likely to outpace demand growth in the medium run, and many Asian refiners are targeting exports for price discovery purposes and to maximise value through import/export arbitrage. Accordingly, as refining capacity East of Suez continues to expand, traditional import flows may be substituted and refined product exports are likely to grow, placing further pressure on the embattled NWE refining sector.²⁰

Initially, the US followed a path similar to that of NWE, but abundant new supplies of LTO helped to more than reverse the decline in capacity. Now the US refining renaissance is not only rapidly making gasoline imports from NWE obsolete, but US refineries are also benefitting from favourable access to refinery feedstocks.²¹ Accordingly, US refiners are turning to a source-refining model to monetise this advantage, further increasing competitive pressure on the NWE refining sector.²²

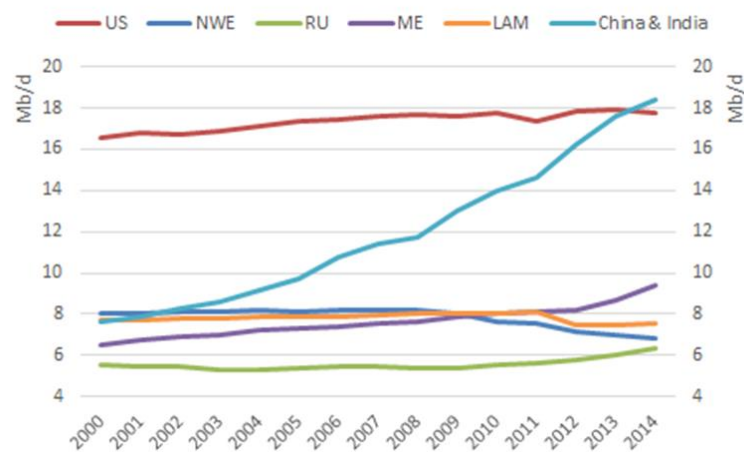


FIGURE 2.3: CRUDE DISTILLATION CAPACITY BY REGION²³

20 Gaffney, Cline & Associates (2014), "Exports or Imports – The Future of Asian Refining".

21 In December 2015 the US government lifted the 1973 ban on crude oil exports. See, for example, <http://www.bbc.com/news/business-35136831>. This might erode the feedstock advantages that US refiners have enjoyed from the shale oil revolution. Its impact, however, is likely to be mitigated by the inability of most US refiners to further increase LTO runs, and the boost the lifting of the export ban is expected to provide to domestic crude oil production. See Aspen Institute (2014), "Lifting the crude oil export ban: The impact on US manufacturing".

22 See, for example, Six, S. (2013), "US refining dynamics", CIEP; or Sen, A. (2013), "US tight oils: prospects and implications", OIES.

23 Figures based on BP Statistical Review (2015).

Investments in source refineries are set to continue. In particular, Middle Eastern refining capacity is poised for further expansion, backed by long-term downstream investment programmes in countries such as Saudi Arabia and Kuwait.²⁴ Moreover, figures based on changes in regional crude distillation capacity paint an overly conservative picture, failing to capture upgrades of existing capacities that allow source refineries to compete more effectively with NWE’s market refineries.²⁵

New and planned refining capacity additions in crude long and high-growth regions are expected to lead to structural overcapacity in the global refining industry (see Figure 2.4). In turn, distillation capacity growth is expected to be outpaced by the growth in conversion capacity.²⁶ Taken together, this constitutes a dire environment for the ageing and fragmented NWE refining sector.

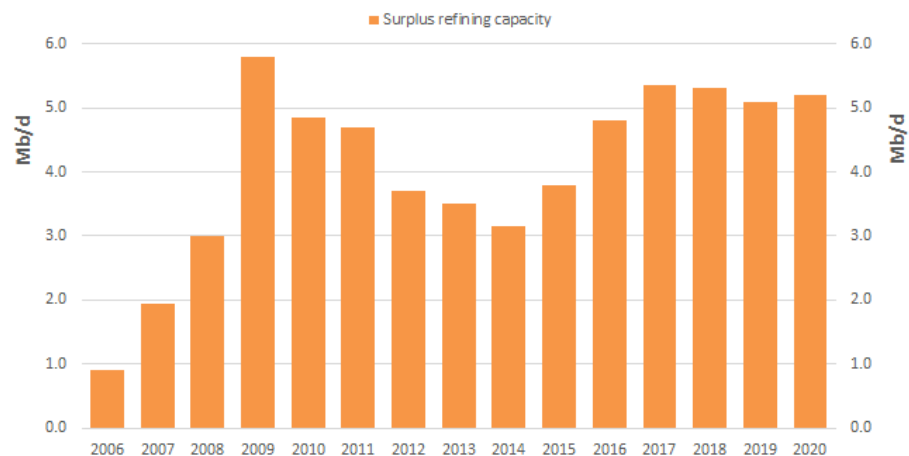


FIGURE 2.4: GLOBAL REFINERY CAPACITY SURPLUS²⁷

24 Although some recent delays have been witnessed, no projects have been cancelled and long-term refining capacity increases remain credible. See, for example, Said, S. (2015), “Middle East Refinery-Expansion Plans Hit Snags” in WSJ, or Ernsberger, D. (2015), “The Race is on as Middle East Refining Capacity Ramps Up for the Future” in The Gulf Intelligence.

25 Russian refinery investments are particularly focused on upgrading existing conversion capacities to increase middle distillate production and to comply with NWE fuel specification standards. See, for example, Rosneft (2014), “Outlook for Russia’s downstream industry, infrastructure development and evolving export strategy”.

26 McKinsey estimates the cumulative annual growth rate (CAGR) for global coking and cracking capacity to be almost two times higher than for crude distillation capacity between 2012 and 2020. See Janssens, T. & Fitzgibbon, T. (2015), “Profitability in a world of overcapacity”. McKinsey & Company.

27 See IEA (2015), Presentation to the Fifth Meeting of the EU Refining Forum, “Recent Developments in EU Refining and in the Supply and Trade of Petroleum Products”.

Absent upgrading, high-cost NWE market refineries may be unable to compete with imports from advanced source refineries. Accordingly, as refining capacity continues to come online in low-cost regions, global refined product oversupply is expected to find its way to premium and transparent NWE markets, setting the stage for ongoing refinery restructuring in NWE (see Figure 2.5).²⁸ The combination of a “non-level playing field”, a weak investment case for NWE refineries, and structural global refining overcapacity allows for the extreme but plausible assumption that post-2025 only must-run capacities in NWE are expected to remain competitive vis-à-vis refined product imports.²⁹

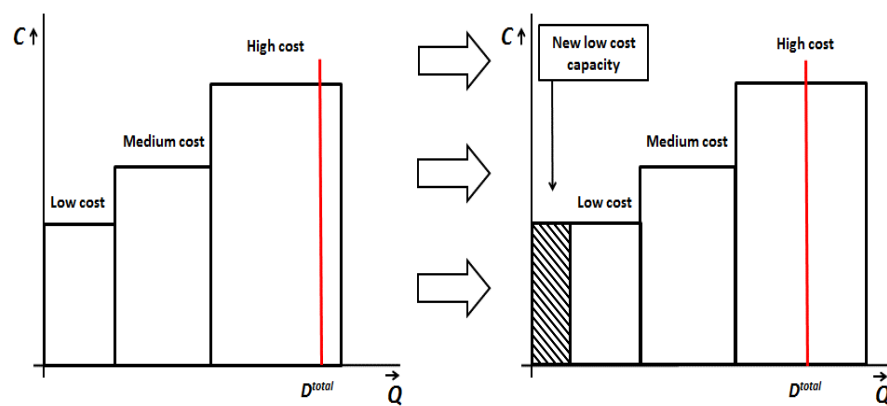


FIGURE 2.5: GLOBAL REFINING CAPACITY DYNAMICS

2.1.2 REGIONAL SCOPE

There is a structural mismatch between NWE refinery supply and refined product demand. NWE’s gasoline-gearred refineries have been unable to keep up with the growth in middle distillates demand (primarily road diesel and jet fuel/kerosene).³⁰ In the short term, as a result of joint production constraints in petroleum refining, regional imbalances have to be solved through two-way trade.³¹ Accordingly, since the early 2000s, trade between NWE and refining centres in Russia, the Middle East, Singapore, and the US east coast has increased significantly (see Figure 2.6).

28 Note that other regions will also suffer refinery restructurings due to modern capacity additions. Net refining capacity reductions are likely to occur mainly in Europe, but as noted above for the purposes of this study we limit ourselves to NWE. Other regions, like OECD Asia’s refining sector, might face pressures similar to the NWE refining sector.

29 Again, we would like to emphasise that the must-run scenario discounts barriers to exit. Accordingly, the must-run scenario could be considered a worst case scenario, which will be balanced by the closure-constrained scenario (see Chapter 4).

30 With the emergence of the ‘Volkswagen scandal’, a change in European fuel demand could potentially take place. However, with an average car engine life cycle of 15 years, its impact will be staggered. See, for example, Platts (2015), “Volkswagen Scandal to hit Diesel, Boost Gasoline”.

31 See Purvin & Gertz (2008), “Study on oil refining and oil markets”.

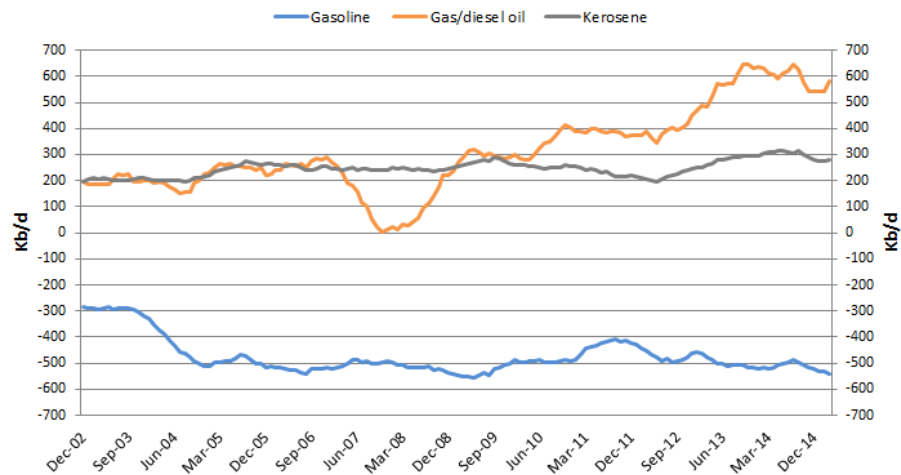


FIGURE 2.6: NWE MIDDLE DISTILLATES AND GASOLINE NET IMPORTS (12MTH ROLLING AVG.)³²

In the long run, however, regional imbalances are solved by upgrading investments or, if investments are not forthcoming, by refinery closures and increased imports (i.e., one-way trade).³³ Following the 2008/2009 recession, the need for a long-term solution for regional imbalances in NWE became more acute as traditional outlets for surplus refined products, such as gasoline, started to disappear. As a result, upgrading an ageing and fragmented asset base is no longer an option but a necessity for the survival of a competitive NWE refining sector.³⁴

Nevertheless, on the basis of our assumptions regarding global refining dynamics, the case for upgrading investments in NWE refineries looks weak. As a result, net capacity reductions are expected to be concentrated in NWE. An oft-repeated argument, however, is that the closure of one refinery increases the chances of survival for the remaining refineries in the region. Yet in the context of an oversupplied global refining industry populated by an increasing number of highly competitive source refineries, this argument does not necessarily hold. As long as a steady stream of capacity additions and upgrades keeps the global refining industry oversupplied, import infrastructure is available, and the price of refined product imports remains below that of NWE refinery supply, it can be assumed that imports will continue to substitute

³² Figures based on JODI data.

³³ Purvin & Gertz (2008), "Study on oil refining and oil markets". Also, as noted above, increased use of product super tankers erodes the transport cost disadvantage of petroleum product vis-à-vis crude oil imports.

³⁴ The disappearance of the US gasoline outlet on the back of the US shale revolution is currently particularly problematic for NWE refineries. Further tightening of heavy fuel oil specifications will only add to current challenges.

for NWE refinery supply until all but must-run capacities have closed.³⁵ In other words, NWE refineries are not necessarily only in competition with each other; they are also competing against imports from advanced source refineries.

2.1.3 INDIVIDUAL REFINERY SCOPE

To convert our assumptions on global and regional refining dynamics to a must-run refining capacity scenario for NWE, we need to identify the individual characteristics that determine a refinery's strategic value to a cluster or supply chain. In our review of strategic refinery characteristics we have shied away from using conventional refinery rankings, such as the Nelson-Farrar complexity index, because we consider cost-based weighted averages inadequate to capture a refinery's long-term strategic value.³⁶ Net cash margins generally provide more insight into the competitive position of individual refineries, but they tend to reflect short- to medium-term refining market dynamics better than long-term strategic value.³⁷

Instead, working with several refining experts and through valuable feedback from industry participants, we have identified four 'must-run' refinery categories: (1) Captive demand refineries; (2) Petrochemicals integrated refineries; (3) Upstream integrated refineries; and (4) Surplus coking capacity refineries. We believe that these four categories are likely to include refineries that are strategic to a supply chain or cluster, tying a refinery's existence to the survival of an entire system. This strategic position is, in turn, expected to secure continued investment in refinery upgrades, supporting a competitive position vis-à-vis refined product imports.

(1) Captive demand refineries are likely to have strategic value to the inland region they serve, providing competitive supply of locally refined products. As long as the infrastructure to facilitate refined product imports is lacking or constrained and crude oil is supplied directly by pipeline, continued investment in these refineries is likely.³⁸

35 One exception to this rule is in case of refining capacity reductions in a 'captive demand' region, but these dynamics are specifically captured in the must-run scenario. Another exception concerns the disappearance of NWE's gasoline length.

36 Consider a comparison between a relatively simple captive demand refinery, such as the Bayernoil refinery in Bavaria, and a highly complex coastal refinery, such as the Klesch Heide refinery. In spite of the significantly lower complexity of the Bayernoil refinery as compared to the Heide refinery, exclusive access to captive local demand provides a much stronger business case for continued investments in the Bayernoil refinery.

37 The Petroplus bankruptcy is a case in point. The consensus at the time was that the Coryton refinery, Petroplus' most profitable refinery, would survive. Nevertheless, the exposure of the London market to refined product imports handicapped the long-term strategic value of the Coryton refinery, and unlike, for example, Petroplus' Ingolstadt refinery, a buyer could not be found. See, for example, House of Commons Energy and Climate Change Committee (2013), "UK oil refining".

38 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 deficits refined products.

(2) Petrochemicals integrated refineries derive strategic value from the 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.³⁹ 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 cluster is likely to provide sufficient rationale for continued upgrading investments.

(3) Upstream integrated refineries are likely to have strategic value to the crude long region they serve, providing a secure and premium outlet for its crude oil. In fact, as long as the crude long region does not have export optionality and production is sustainable in the long term, these refineries are in a strong position to bargain for cheap feedstock supply, and continued upgrading investment is likely.

(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 NWE.⁴⁰ Coking units use deep thermal conversion to upgrade bottom-of-the-barrel streams, avoiding the need to find outlets for HFO volumes.⁴¹ Given the very limited availability of complex refineries with coking capacity in NWE, surplus coking refineries can derive strategic value from providing an HFO outlet to must-run refineries in NWE with a deficit in bottom-of-the-barrel conversion capabilities.⁴² Provided a surplus coking refinery maintains access to third party residue supplies, continued investment in these refineries is likely.

All refineries are different, however, and each refinery has a unique combination of conversion capacities, configurations, integration, and associated infrastructure. Accordingly, we attributed detailed criteria to each must-run refinery category, enabling us to assess refineries on their individual merits. This is necessarily a subjective assessment, as it partially depends on experience and individual judgement. Nevertheless, by codifying our assessment criteria, we believe we not only make our assumptions transparent but also open them up to feedback and the possibility of future iterations (see Figure 2.7 for an overview of must-run criteria by refinery category). The transparency and flexibility of our model is well illustrated by the must-run scenario sensitivity analysis performed in section 2.3.

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

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

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

42 For more details around available coking capacities in NWE see **Annex B**.

Must-run Category	Must-run refinery characteristics	Description
Captive demand	Inland location	The refinery must be located inland
	Crude pipeline connection	The refinery must be connected to an inland crude pipeline
	Refined product pipeline is lacking or constrained	There must either be a lack of refined product pipelines serving the refinery's hinterland, or existing refined product pipelines must be capacity constrained. (Technically, economically, or in terms of control)
	Inland waterway is lacking or constrained	There must either be a lack of inland waterways serving the refinery's hinterland, or existing inland waterways should be significantly constrained in terms of draft/DWTs
	Crude to product pipeline conversion not viable	It is not viable to convert the existing crude pipeline to a refined product pipeline. (Technically, economically, or in terms of control)
	Refining capacity locally intra-marginal	Refinery supply matches captive demand. And if local refinery supply is expected to exceed captive demand, other local refineries must be likelier to close
PetChems integrated	Direct petrochemicals integration	The refinery must have various direct pipeline connections to petrochemicals production units
	World-scale steam cracker or aromatics capacity	Refinery integrated steamcracker \geq 1,000 Kt/a of ethylene capacity + feedstock flexibility > 20%. (Between at least two feedstocks such as naphtha, LPG, gasoil, and hydrowax)
		Refinery integrated aromatics plant \geq 1,000 KT/a. (Benzene + Toluene + Xylene streams)
	Outlet for exess refinery produced feedstocks	Steam cracker feedstock flexibility requires trading outlets for excess production when economics favors one petrochemical feedstock over the other. (To overcome the joint production constraint)
	Petrochemicals cluster long-term viable	Clusters are delineated on the basis of industrial gas networks. (Hydrogen pipeline networks leading)
The refinery should be part of a viable petrochemicals cluster that exhibits internal competition and is likely to survive increased competitive pressure from new/expanding clusters in the US and the Middle East		
Upstream integrated	Direct access to a crude long region	The refinery must have direct access to a land-locked crude long region
	No alternative premium outlets for the crude	There must not be alternative premium crude from the land-locked region
	Not viable to convert existing crude to refined product infrastructure	It must not be viable to convert the existing crude oil infrastructure (e.g. pipelines) to directly supply refined products from the crude long region
	Crude oil production long-term viable	The long-term viability of production in the crude oil region is critical to the strategic value of the upstream integrated refinery
	Surplus coking	Significant coking capacity
Surplus coking capacity		The refinery must have > 15% of its coking capacity available to upgrade third party residue oil supplies
Access to surplus residual oil supplies		The refinery must have access to surplus residue oil supplies from nearby refineries that are deficit bottom of the barrel upgrading capacity. (Coking or residue gasification)

FIGURE 2.7: NWE REFINERY MUST-RUN CRITERIA

2.1.4 MUST-RUN SCENARIO MODEL

To visualise the must-run refining capacity model that informs the scenario, the different categories and refinery criteria have been translated into a binary decision tree. The decision tree consists of five main branches. The first four correspond to the four must-run categories. The fifth branch represents refineries that do not fall within the first four must-run categories and are expected to face direct competition from refined product imports (see Figure 2.8). Each category has its own detailed binary decision tree, incorporating the must-run refinery criteria (see **Annex A** for an overview of detailed binary decision trees and considerations per must-run refinery criteria).

We reviewed each NWE fuel refinery by passing it through the binary decision trees until it either achieved must-run status or was relegated to the refinery restructuring branch. In section 2.2 the must-run refining capacity model output is used to describe the post-2025 NWE refining landscape (see **Annexes B & C** for a more detailed review of each must-run category and must-run comments on all NWE fuel refineries). Further, in Chapter 4 the must-run model output is the point of departure for the closure-constrained scenario. In this scenario barriers to exit present in NWE refining are introduced to moderate the impact of the must-run assumptions.

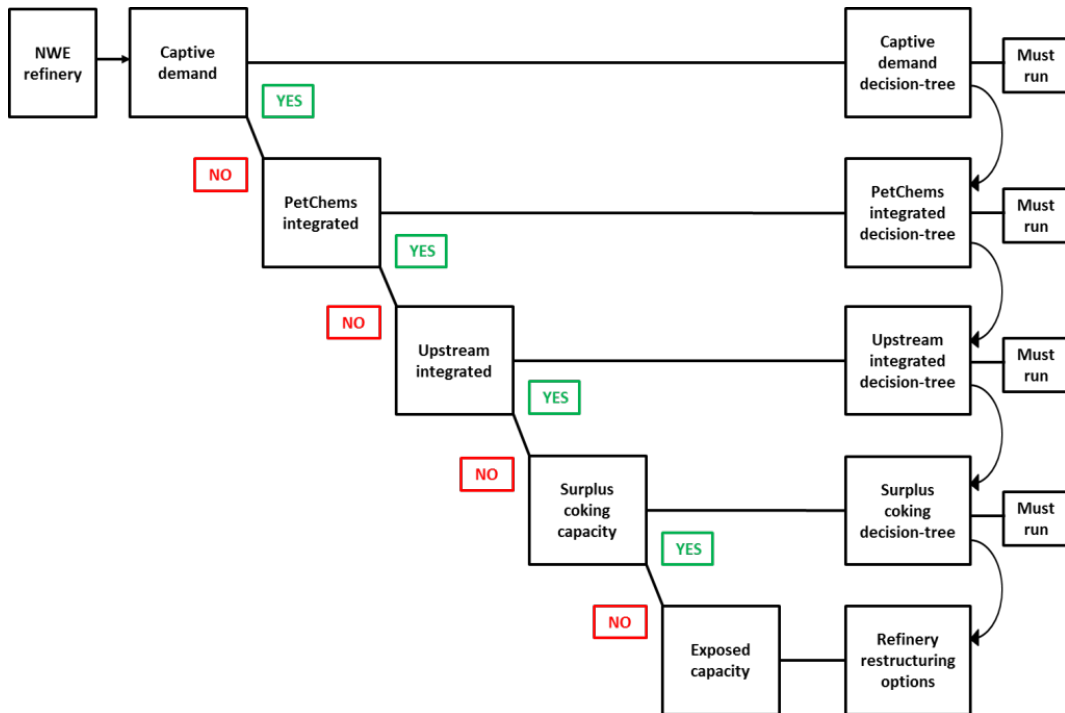


FIGURE 2.8: MAIN BRANCHES OF MUST-RUN REFINERY DECISION TREE

2.2 MUST-RUN SCENARIO – THE POST-2025 NWE REFINING LANDSCAPE

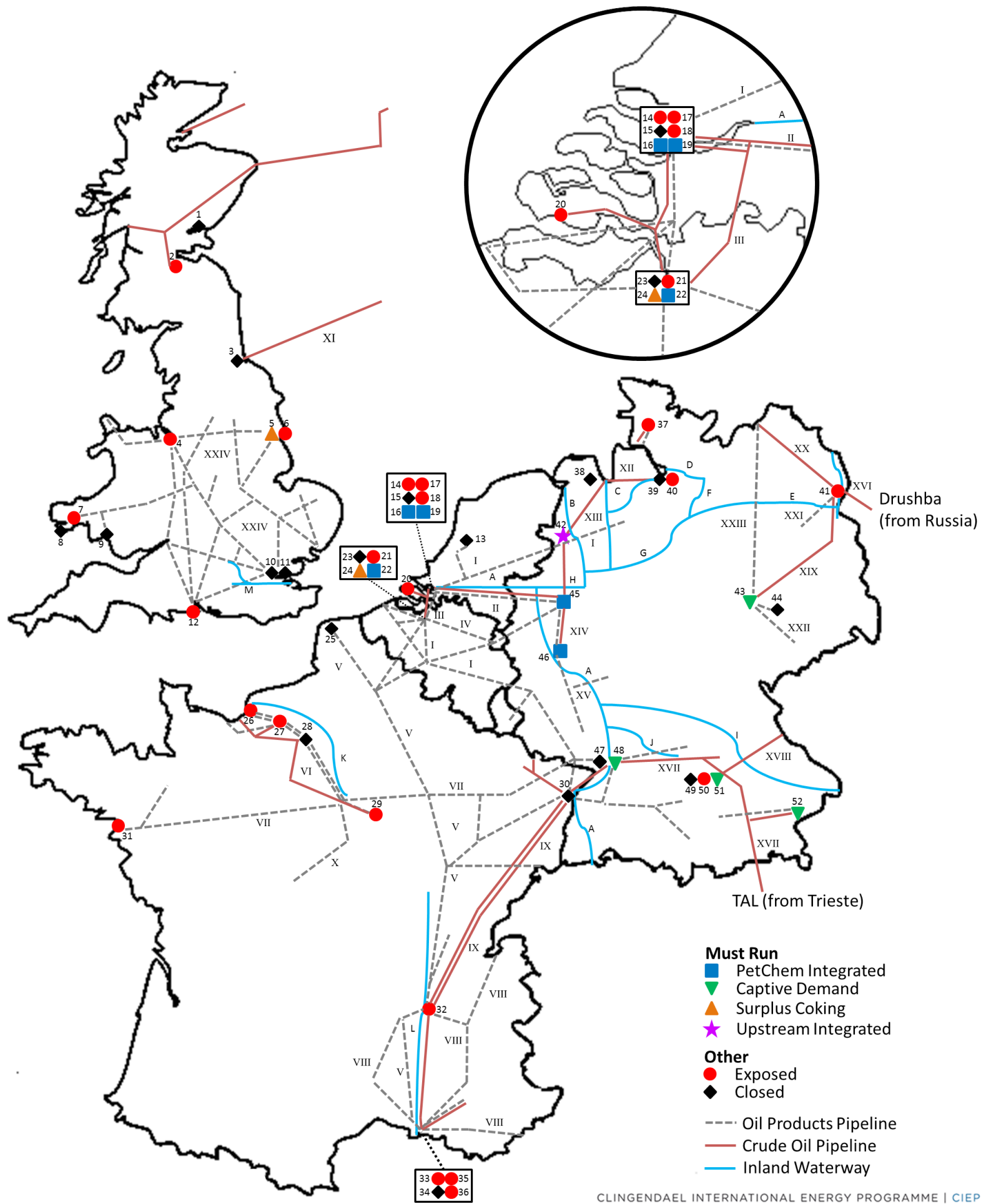
Today, 34 fuel refineries operate 7.1 Mb/d of crude distillation capacity in NWE, covering more than 90% of overall refined product demand.⁴³ Imposing must-run scenario conditions is expected to expose 22 refineries to direct competition from refined product imports (see Figure 2.10). As a result, the scenario foresees that almost 60% of NWE refining capacity may close in the longer run. This leaves 12 must-run refineries operating around 3 Mb/d of crude distillation capacity, implying that the post-2025 NWE refining sector would only cover circa 40% of overall demand (see Figure 2.9).⁴⁴

Name	Owner(s)	Must-run category	Region	CDU Capacity (Kb/d)
Antwerp	ExxonMobil	Surplus coking	ARA	320
Antwerp	Total	Petrochemicals integrated	ARA	350
Pernis Rotterdam	Shell	Petrochemicals integrated	ARA	430
Botlek Rotterdam	ExxonMobil	Petrochemicals integrated	ARA	200
Gelsenkirchen	BP	Petrochemicals integrated	Rhine-Ruhr	270
Rhineland	Shell	Petrochemicals integrated	Rhine-Ruhr	340
Lingen	BP	Upstream integrated	Rhine-Ruhr	100
MiRO	Shell/Exxon/Rosneft/Phillips 66	Captive demand	Southern Germany	320
Burghausen	OMV	Captive demand	Southern Germany	80
Bayernoil	Varo Energy/Rosneft/ENI/BP	Captive demand	Southern Germany	220
Leuna	Total	Captive demand	Northeast Germany	230
Humber	Phillips 66	Surplus coking	UK	230

FIGURE 2.9: LAST MEN STANDING IN NWE REFINING

43 Based on Eurostat (2015) figures.

44 Based on BP (2016), "Energy outlook 2035"; Exxon (2015), "The outlook for energy"; IEA (2015), "World Energy Outlook" and Wood Mackenzie 2025 refined product demand outlook figures from July 2015.



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UK

- 1: DUNDEE (AB NYNAS)
- 2: GRANGEMOUTH (PETROINEOS)
- 3: TEESIDE (PETROPLUS)
- 4: STANLOW (ESSAR)
- 5: HUMBER (PHILLIPS 66)
- 6: LINDSEY (TOTAL)
- 7: PEMBROKE (VALERO)
- 8: MILFORD (PUMA ENERGY)
- 9: LLADARCY (BP AMOCO)
- 10: SHELL HAVEN (SHELL)
- 11: CORYTON (JV)
- 12: FAWLEY (EXXON)

ARA

- 13: AMSTERDAM (MOBIL)
- 14: ROTTERDAM (GUNVOR)
- 15: ROTTERDAM (TEXACO)
- 16: ROTTERDAM (SHELL)
- 17: ROTTERDAM (KOCH)
- 18: ROTTERDAM (BP)
- 19: ROTTERDAM (EXXON)
- 20: ZEELAND (TOTAL/LUKOIL)
- 21: ANTWERP (GUNVOR)
- 22: ANTWERP (TOTAL)
- 23: ANTWERP (VITOL)
- 24: ANTWERP (EXXON)

FR

- 25: MARDYCK (TOTAL)
- 26: GONFREVILLE (TOTAL)
- 27: PORT JEROME (EXXON)
- 28: PETIT COURONNE (PETROPLUS)
- 29: GRANDPUITS (TOTAL)
- 30: REICHSTETT (PETROPLUS)
- 31: DONGES (TOTAL)
- 32: FEYZIN (TOTAL)
- 33: FOS-SUR-MER (EXXON)
- 34: BERRE L'ETANG (LYONDELL)
- 35: LAVERA (PETROINEOS)
- 36: LA MEDE (TOTAL)

DE

- 37: HEIDE (KLESCH)
- 38: WILHELMSHAVEN (HESTYA)
- 39: HARBURG (SHELL)
- 40: HOLBORN (TAMOIL)
- 41: SCHWEDT (JV)
- 42: LINGEN (BP)
- 43: LEUNA (TOTAL)
- 44: BOHLEN (STATE)
- 45: GELSENKIRCHEN (BP)
- 46: RHINELAND (SHELL)
- 47: WOERTH (MOBIL)
- 48: MIRO (JV)
- 49: INGOLSTADT (BAYERNOIL)
- 50: INGOLSTADT (GUNVOR)
- 51: BAYERNOIL (JV)
- 52: BURGHAUSEN (OMV)

PIPELINES

- I: CEPS
- II: RRP/RMR
- III: RAPL
- IV: PALL
- V: ODC
- VI: LHP
- VII: DMM
- VIII: SPMR
- IX: SPSE
- X: TRAPIL
- XI: NORPIPE
- XII: NDO

PIPELINES

- XIII: NWO
- XIV: RRP/RMR/NOW
- XV: RMR
- XVI: DRUSHBA
- XVII: TAL
- XVIII: IKL (MERO)
- XIX: MVL (DRUSHBA)
- XX: PCK
- XXI: SEEFELD-BERLIN
- XXII: MIPRO
- XXIII: RRB
- XXIV: UK SYSTEM

INLAND WATERWAYS

- A: RHINE
- B: EMS KANAL
- C: WESER
- D: ELBE
- E: ALTE ODER
- F: ELBE-SEITEN KANAL

INLAND WATERWAYS

- G: MITTELLAND KANAL
- H: RHEIN-HERNE KANAL
- I: DONAU
- J: NECKAR
- K: SEINE
- L: RHONE
- M: THAMES

2.2.1 NWE REFINING ASSET BASE PER REGION

Under must-run scenario conditions, refinery capacity reductions are concentrated in France, the UK and northern Germany. This is mainly driven by the coastal orientation of these refining centres, good availability of inland transportation infrastructure, and sub-world scale petrochemicals clusters. On the other hand, refining centres in ARA, Rhine-Ruhr, and southern Germany are more resilient. Core refineries in the ARA and Rhine-Ruhr regions benefit from deep integration with large and competitive petrochemicals clusters, and the majority of refineries in southern Germany benefit from local captive demand (see Figure 2.11).⁴⁵

As a result, the must-run scenario foresees significant variations in refined product consumption and production balances per country. As illustrated by Figure 2.11, France would have to import 100% of its refined product requirements, and the last remaining refinery in the UK would cover less than 20% of overall demand. At the same time, domestic refineries in Germany and the Netherlands continue to cover the majority of overall demand, and Belgium will even continue to have a refined product surplus.⁴⁶

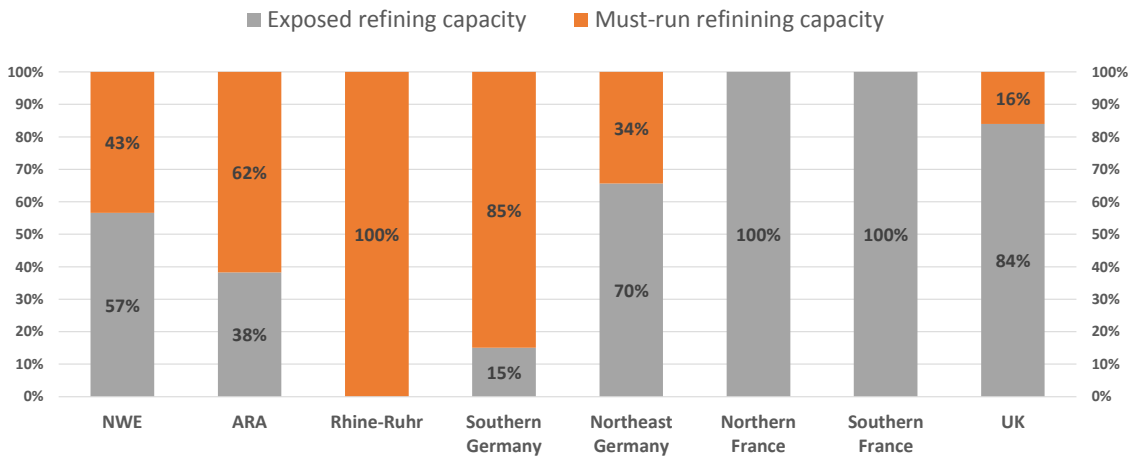


FIGURE 2.11: MUST-RUN AND EXPOSED REFINING CAPACITY SHARES PER REGION

45 The strong position of the core refineries in the ARA cluster is reflected in the high number of new investment projects that have recently been announced: e.g. the delayed coking capacity investment for Exxon Antwerp, the solvent de-asphalting investment for Shell Pernis, and the hydrocracker expansion investment for Exxon Rotterdam.

46 Based on BP (2016), "Energy outlook 2035"; Exxon (2015), "The outlook for energy"; IEA (2015), "World Energy Outlook" and Wood Mackenzie 2025 refined product demand outlook figures from July 2015.

A significant increase in average refinery size is foreseen, as closures disproportionately impact smaller refineries. Figure 2.12 shows that the increase in average refining capacity is particularly striking in the ARA region, where there is a concentration of must-run capacities at large, petrochemicals integrated sites in Rotterdam and Antwerp. This leaves a flexible layer of small-scale refineries, typically owned by trading houses, exposed to direct competition from imports.⁴⁷ The increase in northeast Germany results from the closure of the sub-scale refineries clustered around the Hamburg port area, which again hits NOCs and merchant refiners particularly hard.

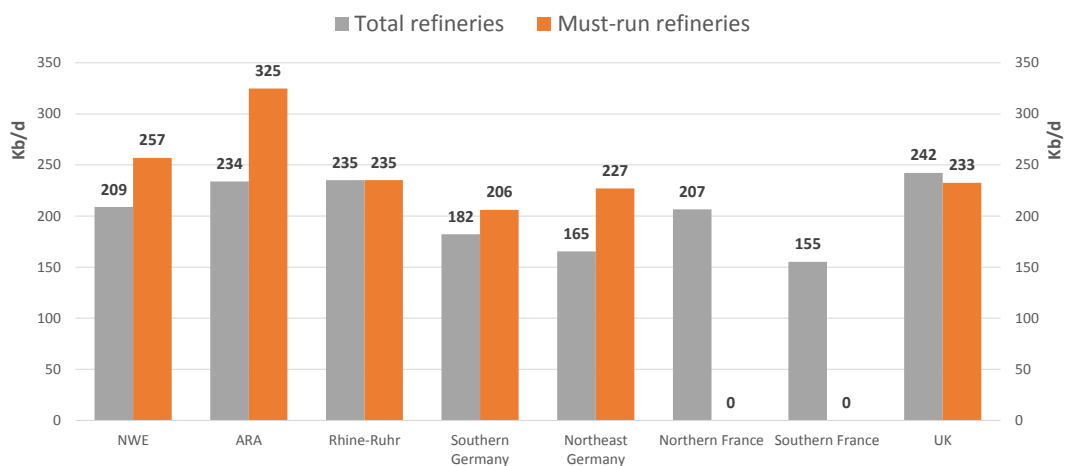


FIGURE 2.12: AVERAGE SIZE OF MUST-RUN AND EXPOSED REFINING CAPACITY PER REGION

2.2.2 NWE REFINING ASSET BASE PER OWNERSHIP CATEGORY

Today, international oil companies (IOCs) dominate the NWE refining sector, owning 21 out of 34 fuel refineries and over 60% of refining capacity. Pure play refiners, national oil companies (NOCs), and merchants own the remaining capacities in NWE.⁴⁸ Under must-run scenario conditions, the dominant position of IOCs would be further reinforced. In the long run, IOCs are expected to own 10 of the 12 must-run refineries, representing over 80% of NWE refining capacity. Pure play and merchant refiners would only retain a marginal position in the NWE refining sector, and NOC refiners are expected to exit the region altogether (see Figure 2.13).

47 The BP Rotterdam refinery, with close to 400 Kb/d of crude distillation capacity, is the exception.

48 Pure play refiners are companies that unlike IOCs only focus on the refining part of the oil supply chain. Merchant refiners are companies that combine refining activities with outsized oil trading portfolios. At times a black and white distinction between pure play and merchant refiners can be somewhat blurred.

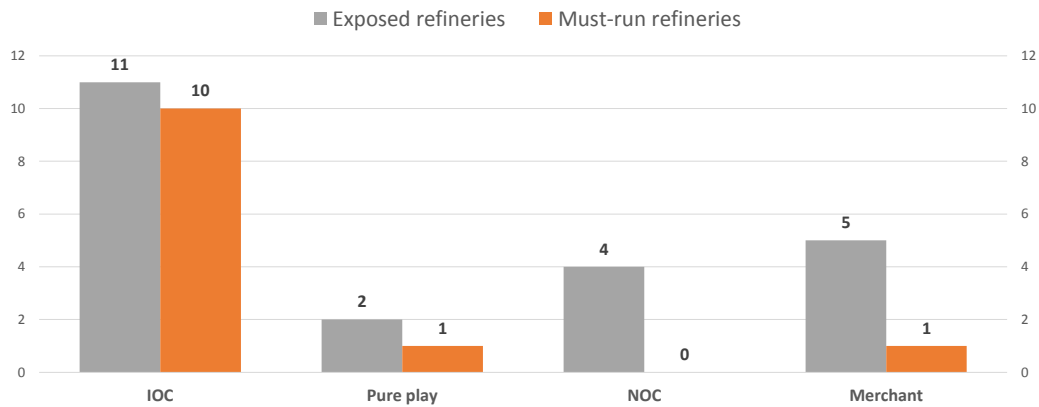


FIGURE 2.13: MUST-RUN AND EXPOSED REFINERIES PER OWNERSHIP CATEGORY

The increased dominance under must-run scenario conditions closely aligns with IOCs' strategy to be the 'last men standing' in the refining sector.⁴⁹ Over the last 15 years, IOCs have proactively restructured their portfolios, selling or closing non-core assets and focusing investments on a handful of complex and highly integrated strategic refineries. The must-run scenario shows that IOCs have likely been ahead of the curve in the NWE refining sector. Only time will tell, however, if continued investment in must-run NWE refining capacities also compares favourably to investments in equivalent source-refining capacities.

Nonetheless, there is a great divide among the IOCs that remain active in NWE refining: Total and Exxon, on the one hand, and Shell and BP on the other. Total and Exxon still have significant French and UK refining footprints, whereas Shell and BP have completely withdrawn from refining in these countries. As a result, Total and Exxon bear the brunt of IOC-owned refinery closures in the must-run scenario. Together they own 10 out of the 11 IOC-owned refineries that are expected to be exposed to direct competition from imports.

49 The terminology 'last men standing' is derived from BP's 'last man standing', see for example, "BP full year 2014 results & investor update", February 3, 2015; and "Die zukünftige Raffinerieentwicklung in Europa Vortrag bei der GESTRATA-Hauptversammlung", November, 2012.

The poor showing of, for example, merchant refiners under must-run conditions might very well be a function of assumed frictionless refinery restructuring in NWE. Nimble, cost-conscious, and trading-oriented refineries are likely best positioned to exploit inefficiencies in the NWE refinery restructuring process. In Chapter 3, barriers to exit and its implications for NWE refining are discussed in more detail.

2.2.3 NWE REFINING ASSET BASE PER MUST-RUN CATEGORY

The high proportion of petrochemicals integrated must-run refineries is explained by the presence of a large chemicals sector in NWE that has traditionally depended on refineries for feedstock supply (see Figure 2.14).⁵⁰ EU chemicals sales are still only second to those of China, and both Germany and France consistently rank in the top-10 of chemicals sales by country.⁵¹ Yet, the must-run scenario foresees that the great majority of NWE's petrochemicals integrated refineries will be exposed to direct competition from refined product imports. This is a function of both sub-world scale petrochemical units and the long run viability of several clusters in NWE. As a result, only 5 out of 22 petrochemicals integrated refineries in NWE are expected to have sufficient strategic value to secure continued investment in upgrades (see **Annexes B & C** for more details on petrochemicals integrated must-run refineries).

The relatively high number of captive demand refineries owe their position to NWE's market refining legacy (see Figure 2.14). German and French inland refineries continue to benefit from an extensive crude pipeline system that was commissioned in the heydays of the NWE market refining model.⁵² As a result, inland refineries exhibit the highest survival rate under must-run conditions, with 4 out of 11 inland refineries expected to be of strategic value. It is worth noting that all 4 must-run inland refineries are located in the south and east of Germany. As opposed to central France and the Rhine-Ruhr area, the south and east of Germany do not benefit from an extensive refined product pipeline network to rival the area's crude oil pipeline network (see **Annexes B & C** for more details on captive demand must-run refineries).

50 In 2014, in spite of a growing role for gaseous feedstocks such as ethane and LPGs, 68% of feedstock supply for European steam crackers (olefins) was naphtha-based, and the great majority of aromatics are directly derived from naphtha or pygas, a steam cracker byproduct. For more details see Petrochemicals Europe "Facts and Figures 2014".

51 For more details see the CEFIC "2014 facts and figures" report. It is worth noting that as recent as the early 2000s EU sales represented over 30% of global chemicals sales.

52 The TAL, SPSE, RRP, NWO, and Drushba crude pipelines supplying German inland refineries all trace their origins back to the 1950s and 1960s.

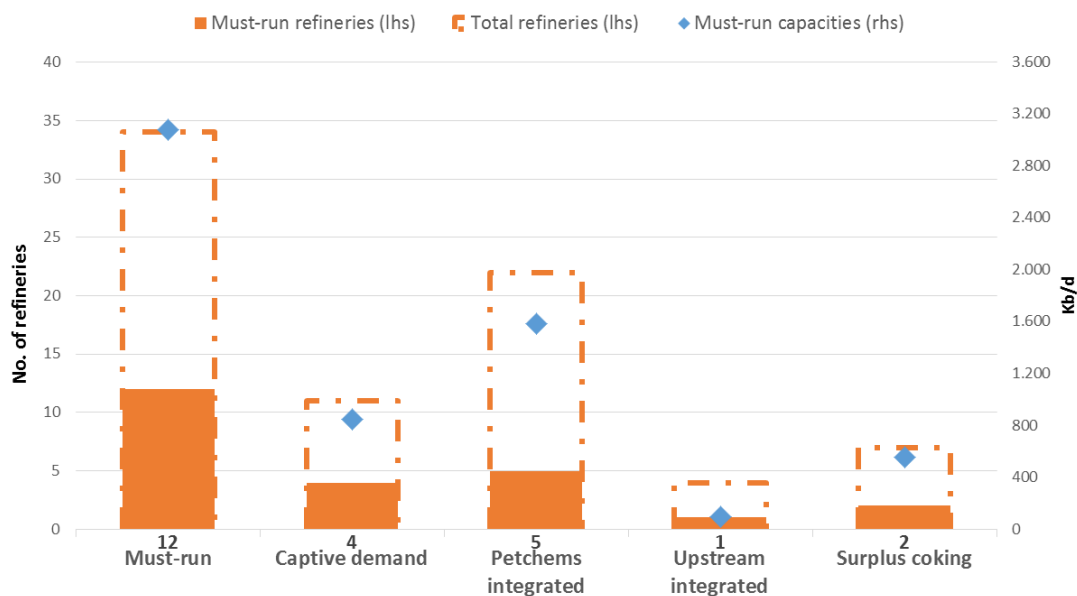


FIGURE 2.14: REFINING CAPACITIES PER MUST-RUN CATEGORY

The low proportion of upstream integrated refineries is not surprising (see Figure 2.14). NWE is a crude short region, and the limited indigenous crude oil production is concentrated in the North Sea.⁵³ Some refineries in eastern Germany do enjoy direct access to Russian crude production via the latter's extensive Drushba pipeline system. The 2012 extension of Drushba to the Gulf of Finland has, however, significantly improved Russia's crude export optionality. As a result, the two eastern German refineries with access to Drushba crude are no longer expected to derive long-term strategic value from their upstream integration.⁵⁴ Surprisingly, given NWE's limited inland oil production, there are two other candidates. The first candidate is linked to local crude supply from the Bassin Parisien, while the second is linked to local crude supply in the northwest of Germany and the east of the Netherlands.⁵⁵ Bassin Parisien crude supply, however, is too limited to provide a strategic advantage to even a small-scale refinery, leaving only one upstream integrated must-run refinery in NWE (see **Annexes B & C** for more details on upstream integrated must-run refineries).

53 Crude oil from North Sea offshore fields can easily be loaded on tankers and shipped to various refining centres in the Atlantic Basin.

54 Today, the Drushba refineries probably still obtain a \$1 – 1.5 discount per barrel compared to seaborne Urals pricing, but the availability of export alternatives to Europe has likely undermined the long-term bargaining position for these refineries.

55 The Schoonebeek oilfield (with estimated production of another 25 years) is directly connected to the BP Lingen refinery. See, for example: <http://www.nam.nl/our-activities/schoonebeek/about-schoonebeek.html>

Surplus coking refineries also thank their strategic value to historical developments in the NWE refining sector. In the past the ready access to significant bunker fuel demand from its many large sea ports has made coking capacities an unnecessary luxury for NWE refineries. In fact, only 7 out of 34 fuel refineries have coking capacity, with only two or three having sufficient capacity to be of strategic value to refining centres that need to avoid future HFO surpluses (see Figure 2.14).⁵⁶ In similar fashion to that of upstream integrated refineries, the contribution of surplus coking refineries to must-run refining capacities is therefore limited (see **Annexes B & C** for more details on surplus coking must-run refineries).

2.3 NWE MUST-RUN SCENARIO APPRAISAL

By identifying the refineries that are of critical value to NWE's clusters and supply chains, the must-run scenario aims to provide insight into the structural competitive advantages of the NWE refining sector. It cannot be ignored, however, that the must-run model has reduced the complex reality of NWE refining to only a handful of binary criteria. It is therefore important to understand both the limitations of our must-run model and the sensitivity of its scenario outcomes.

2.3.1 NWE MUST-RUN MODEL LIMITATIONS

The binary character of the must-run model aids its clarity and transparency, but it also holds the threat of oversimplification. Two important limitations of our model stand out: (1) the four must-run categories are **not exhaustive**; and (2) the criteria across different must-run categories are **not additive**. In reality, the set of refinery characteristics combinations that could provide structural advantages to NWE refineries is more extensive than has been represented in our must-run model.

The must-run model exclusively focuses on strategic considerations and ignores operational refinery performance as a source of structural competitive advantage vis-à-vis refined product imports. This is an important limitation because operational refinery performance in terms of, for example, first-time right manufacturing, safety, unplanned outages, or energy efficiency, not only greatly impacts costs but is also a key consideration in refinery investment decisions.⁵⁷ Unfortunately, the sensitive and private nature of individual refinery performance data precludes us from incorporating such considerations in the must-run model.

⁵⁶ One of these, the Exxon Antwerp refinery, is installing new delayed coking capacities as we speak. The decision to add such capacity has likely been a function of the good availability of hydrogen in the Antwerp cluster, as refineries require increasing amounts of hydrogen to supply mandated low sulfur fuels.

⁵⁷ Based on feedback in interviews with several industry participants.

Since the emergence of liquid spot markets for crude and oil products in the 1970s/80s, leveraging refinery flexibility through spot trading has been critical to the bottom line of refinery operations. Superior operational flexibility to play the market may, therefore, provide a refinery with structural competitive advantages. The 400 Kb/d BP Rotterdam refinery may be a case in point. Its refinery complex combines a very high degree of operational flexibility with a beneficial location at the heart of the ARA trading hub.⁵⁸ In similar fashion to that of a refinery's operational performance, however, it is very difficult to determine on the basis of public data alone the extent to which a refinery derives structural and above average added value from its trading performance.

In the must-run model we have only identified one refinery configuration, surplus coking capacity, which is likely to provide a refinery with long-term strategic value and thus with structural competitive advantages vis-à-vis refined product imports. Nevertheless, future oil demand developments in NWE have the capacity to strengthen or undermine specific refinery configurations. Widespread adoption of on-board sulfur dioxide scrubbers in the shipping industry could, for example, reduce cheap supplies of third party residue oil and leave surplus coking capacities underutilised.⁵⁹ At the same time, 'Dieselgate' could, for example, stem the destruction of gasoline demand in NWE, benefiting refineries with large and competitive catalytic cracking configurations.⁶⁰

Last but not least, the strict boundaries demarcating each must-run refinery category prevent the appropriate assessment of so-called hybrid refineries, combining several refinery characteristics from each must-run category. Some refineries may not achieve must-run status from specialisation in one category, but rather gain structural competitive advantage by combining added value from each category. To some extent we aim to address this shortcoming in the next section, covering the sensitivity of the must-run scenario outcomes. Nevertheless, following extensive discussions with several industry participants we do not believe that the limitations of our model will materially impact the outcomes of the must-run scenario.

58 Interviews with several industry participants have revealed a common understanding that the BP Rotterdam refinery is indeed highly flexible in both its crude intake and its blending capabilities. Also aided by its large integrated storage complex, with a capacity close to 4M cubic meters.

59 To some extent this is already happening. See, for example, HIS Maritime & Trade (2014), <http://blog.ihs.com/q14-scrubbers-gain-favor-as-shipowners-gird-for-sox-regulations>

60 See, for example, BBC (2015), <http://www.bbc.com/news/business-34324772>; or Goldman Sachs (2015), "Dieselgate shifts opportunity set towards suppliers".

2.3.2 NWE MUST-RUN SCENARIO SENSITIVITY

This section discusses the results from relaxing some of the more stringent must-run refinery characteristics, revealing second-best must-run refinery candidates that fall just short of enjoying a strategic position in the NWE refining sector. This does not imply that we consider these criteria less critical in determining the strategic value of a refinery. Performing a sensitivity analysis merely allows us to entertain the real possibility that one or more of our premises in the must-run scenario do not hold, and to assess how this would impact the post-2025 NWE refining landscape (see Figures 2.15 and 2.17).

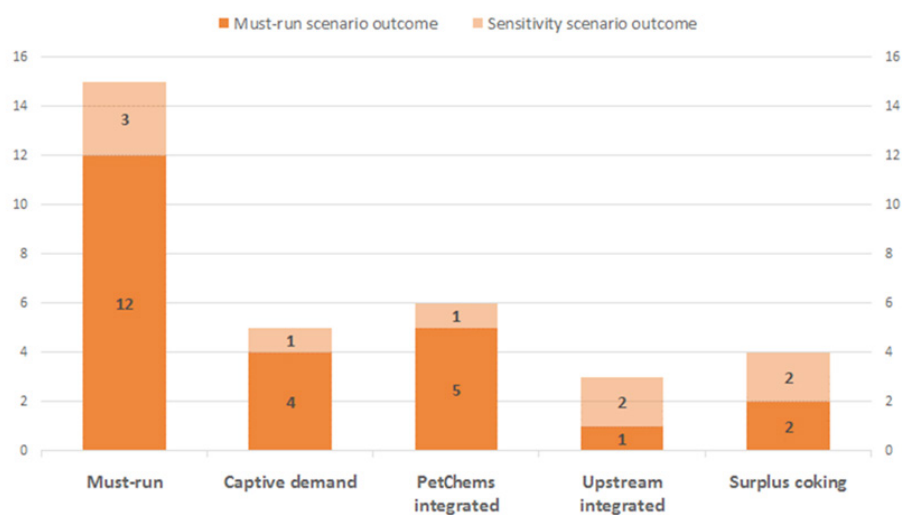


FIGURE 2.15: MUST-RUN SCENARIO SENSITIVITY⁶¹

In the **captive demand category**, relaxing the criterion that refining capacity has to be locally intra-marginal reveals the Gunvor Ingolstadt as a second-best refinery. The Ingolstadt refinery failed to achieve must-run status because long-term southern German gasoline demand is expected to fall short of local refinery supply (see **Annex B**). Nevertheless, the recent upset around Volkswagen’s emission tests scandal illustrates how assumptions on long-term trends (i.e., a growing gap between gasoline and middle distillates demand in Europe) could be overtaken by events.⁶² If ‘Dieselgate’ results in the removal of favourable tax treatment for diesel, long-term

⁶¹ It is important to note that the number of second-best refineries per category do not add up to a total for NWE, because in some cases the second-best refinery in one category is a must-run refinery in another category.

⁶² See, for example, BBC (2015), <http://www.bbc.com/news/business-34324772>; or Goldman Sachs (2015), “Dieselgate shifts opportunity set towards suppliers”.

rebalancing between diesel and gasoline demand could very well take place. In fact, a reversal in the growing gap between German gasoline and middle distillates demand would likely alleviate future joint production constraints for all captive demand refineries in the south and east of Germany (see Figure 2.16).

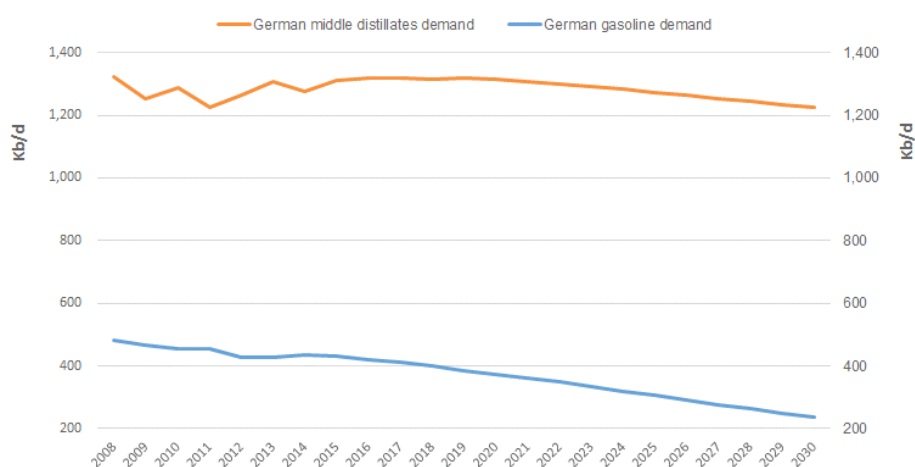


FIGURE 2.16: GERMAN GASOLINE VS MIDDLE DISTILLATES DEMAND OUTLOOK⁶³

In the **petrochemicals integrated refinery category**, relaxing the steam cracker feedstock flexibility criterion reveals the Total/Lukoil Zeeland refinery as a second-best must-run candidate. Until 2009, Dow Chemical-owned a 45% stake in the Zeeland refinery, providing its steam cracker complex in Terneuzen with a degree of backward integration through a direct naphtha pipeline connection.⁶⁴ In combination with its outsized hydrocracker and its function as a direct crude outlet for Lukoil, its Russian co-owner, the Zeeland refinery is likely to withstand competition from refined product imports longer than most in the NWE refining sector.

Surprisingly, the petrochemicals integrated category outcomes are not sensitive at all to lowering the steam cracker and aromatics capacity cut-offs by 25%. Relaxing the aromatics capacity assumption only reveals BP's Gelsenkirchen refinery, which is already a must-run refinery on the back of its steam cracker integration. Furthermore, relaxing the steam cracker capacity assumption does not reveal any second-best

63 Based on BP (2016), "Energy outlook 2035"; Exxon (2015), "The outlook for energy"; IEA (2015), "World Energy Outlook" and Wood Mackenzie 2025 refined product demand outlook figures from July 2015.

64 Due to the small size of the Zeeland refinery, the Dow Terneuzen complex will likely remain dependent on feedstock imports. With less than 150 Kb/d of CDU capacity, the refinery is simply too small to supply all Dow Terneuzen's feedstock requirements.

refinery candidates, because refineries outside ARA and Rhine-Ruhr are handicapped by a lack of long-term viable petrochemicals clusters (see **Annex B**).⁶⁵

In the **upstream integrated refinery category**, relaxing the export optionality criterion places the two Drushba refineries back on the radar. Total’s Leuna refinery is already a captive demand must-run refinery, but PCK Schwedt is an excellent example of a refinery that only narrowly falls short of enjoying a strategic position. It is an advanced refinery with direct access to Russian pipeline crude as well as the relatively sheltered Berlin demand region, and in 2015 it became majority owned by Rosneft, Russia’s biggest oil company.

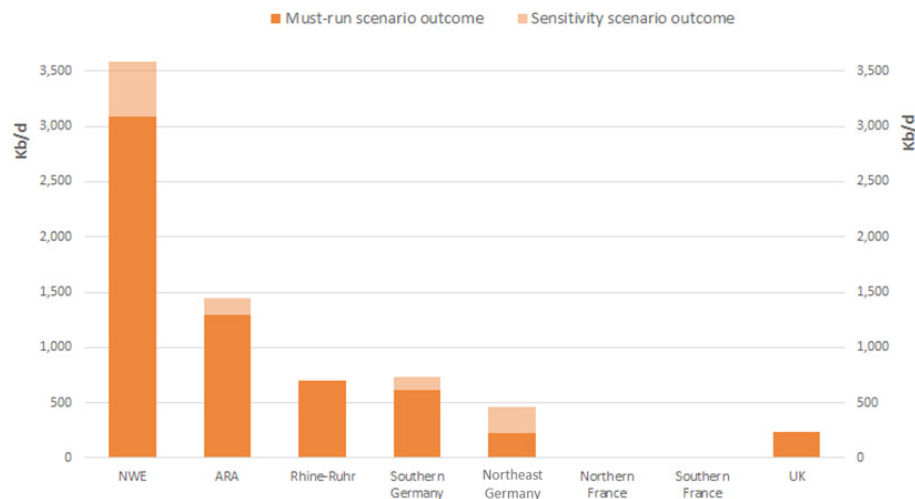


FIGURE 2.17: MUST-RUN SCENARIO SENSITIVITY PER REGION

In the **surplus coking refinery category**, relaxing the absolute capacity cut-off criterion would double the number of surplus coking refineries in NWE. Exxon’s Rotterdam flexi-coking capacity falls just short of 50 Kb/d, but in combination with Exxon’s new delayed coking capacity in Antwerp it is likely critical to avoid HFO exports from the ARA and Rhine-Ruhr regions in the long run. Similarly to Exxon’s Rotterdam refinery, the OMV Burghausen refinery does not depend on its outsized coking unit for its strategic value. Nevertheless, OMV’s Burghausen coking capacity is also likely to make an important contribution to avoiding HFO exports from the captive demand region of southern Germany.

65 The gap between the Antwerp-Rotterdam and Rhine-Ruhr clusters and the other NWE clusters is so significant that relaxing the criteria for long-term cluster viability would not be sensible (see Figure B.2). Moreover, relaxing the cluster viability would not reveal any second-best refinery candidates, because the steam cracker and aromatics units outside ARA and Rhine-Ruhr still remain sub-scale.

Overall, the must-run model using only four refinery categories has proven capable of providing substantial insight into the structural competitive advantages of the NWE refining sector. Limiting the model to just four categories benefits clarity and transparency, but it comes at a risk of oversimplifying the dynamics of the NWE refining sector. The model is also specifically focused on the external strategic position of a refinery, and it ignores important internal considerations such as operational and safety performance.⁶⁶ This might be the reason why refineries that are clearly considered to be core assets by their owners, such as Exxon's Fawley and BP's Rotterdam refinery, are classified as exposed refineries in our must-run model.

⁶⁶ Unfortunately, but for understandable reasons, internal refinery performance data is not publicly available.

3 REFINERY RESTRUCTURING IN NWE

Under must-run scenario conditions, 22 NWE refineries are expected to be exposed to direct competition from refined product imports (see Figure 3.1). This would set the stage for ongoing restructuring in the NWE refining sector over the next decade. However, NWE refining is subject to significant barriers to exit, impacting the economic logic of the restructuring process. Arguably, the common denominator in historical refinery restructuring cases has been the aim to avoid a complete refinery site closure at almost any cost. In this chapter we therefore aim to identify the main barriers to exit in NWE refining and clarify their role in past refinery restructuring cases. In section 3.1, the overall barriers to exit for NWE refineries is discussed. Subsequently, section 3.2 provides an overview of selected historical restructuring cases, dividing them into 5 generic restructuring options available to NWE refiners. Finally, section 3.3 attempts to establish a hierarchy among the different restructuring options that are available to NWE refinery site owners.

3.1 BARRIERS TO EXIT IN NWE REFINING

NWE refineries that face the prospect of restructuring encounter two major barriers to exit: environmental clean-up costs and political intervention. The former is a function of the increasingly stringent environmental legislation that has been enacted since the 1970s, and the latter is a function of the impact of refinery closures on local economic activity and security of supply.⁶⁷ Apart from these external barriers to exit, an internal barrier to restructuring is the negative impact that the recognition of stranded assets can have on a refiner's balance-sheet. Accordingly, a complete closure of a refinery site in NWE is associated with significant cash outlays, political friction and reduction of shareholder value.

3.1.1 ENVIRONMENTAL CLEAN-UP COSTS

The size, duration and complexity of refining activities result in significant above- and below-ground contamination. NWE legislation has installed a 'duty-to-care' for companies, requiring refiners to minimise pollution and return a contamination-free site after termination of the refining activities. This includes the cleaning of any mobile and immobile contamination and the demolition of all existing structures

67 In 1972 the OECD instigated the 'polluter pays' principle. See, for example: "Polluter-Pays-Principle", OECD Analyses and Recommendations – Environment Directorate (1992).

before the owner is allowed to vacate the site.⁶⁸ The distinction between above- and below-ground contamination is important. The cost of demolishing above-ground buildings and infrastructure is relatively modest and partly offset by the salvage value of the equipment and reclaimed steel or scrap.⁶⁹ In contrast, remediation costs for below-ground contamination of the soil and groundwater are very significant, constituting the majority of the clean-up cost for a refinery site.⁷⁰

Clean-up costs tend to increase with age, size and complexity of refining operations, whereas the future use of the site determines the extent of clean-up that is required. If the land will be used for residential purposes, both mobile and immobile contamination have to be fully remedied, leading to maximum clean-up costs. If the designated purpose for the land remains industrial use, a less extensive clean-up of immobile contamination is generally required. And in the case of future use as a landfill, generally only containment of immobile contamination is required.⁷¹

Contamination of a refinery site is heterogeneous and corresponds more or less with the production set-up of a refinery. Various common forms of contamination encountered on a refinery site include aromatics, heavy metals, asbestos, and other hydrocarbons. Often large quantities of topsoil need to be excavated and rinsed on-site in order to remediate the more heavily polluted areas.⁷² However, each area requires different remediation methods, resulting in customised and costly clean-up plans.⁷³ All in all, even if the land remains in use for industrial purposes, total clean-up and remediation of a refinery site can easily add up to several hundred million euros.⁷⁴ This ballpark figure is also supported by recent refinery site closures in Europe, although exact and comparable figures are hard to come by (see section 3.2.5. for more details).

68 EC directive 2004/35/EC: Environmental Liability Directive. This directive states that the polluter remains liable for any environmental pollution it has caused and hence has an obligation to clean any caused pollution.

69 There are even some cases in which assets have been sold or reused entirely: The Mobil refinery in Wörth was sold and reused in India, and the Rhineland Shell refinery reused some of the decommissioned units from its closed Shell Haven site. Also, the decommissioned Wilhelmshaven refinery is up for sale by the current owner Hestia International, following its conversion into a storage terminal Sources: <http://www.hydrocarbons-technology.com/projects/nagarjuna-oil-corporation-cuddalore-tamil-nadu/> and <http://www.wzonline.de/nachrichten/wilhelmshaven/detail/artikel/umbau-zur-tankfarm-fast-abgeschlossen.html>

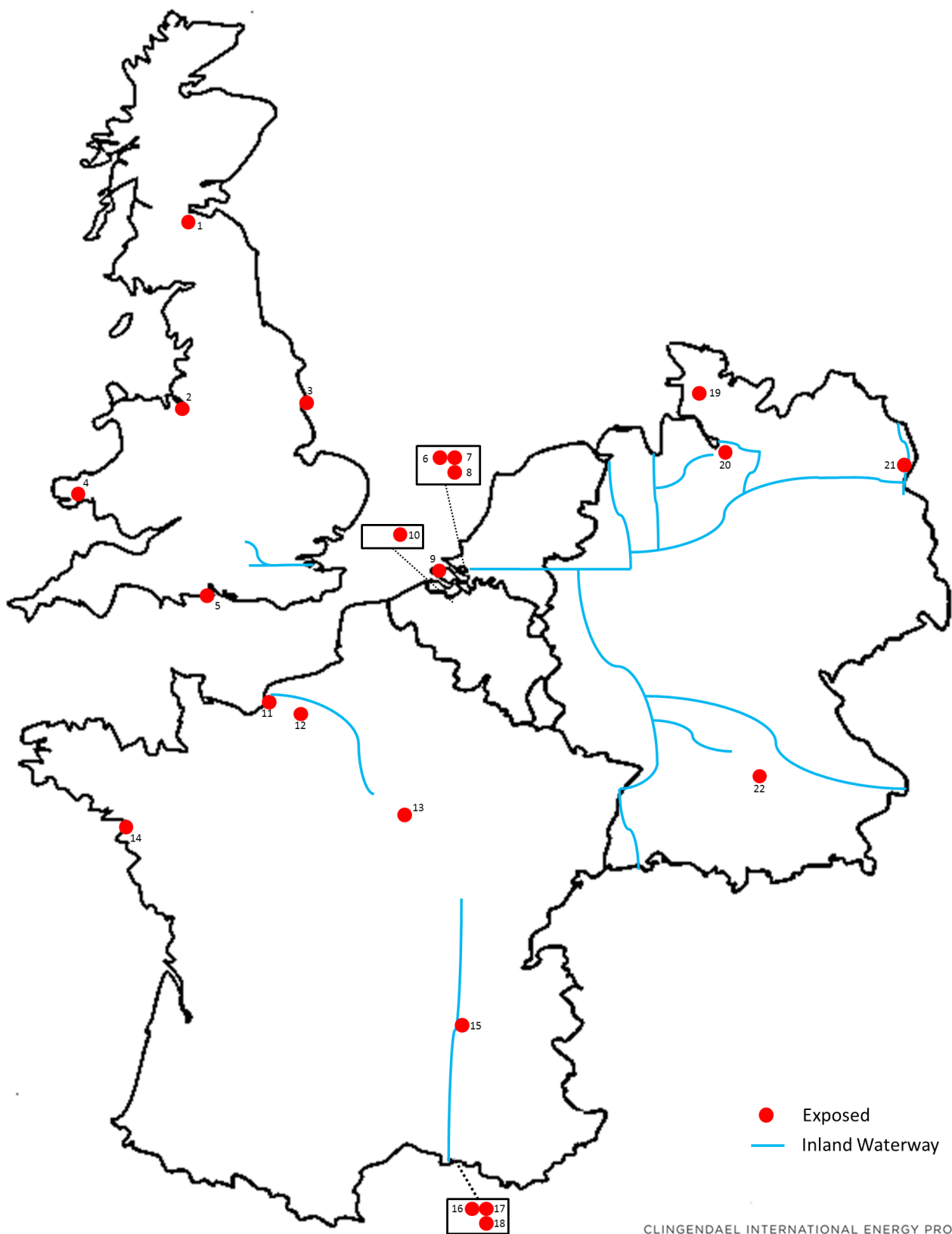
70 Groundwater remediation can require up to 30 years of treatment and monitoring, usually via an on-site plant, whereas soil remediation usually includes excavations up to 8m followed by extensive soil treatment.

71 Ecorys (2012), "A Sustainable Future for Curacao – Final Report". It is worth noting that higher clean-up costs are also likely to be offset by higher land values.

72 However, clean-up costs are strongly influenced by the structure of the soil. A layer of clay, for example, will help to contain hydrocarbons, resulting in less extensive below-ground contamination.

73 Various reports from Valgo (2014), Brownfields (2013), DCMR (1996-2006), Ecorys (2012) and interviews by authors.

74 This range is supported by several interviews with experts in the field. See Ecorys (2012), "A Sustainable Future for Curacao – Final Report". Total cost were estimates at €513 mln, including isolation, removal and treatment of toxic soil/water and the minimisation of landfills. Note that the Curacao case is very specific and might not be representative.



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UK

- 1: GRANGEMOUTH (INEOS)
- 2: STANLOW (ESSAR)
- 3: LINDSEY (TOTAL)
- 4: PEMBROKE (VALERO)
- 5: FAWLEY (EXXON)

ARA

- 6: ROTTERDAM (GUNVOR)
- 7: ROTTERDAM (KOCH)
- 8: ROTTERDAM (BP)
- 9: ZEELAND (TOTAL/LUKOIL)
- 10: ANTWERP (GUNVOR)

FR

- 11: GONFREVILLE (TOTAL)
- 12: PORT JEROME (EXXON)
- 13: GRANDPUITS (TOTAL)
- 14: DONGES (TOTAL)
- 15: FEYZIN (TOTAL)
- 16: FOS-SUR-MER (EXXON)
- 17: LAVERA (PETROINEOS)
- 18: LA MEDE (TOTAL)

DE

- 19: HEIDE (KLESCH)
- 20: HOLBORN (TAMOIL)
- 21: SCHWEDT (JV)
- 22: INGOLSTADT (GUNVOR)

FIGURE 3.1: MAP OF EXPOSED REFINERIES IN NWE

Due to the private nature of clean-up cost, the small sample size, and great diversity in NWE refining operations, the above-mentioned figures should be used with caution. Nevertheless, the dearth of complete refinery site closures in NWE, in spite of a significant number of restructuring cases, does seem to suggest that environmental clean-up cost are a real and substantial barrier to exit.

3.1.2 POLITICAL INTERVENTION

The economic footprint of a refinery and its impact on security of supply are the two main reasons for governments to intervene in refinery restructurings. Nonetheless, concerns about accountability for the environmental clean-up costs as discussed in the previous section cannot be underestimated as a motive for government intervention as well.⁷⁵

Refining activities have a relatively large economic footprint and involve a medium sized work force. Direct employment of a refinery averages around several hundred well-paid and skilled jobs (depending on its size and complexity), and including indirect employment may increase this figure by a factor of four to eight.⁷⁶ Also, the economic contribution of a refinery to secondary business activity is significant, leading economic rents to trickle down. At the same time, despite Europe's aim to reduce fossil fuel consumption, secure and adequate refined product supply remains crucial to almost all economic and military activities in Europe. In fact, for all intents and purposes Europe's transport sector is almost exclusively dependent on oil.⁷⁷ In this light, government intervention can be expected to ensure that security of supply concerns effectively become a barrier to exit for NWE refineries.

The 'polluter pays' principle equips governments with the legal framework to hold refinery owners accountable for the clean-up of refining sites. Yet governments also have to contend with the financial ability of stand-alone refiners to absorb these clean-up costs. A laissez-faire policy may risk leaving governments to deal with 'idled polluted sites' which lack remediation plans and adequate financial resources. In this light, governments may find it more expedient to intervene and support ongoing refining activities, emphasising the protection of local economic activity and jobs,

75 The reluctance of Mobil to remediate its Wörth refining site forced local government to intervene (see sections 3.2.4 and 3.2.5).

76 Depending on its upstream and downstream integration, indirect employment may range from as high as 10,000 (Grangemouth) or as low as 1,500 (Donges). Interviews within the industry reveals that on average this number is on the lower end of the range, depending on accounting methods.

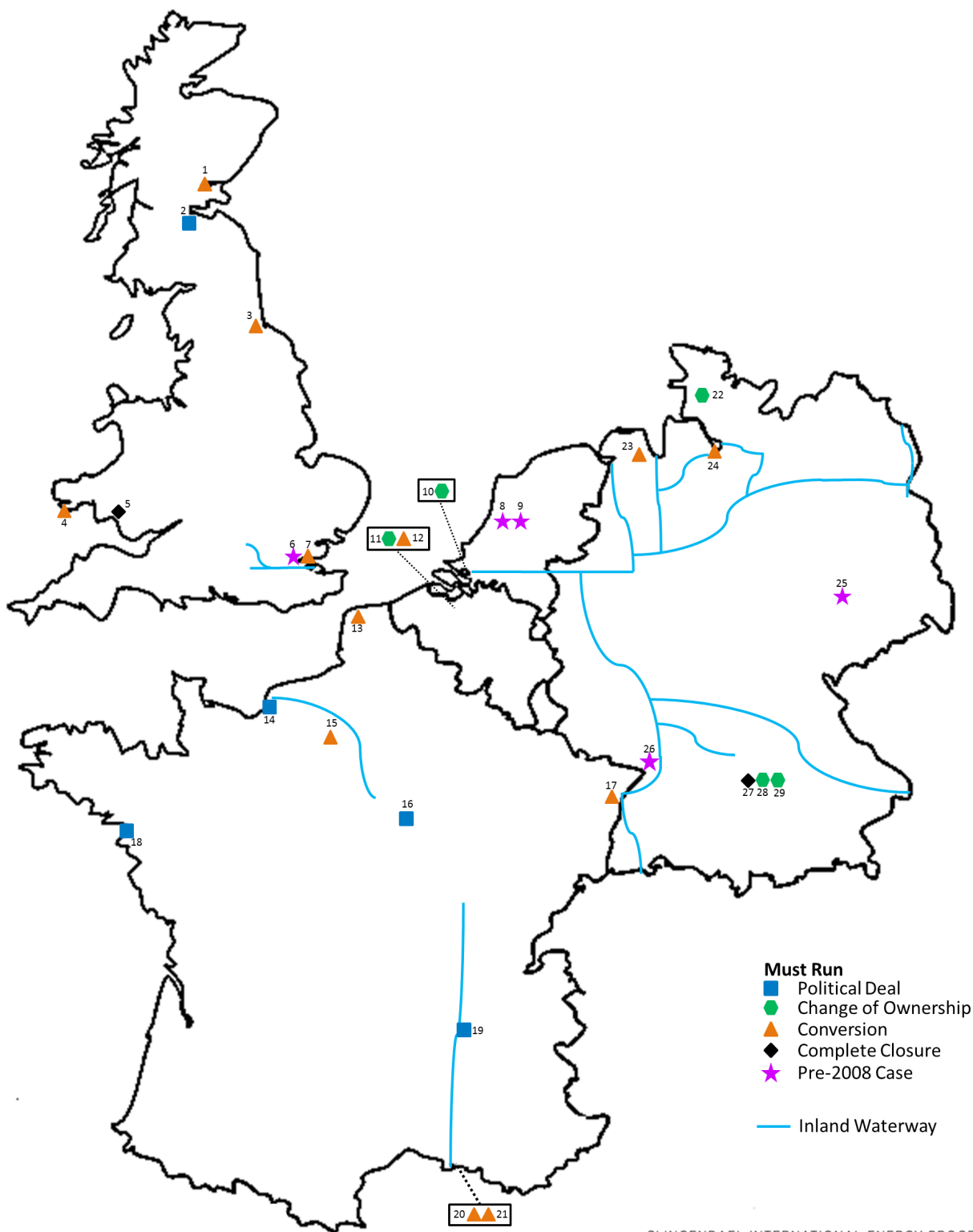
77 Oil derived fuels account for 93% of total fuel demand in EU transport (2013), <http://www.eea.europa.eu/data-and-maps/indicators/transport-final-energy-consumption-by-mode/assessment-5>

instead of dealing with the public relations nightmare of bailing out the polluter when environmental clean-up costs turn out to be prohibitive.

The economic footprint, security of supply concerns, and the extent of environmental clean-up costs combine to provide a strong incentive for governments to support and retain local refining activities. Accordingly, political intervention is considered another real and substantial barrier to exit in the NWE refining sector.

3.2 HISTORICAL RESTRUCTURING CASES

History shows a diverse set of refinery restructuring cases in NWE. Most cases fall into one or more of the following five categories: (1) Political deals; (2) Merchant refining deals; (3) Conversions; (4) Site mothballing; or (5) Complete closure (see Figure 3.2). To get a better understanding of the restructuring options available to NWE refiners, the following section aims to discuss some of the recent cases in more detail. These cases provide a good benchmark for restructuring both because identical barriers to exit were encountered and because the refineries involved share similarities with the 22 exposed refineries (see **Annex D**).



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UK

- 1: DUNDEE (AB NYAS)
- 2: GRANGEMOUTH (INEOS)
- 3: TEESIDE (PETROPLUS)
- 4: MILFORD (PUMA ENERGY)
- 5: LLANDARCY (BP AMOCO)
- 6: SHELL HAVEN (SHELL)
- 7: CORYTON (PETROPLUS)

ARA

- 8: AMSTERDAM (MOBIL)
- 9: AMSTERDAM (SHELL NTC)
- 10: ROTTERDAM (GUNVOR)
- 11: ANTWERP (GUNVOR)
- 12: ANTWERP (VITOL)

FR

- 13: MARDYCK (TOTAL)
- 14: GONFREVILLE (TOTAL)
- 15: COURONNE (PETROPLUS)
- 16: GRANDPUITS (TOTAL)
- 17: REICHSTETT (PETROPLUS)
- 18: DONGES (TOTAL)
- 19: FEYZIN (TOTAL)
- 20: BERRE (LYONDELL)
- 21: LA MEDE (TOTAL)

DE

- 22: HEIDE (KLESCH)
- 23: WILHELMSHAVEN (HESTYA)
- 24: HARBURG (SHELL)
- 25: BOHLEN (STATE-OWNED)
- 26: WÖRTH (MOBIL)
- 27: INGOLSTADT (BAYERNOIL (JV))
- 28: INGOLSTADT (GUNVOR)
- 29: BAYERNOIL (JV)

FIGURE 3.2: MAP OF HISTORICAL RESTRUCTURING CASES

3.2.1 POLITICAL DEALS

The strategic position of refining activities in the economy means that local and national politics often play an important role in restructurings. In some cases, politics is the dominant factor in deciding the outcome of the restructuring process, resulting in a political deal between the various stakeholders to ensure that refining activities continue. Two cases in the first half of this decade stand out, providing a good illustration of the role of politics in NWE refinery restructurings. In 2014 Petroineos used its leverage as the owner of Scotland's last refining complex to renegotiate labour costs with the unions and extract financial support from the UK government. Four years prior to that, in 2010, the reverse had happened, when Total was strong-armed by French unions to keep all its remaining refineries in France open for at least another 5 years.

In Scotland, declining demand, increasing costs and falling feedstock supply placed significant pressure on the competitive position of the Grangemouth refinery, providing a credible closure threat. Since the Dundee refinery closure in 2014, Grangemouth is Scotland's last remaining refinery. It covers 70% of overall Scottish fuel demand, and together with the adjacent chemicals site represents a direct workforce of 1,400 and indirectly supports 10,000 jobs, accounting for 4% of Scottish GDP.⁷⁸ As a result, the Grangemouth owners were able to claim that its operations were critical to the local economy.

Rescue plans were blocked by unions being unwilling to lower wage and pension standards, jeopardising 4% of Scottish GDP at a time that a highly contentious referendum on Scottish independence was being considered.⁷⁹ In an effort to keep Britain united, the UK government decided to drop its support for the union's cause, paving the way for labour cost restructuring.⁸⁰ In addition, the government granted a loan guarantee to Ineos, the owner of the petrochemicals site.⁸¹ Backed by the credit of the UK government, Ineos was able to negotiate favourable terms for the £230 mln it required to fund new investments. Both measures aimed to protect local economic activity and jobs, and to assuage local security of supply concerns.

78 After decades of BP ownership, today the refining complex is owned by Petroineos, which is a joint venture between Ineos and PetroChina. Nevertheless, the chemicals site is owned by Swiss-based Ineos and the combined site is operated by Ineos.

79 BBC (October 25, 2013), "Why Grangemouth matters".

80 By dropping support of the unions' claim, the UK government helped save jobs and signalled continued support for Scottish economy. As Ineos' threat of closure was credible, continued support for unions would have led to contrary results.

81 The loan guarantee was granted to Ineos for the construction of an ethane facility (i.e., importing, storing and processing of US shale gas) on its chemicals site. See: <http://www.theguardian.com/business/2014/jul/17/ineos-230m-loan-guarantee-shale-gas-facility-grangemouth>

In 2010, overcapacity in the French market severely depressed refining margins. In response, Total, owning 6 of the 11 remaining refineries, decided to permanently cease refining activities at its Dunkirk/Mardyck site and convert it to a storage terminal and educational centre.⁸² A local French court approved Total's social plan and provided them with a 'dismissal visa', allowing them to proceed with the refinery restructuring.⁸³ Nevertheless, unions, supported by strong French employment laws and Total's large asset base in France, challenged Total's license to operate, using their political leverage to constrain further refinery closures in spite of depressed refining economics. Subsequently, co-ordinated strikes at all 6 of Total's French refineries forced government intervention, brokering a political deal to end the strikes in return for a five-year moratorium on restructuring at Total's remaining French refineries.⁸⁴

When the moratorium ended in 2015, Total opted for a less radical restructuring approach. Its recent announcement to close the La Mède refinery was accompanied by an elaborate plan to convert the site to a bio-refinery and storage terminal, preserving employment in comparison to alternative restructuring options.⁸⁵ Simultaneously, Total announced a €400 mln investment in its Donges refinery, bolstered by a pledge from the government to provide financial support for the rerouting of an on-site railway.⁸⁶ Clearly, with its 'La Mède approach', Total has learned from past experience and negotiated a political deal in the background before announcing rigorous restructuring plans.

Both the Grangemouth and Total cases show that political deals in various guises can have a significant impact on the restructuring process. Political pressure can work against a refinery owner, forcing the owner to re-evaluate its restructuring decisions, or it can work in favour of a refinery owner, forcing governments to step in and support ongoing refining activities. Either way, the result of political intervention is a prolongation of economic activities at a refinery site, postponing complete closure and associated remediation costs.

82 The six Total SA refining sites in France include: Dunkirk (137 Kb/d), Donges (230 Kb/d), Gonfreville (247 Kb/d), La Mède (158 Kb/d), Grandpuits (101 Kb/d) and Feyzin (117 Kb/d). See, for example, Total (2010) "Total Announces to repurpose its Dunkirk Refinery Site", <http://www.total.com/en/media/news/press-releases/total-announces-plan-repurpose-its-dunkirk-refinery-site>

83 As Total agreed to convert the Mardyck site into a research/training facility, several hundred jobs were maintained, mitigating social impact.

84 <http://www.argusmedia.com/pages/NewsBody.aspx?id=726655&menu=yes>

85 Total's French Refining Roadmap. Source: <http://www.total.com/en/media/news/press-releases/totals-french-refining-roadmap-upgrade-donges-and-transform-la-mede>

86 Rose, Michael (2015), <http://af.reuters.com/article/energyOilNews/idAFFWN13008T20151105>

3.2.2 MERCHANT REFINER DEALS

There are several cases in NWE where traditional refinery owners have sold refining activities to new entrants, promising to change the business model and turn around struggling operations. Recent examples have been the entry of oil trading houses such as Gunvor, Vitol, and Klesch. Prior to the great recession, Petroplus was the most active player in buying up marginal refineries across NWE. Figure 3.3 shows that, in spite of the Petroplus bankruptcy in 2012, the footprint of these so-called merchant refiners is still substantial in NWE.

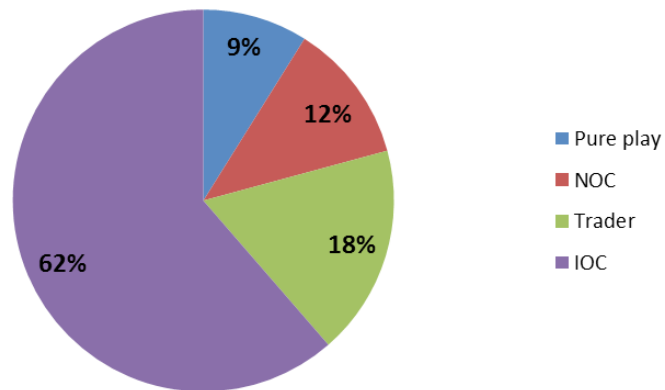


FIGURE 3.3: NWE REFINERY OWNERSHIP PER OWNERSHIP CATEGORY

At its peak, Petroplus operated seven refineries in NWE.⁸⁷ In contrast to traditional refiners, Petroplus used spot market trading and significant leverage to enhance refinery flexibility and profitability.⁸⁸ When refining market conditions turned sour following the great recession, Petroplus' use of leverage undermined its business model, forcing it to sell off assets and eventually declare bankruptcy in 2012. The emergence of a political deal to preserve Petroplus' refining activities was complicated by the diverse asset portfolio that they operated. As a result, after Petroplus' bankruptcy, many of its remaining refining operations were either closed, converted, or sold to oil trading houses such as Gunvor.

87 Antwerp (Belgium), Coryton and Teesside (UK), Petit Couronne and Reichstett (France), Ingolstadt (Germany), Cressier (Switzerland).

88 See Petroplus (2007), "Annual report"; or Rowley (2012), <http://www.telegraph.co.uk/finance/commodities/9047739/The-Petroplus-failure-is-just-the-tip-of-the-iceberg-in-the-oil-sector.html>

As such, Gunvor entered the merchant refining business by acquiring two former Petroplus refineries: one in Ingolstadt and another in Antwerp.⁸⁹ Unlike Petroplus, though, Gunvor has an existing global oil trading business, in which the new refinery operations have been integrated.⁹⁰ In fact, the acquisition of refineries can be seen as a natural extension of the asset-backed trading model, in which assets are acquired to support a growing role for trading houses in the oil industry. Refinery operations not only provide market access and a trading back-stop, but they also allow access to new arbitrage opportunities to support the existing oil trading business.⁹¹

In contrast to Gunvor, Vitol participates in the NWE refining sector via a JV construction. Where Gunvor prefers sole ownership to maximise flexibility and market responsiveness, Vitol has used the Varo Energy JV to gain indirect access to refining activities.⁹² Varo Energy holds stakes in the Bayernoil refinery in Bavaria, the Cressier refinery in Switzerland, and various oil terminals, aiming to bring a leaner business model to the NWE refining sector and benefit from buying up distressed refining assets.^{93,94} The exact interaction between Vitol's oil trading business and Varo Energy's midstream portfolio is not clear, but the construction allows Vitol to have exposure to NWE refining without directly risking its own balance-sheet.

The recent history of merchant refining deals suggest that flexibility in refinery operations and site logistics are key considerations. Refineries classified as merchant refining candidates are not overly complex nor integrated, allowing close connection with upstream and downstream spot markets to exploit asset-backed arbitrage opportunities. Equally important, simple and spot-oriented refinery operations minimise the opportunity cost of converting the refinery site to a dedicated oil terminal, limiting the investment downside for the merchant refiner. Investment downside considerations are also likely to limit merchant refining deals to assets with modest or capped future regulatory compliance and clean-up cost. In some cases, merchant refining deals seems to have excluded existing environmental liabilities from the takeover deal altogether.^{95,96}

89 Gunvor is in the process of finalising the acquisition of a third refinery: The Q8 Rotterdam refinery.

90 Gunvor has acquired the Ingolstadt refinery for \$150 mln and the Antwerp refinery for \$8 mln. See: https://www.downstreamtoday.com/news/article.aspx?a_id=39547

91 Both the favourable inland location of the Ingolstadt refinery and the direct access of the Antwerp refinery to the ARA oil trading hub should be supportive of Gunvor's ability to execute on its trading strategies.

92 Varo Energy is jointly owned by Vitol, the Carlyle Group, and Reggeborgh.

93 See: <http://www.varoenergy.com>

94 Bousso, Ron (2015), <http://uk.reuters.com/article/2015/06/16/europe-refining-idUKL5N0Z3VW20150616>

95 The port of Rotterdam, for example, facilitates this by taking 'zero-level' measurements to establish benchmark contamination levels per period of time. Several reports derived from www.dcmr.nl/eng

96 Discussions and interviews with industry players have indicated that in some cases government has even stepped in to guarantee that existing environmental liabilities would not transfer to the acquirer.

There is great diversity among these new entrants and the business models they profess, but on closer inspection they all share the common aim to increase flexibility and integrate refinery operations within existing trading operations. All in all, past restructuring cases in the NWE refining sector show the important role of merchant refining deals in prolonging the economic life of refineries and avoiding refinery site closures. Accordingly, merchant refineries could in the future play an increasingly important role in providing security of supply in NWE, providing a layer of flexible refinery supply around a core of must-run refineries that complements refined product imports in balancing the NWE market.⁹⁷

3.2.3 REFINERY SITE CONVERSIONS

Another set of historical refinery restructuring cases in NWE concerns the conversion of refinery sites to alternative uses. Refining activities are suspended, but some equipment and infrastructure remains operational. There are several examples of refinery site conversions to dedicated oil terminals, and there are even a few cases in which sites have been converted to bio- or specialty refineries.

BIO-REFINERY CONVERSIONS

In 2013, facing overcapacity in the Italian refining market, ENI decided to convert its struggling Porto Marghera refinery into a bio-diesel plant.⁹⁸ The conversion ensured that existing refining equipment and infrastructure at the site found an alternative use, although refining capacity was reduced to a mere 6 Kb/d.⁹⁹ Recently, Total announced a similar strategy for its La Mède refinery site in southern France. A €200 mln investment will convert the site into a bio-refinery and an oil storage terminal, preserving a substantial number of jobs.¹⁰⁰ Specific details for the bio-refinery conversion have not yet been announced, but it is safe to assume that existing equipment and infrastructure will be minimally used in this case as well.¹⁰¹

97 It must be noted, however, that merchant refineries will also have to deal with barriers to exit and that their exact future role remains speculative.

98 It is worth noting that an oil terminal conversion had been considered as well, but employment reductions encountered union interference. See: <http://www.platts.com/latest-news/petrochemicals/london/feature-porto-marghera-shutdown-spotlights-non-26895376>

99 Only 20% of Capex was needed compared to completely new bio-refinery of same capacity as desulphurisation units and (pipeline) infrastructure were reused. The entire investment (€200 mln) was paid by ENI; no subsidies were awarded. Source: ENI (2014) Press release "An agreement has been reached with the unions for investments of about €200 mln" and interview with ENI officials.

100 Total's French Refining Roadmap. Source: <http://www.total.com/en/media/news/press-releases/totals-french-refining-roadmap-upgrade-donges-and-transform-la-mede>

101 Based on several interviews with industry experts.

Both cases strongly suggest that bio-refinery conversions are not a serious alternative to oil refining, despite the ability to reuse some refining equipment and infrastructure. Nevertheless, a bio-refinery conversion allows a refinery owner to avoid a complete closure and the associated clean-up of the refinery site, while restructuring loss-making operations and lowering the chances of a political backlash by preserving jobs and supporting its green credentials.

OIL TERMINAL CONVERSION

Historical cases of storage facility conversions are more widely available. Refining sites are equipped with vast amounts of storage capacity to facilitate their refining activities, providing the opportunity to convert struggling refineries to dedicated oil terminals, avoiding the need for expensive greenfield projects. Oil terminal conversions, however, are not without costs. At a minimum significant investments in above-ground works, such as replacing existing crude tanks, are required, and existing structures and mobile contamination need to be cleaned-up as well. In more severe cases, costly investments in below-ground structures are also required, discouraging a potential conversion. In general, a low-investment case refinery conversion is favoured over a greenfield terminal when storage capacity exceeds 500,000 m³. Accordingly, an oil terminal conversion is not an option for every struggling refinery operation.

In 2011, the Wilhelmshaven refinery operated by ConocoPhillips was converted into a storage facility by Hestya, aiming to capture the benefits of existing port facilities.¹⁰² The Wilhelmshaven port can handle up to 250K DWT tankers, has excellent transport connections, and is in close proximity to the important economic region of Hamburg, which happens to lack a long-term competitive refining centre. Hestya benefitted from relatively low conversion costs (< €60 mln), and the potential sale of the existing refinery equipment. Equally important, at the time Hestya was also able to capitalise on ConocoPhillips' continued presence in the northwest German downstream market, guaranteeing long-term storage contracts for its new facility.¹⁰³

In France, two former Petroplus refineries, Reichstett and Petit Couronne, have been closed and are in the process of a partial conversion to an oil terminal. In both cases Petroplus' bankruptcy in 2012 significantly delayed the realisation of the conversion plans. In 2013, the southern part (180 ha) of the Reichstett site was bought by

¹⁰² ConocoPhillips had already come to an agreement to close the refining operations and, hence, any political intervention was absent during the Hestya conversion.

¹⁰³ Abeldt, Gerd (2015), <http://www.wzonline.de/nachrichten/wilhelmshaven/detail/artikel/umbau-zur-tankfarm-fast-abgeschlossen.html>

Rubis, a French petroleum and chemicals storage company, with plans to invest €37 mln to ensure decontamination and regulatory compliance of the site, and to integrate it with its existing terminal activities in the Strasbourg area.¹⁰⁴ Although the final investment was higher, the connection with the Rhine and integration with its existing Strasbourg assets justified the cost. In 2014, French bankruptcy courts allowed Valgo and Bolloré Energie to buy the 240 ha Petit Couronne site with the aim of remediating and preparing it for a €200 mln investment to redevelop the entire site. €70 mln was reserved to modernise and increase existing storage capacity, and invest in infrastructure and regulatory compliance.¹⁰⁵

In the UK, several former refineries are in the process of conversion to storage. The closure of Petroplus' Coryton refinery attracted a consortium of Vopak, Shell and Greenergy to convert the site into storage terminal that would serve greater London. Changing market conditions have put the project on hold, though, leading to the decision to sell part of the surplus land.¹⁰⁶ The remaining 161 acres are still intended for the future Thames Oilport terminal, which is expected to come on-stream in mid-2016.¹⁰⁷ Other UK oil terminal conversions include Milford Haven and Teesside.¹⁰⁸ To date, the Teesside refinery has been converted to a terminal by Greenergy and renamed North Tees, benefitting from integration with existing Greenergy assets and access to the relatively remote and secluded market in the northeast of the UK.¹⁰⁹

Ideally, sites for terminal conversions have direct access to a port-based trading hub or a large hinterland, a strong investment and maintenance track record, and substantial storage capacity (> 1 mln m³). Normally, storage tank/pipeline conversions and regulatory compliance (e.g. fire prevention systems) account for the bulk of the investment cost. However, if a refinery site requires significant below-ground works, such as concrete containment walls, investment costs can quickly escalate and undermine the business case for a terminal conversion.

104 ICIS (2013), "France's Rubis to acquire storage assets at Reichstett refining site"; and Rubis-terminal (2013), Press release "Rubis takes over the storage facilities of Petroplus raffinage Reichstett".

105 Paris-Normandie (2015), "L'ancienne raffinerie Petroplus en cours de démontage à Petit-Couronne"; Normandinamik (2014), "Petroplus – La Vente au groupement Bolloré Energie/Valgo est confortée"; Communiqué de Presse (2014), "Valgo et Bolloré Energie présentent le nouveau pôle industriel de Petit-Couronne"; and CREA le Mag (2014), – Magazine de la Métropole Rouen Normandie – Dossier Petroplus.

106 Vopak has recently sold its stake to Greenergy. Source: <https://www.vopak.com/newsroom/news/royal-vopak-agreement-sale-all-uk-assets>

107 Source: <http://vopak.co.uk/pages/thames-oilport>

108 Refining operations in Milford Haven refinery have been closed since 2014 and, hence, conversion details are not yet clear.

109 See: <http://fueloilnews.co.uk/2012/12/supply-commences-at-north-tees/>; and http://www.forecourtrader.co.uk/news/archivestory.php/aid/8684/Greenergy_investing_in_Teesside_fuel_terminal.html

In general, investment costs for storage terminals range from €50/m³ for refinery site conversions to €150/m³ for greenfield investments.¹¹⁰ This price difference explains the incentive to opt for a terminal conversion if the refinery site is well located, has significant existing storage capacities, and a good investment and maintenance track record. The potential for future terminal conversions will, however, not only be a function of the availability of suitable refinery sites, but also of the demand for additional petroleum product storage capacity.

SPECIALTY REFINERY CONVERSION

In several instances, refinery sites have restructured fuels refining activities but have left specialty production untouched. When Shell, for example, closed its fuel refinery on the Harburg site in Germany, AB Nynas agreed to operate the base-oil and lubricants plants on the basis of a 25-year lease agreement.¹¹¹ Existing infrastructure and equipment continue to be used, and the site remains operational. However, as both parties have an option to convert the lease into an asset deal, it remains unclear as to who carries the liabilities, but it seems likely that Shell will retain responsibility for the eventual clean-up.¹¹²

In 2014, Nynas used similar tactics with its Dundee refining assets, where it closed the refining operation but maintained the bitumen plant.¹¹³ In 2010, Vitol took over Petroplus' Antwerp refinery site and immediately closed its fuels refining activities but continued to operate the 850 Kt/a bitumen plant.¹¹⁴ These developments can be viewed in the context of downsizing operations while retaining some valuable assets and avoiding a complete closure.

Overall, conversions extend the operational life of a refining site, albeit the scale and scope of the activities are greatly reduced. Although the profitability of these restructuring options are questionable, it does ensure that the refinery site remains operational, avoiding complete closure and associated environmental clean-up cost. Clearly, environmental clean-up costs are a key consideration in many of the conversion restructuring cases that can be observed in recent history.

110 Estimates are derived from historical cases and interviews with industry specialists. However, a clear-cut number is hard to determine since prices tend to differ per specific case.

111 Reuters (2013), "Shell to close most Harburg refinery units in March"; Nynas Press release (2013), "Nynas starts to operate the Harburg base oil plant".

112 A put option for Shell and a call option for Nynas allows the assets to change ownership, although the associated liabilities remain unclear. See Official Journal of the European Union (2014), "Final Report of the Hearing Officer – Nynas/Shell/Harburg refinery assets (M.6360)".

113 Nynas has been operating the Dundee refinery since 1992. Source: <http://www.nynas.com/Media/News/Changes-planned-for-Dundee-refinery/>

114 This could be related to the need to honour an existing long-term contract with AB Nynas for the sale of bitumen.

3.2.4 SITE MOTHBALLING

The ultimate measure to postpone a refinery site's complete closure is to cease all activities while still retaining control and ownership of the land. This 'wait-and-see' option in theory allows indefinite postponement of a refinery site's remediation costs. An important prerequisite is that the site is directly owned by the refining operator. Land that has been given in concession (e.g. most port-based refineries) lacks mothballing potential, as industrial activity is often a requirement to keep the concession.¹¹⁵

With the termination of refining activity at the Wörth site in 1995, Mobil decided to decommission its refining assets and sell the equipment to India. The remaining site was kept under direct Mobil ownership, but lost any operational function. Lacking the need for remediation, stalling seems to have been the 'loss-minimising option' for Mobil, ultimately leading to the involvement of local government in the early 2000s. A similar case is the Exxon refinery in Milford Haven, where operations were closed in 1983, but Exxon has retained the ownership of the site ever since. After decades of disuse, in 2003 construction of the South Hook LNG terminal started, repurposing the terrain.¹¹⁶

Mothballing a refinery site remains a last resort option before complete closure, provided the land is directly owned by the refiner. Three motifs stand out: (1) future opportunities might occur (as in the case of Milford Haven); (2) remediation costs might be shared (as happened in Wörth); and, most importantly, (3) environmental clean-up costs are in theory postponed indefinitely.

3.2.5 COMPLETE CLOSURE

There are very few historical cases of complete refinery closures in NWE. This is a direct function of the high barriers to exit related to the clean-up cost of the site. Since 2008 there have been only two cases of complete closure and remediation of a refinery site, one in Germany and one in Wales. Complete closure and remediation of a sub-section of a refinery site are more common, often embedded in larger conversion projects. Shell's R&D facility in Amsterdam, for example, has recently been downsized and part of the site has been remediated. Terminal conversion projects at the Reichstett, Petit Couronne and Coryton refinery sites have also been accompanied by complete remediation of some redundant sections. Below, several relevant cases are discussed. More details can be found in **Annex E**.

¹¹⁵ The Port of Rotterdam's revenues originate both from leasing contracts for land and via derived industrial activity, leading to harbour fees. Ideally all tenants need to fulfil both requirements.

¹¹⁶ Sources: <https://www.southhooklng.com/> and http://news.bbc.co.uk/2/hi/uk_news/wales/south_west/7881826.stm

In 2005, Bayernoil decided to invest in the integration of two of the three refineries it owned in southern Germany, leaving its Ingolstadt refinery slated for closure.¹¹⁷ After initial concerns by its shareholders, it was decided to completely remediate the refining site, balancing the clean-up costs with proceeds of the land sale. The clean-up included remediation of the ground water and soil, and the demolishing of constructions (both above- and below-ground). The terrain is now eligible for reuse, although water treatment plants will remain operational for several decades.¹¹⁸

Although no actual figures were disclosed, the entire project had been completed without direct government subsidies, indicating that in some cases remediation costs can be offset by increased land values.¹¹⁹ Nonetheless, it is worth noting that the local government was critical in facilitating an increase in land values after complete closure and remediation of the refinery site. Not only did it alter the land's destination clauses, it also financed the construction of a new football stadium on the former refinery site.¹²⁰ This suggests that indirect government support and guarantees were needed to achieve the complete closure and remediation of the refinery site.

In 1995, Mobil decided to halt operations of its Wörth refinery amid competitive pressure and high operational costs. Unable to find a buyer, the 120 ha site was closed, 318 jobs were lost, and demolition of the refinery was started.¹²¹ Although the price was not disclosed, it is safe to assume that the costs of demolition were covered by the proceeds of the sale to Nagarjuna Oil Corporation Limited. This still left a contaminated refinery site in need of groundwater and soil remediation.¹²² Alarmed by permanent environmental damage and loss of employment, the regional government decided to buy the entire site in the early 2000s. By late 2005 the government had finished remediating the site and created the new 'Oberwald' industrial site.¹²³ It is unlikely that industrial land values have covered the full cost of redevelopment, implying that tax payers have footed at least part of the clean-up costs.

117 Bayernoil (2005), Press release on the ISAR study for the future of Bayernoil.

118 Interview with dr. Karl Noé – Arcadis.

119 All the land (107 Ha) had been sold to several parties for commercial use. Also the existing constructions were sold as scrap, aiding to the revenue stream.

120 Reinhold, Jan (2013), <http://www.sueddeutsche.de/sport/fc-ingolstadt-symbiose-zwischen-fussballverein-und-autokonzern-1.1810348>

121 The refining assets were demolished and sold to be rebuilt at the Indian NOCL refinery in Cuddalore. <http://www.hydrocarbons-technology.com/projects/nagarjuna-oil-corporation-cuddalore-tamil-nadu/>

122 Contamination of both groundwater and soil, required cleaning of groundwater and remediation of 640,000 m³ of earth via on-site treatment plants. See Rheinlandpfalz Struktur- und Genehmigungsdirektion Süd (2013), Jahresbericht 2013.

123 Wörth am Rhein – Amtsblatt (2006), "Gute Kunde in der Einwohnerversammlung".

The partial closures of the Reichstett, Petit Couronne and Coryton refineries concern the non-terminal parts of the respective sites. In all three cases an industrial development plan has been executed by brownfield companies with some form of support from (local) government.¹²⁴ Government involvement ranges from buy-back guarantees to low takeover prices, additional investments, and preferential bureaucratic treatment.¹²⁵

It can be concluded that environmental clean-up costs related to a complete refinery site closure are often prohibitive for stand-alone refiners to absorb. The low number of observed complete closure cases in NWE suggests that this is the least preferred restructuring option for refinery owners. Even though land values can offer some relief, it is unlikely to cover the full cost of clean-up and remediation. Accordingly, all closure cases reveal some form of governmental involvement, aiding the remediation process either by capping liabilities or via direct or indirect financial support. Nevertheless, since a common policy approach is lacking, complete closures and clean-up of refinery sites will likely be postponed by refinery owners as long as possible.

3.3 RESTRUCTURING OPTIONS – DEGREES OF DOWNSIZING

Significant barriers to exit in the NWE refining sector are forcing refiners to consider restructuring options that avoid a complete closure. History shows that NWE refiners have opted for various restructuring measures, allowing them to postpone complete closures and minimise long-term restructuring costs (see Figure 3.4).¹²⁶ Given the costs, future revenues, and the likelihood of restructuring success (i.e., political support), it is possible to create a hierarchy of restructuring options. It should, however, be clear that all restructuring options merely aim to minimise losses while kicking the proverbial can of complete closure down the road.

124 The Reichstett site is developed by Brownfields, Petit Couronne is developed by Valgo and Coryton by a consortium 'Thames Enterprise Park'. <http://www.costar.co.uk/en/assets/news/2015/June/Giant-London-Gateway-neighbour-site-comes-to-market/>

125 Reunion Du Conseil De La Communauté Urbaine De Strasbourg (2014); Crea le Mag – Metropole Rouen Normandie (2014); and Valgo – Ville De Grand Couronne et de Petit Couronne (2015).

126 The handful of complete refinery closures in NWE suggests there are some exceptions to the rule. One such exception might be refineries that on potentially valuable land, such as the Bayernoil Ingolstadt refinery in Germany.

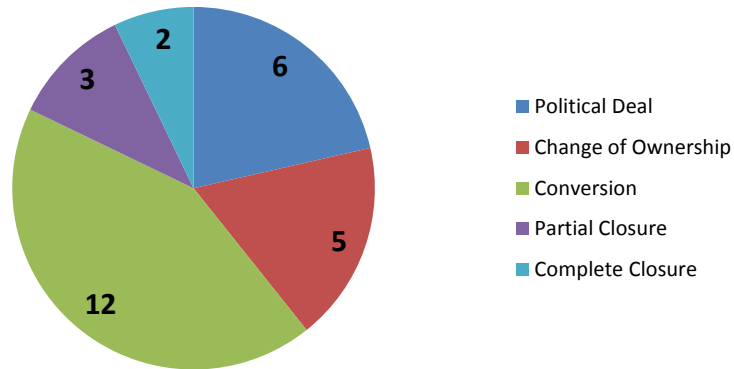


FIGURE 3.4: DOWNSIZING VS COMPLETE REFINERY CLOSURES IN NWE (POST-2008)

Although political deals can restrict manoeuvrability, in general these are preferred, as they allow for burden sharing (both risk and financial). The impact on both the economy and environment provides the refiner with a bargaining chip with which to enlist government support and moderate restructuring costs. Nevertheless, political horse trading can only hold economic logic at bay for so long, and in the face of structural shifts in the NWE refining sector struggling refineries will have to face up to their lack of competitiveness sooner or later. Yet the Grangemouth case shows that when it comes to an economically significant cluster or the last remaining refinery, political intervention can become very persistent and economic reality is likely to be suspended for some time to come.

Merchant refiner deals (change of ownership) are a first step in downsizing struggling refining activities. Merchant refiners simplify and increase the flexibility of refining operations, allowing refineries to become more responsive to local supply and demand fluctuations. Merchant refiners, in particular those with a global trading footprint, are also likely to leverage the increased optionality between crude oil and refined product imports, thereby providing a valuable service to security of supply in the NWE refining sector. Nevertheless, refinery flexibility is inherently constrained, and a successful merchant refining model depends on its low-cost structure and efficient use of capital, offering limited headroom for investments to support long-term competitiveness.¹²⁷ Some refining assets, though, such as Gunvor's Antwerp refinery, have been operated as merchant refineries for close to a decade now, suggesting that the merchant refining model can have an extended shelf life.

¹²⁷ Refineries can reduce throughput to maybe 60% of capacity, but refining capacity cannot be kept in reserve to ramp up when demand requires it. The temperature variations would simply wreak havoc on the refining equipment and infrastructure.

Terminal or bio-refinery conversions significantly downsize a refinery site, while avoiding a complete closure and leveraging existing equipment and infrastructure. In a scenario where refined product imports replace refinery supply but oil demand does not collapse, conversion to an oil terminal may offer a long-term solution. However, the storage market is prone to overcapacity and conversion sweet-spots might have been exhausted already. Similarly, bio-refinery conversions pay lip service to a low-carbon economy, but its prospects are unsure, especially as a revision of the current EC bio-fuel directive has lowered the projected share of bio-fuels usage to 7% (down from 10%).¹²⁸

In general, it can be concluded that significant barriers to exit may lead refiners to postpone complete closure as long as possible. To that end, several options may be exercised to extend the lifetime of a site, mitigating the long-term clean-up and remediation costs (see Figure 3.5). In this respect it is important to understand that the environmental clean-up costs are the centre of gravity around which all options orbit. Even though liabilities will largely remain with the original polluter, the prolonging of industrial activity on the site could avoid the realisation of significant off-balance-sheet liabilities.

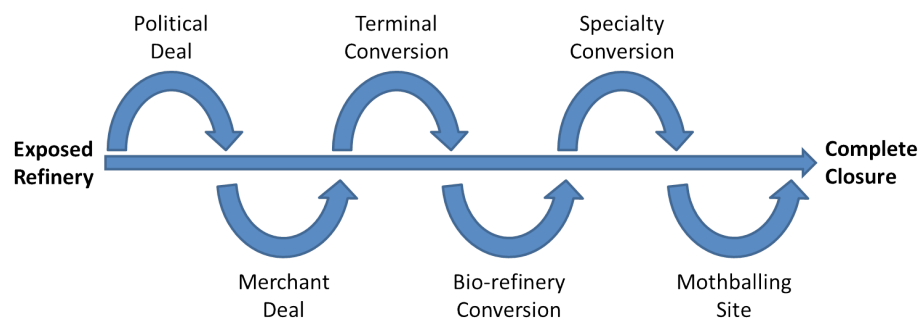


FIGURE 3.5: REFINERY RESTRUCTURING OPTIONS

128 European Parliament legislative resolution (2015) on the use of renewable energy: <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P8-TA-2015-0100+0+DOC+XML+V0//EN>

4 NWE CLOSURE- CONSTRAINED SCENARIO - A NEW LEASE OF LIFE

Significant barriers to exit encourage NWE refiners to avoid complete refinery site closures at almost any cost. Since 2008, only 2 out of 28 refinery restructuring cases resulted in the complete closure and remediation of a refinery site (see Chapter 3). The political and environmental clean-up costs associated with a complete closure are so substantial that refiners are willing to stomach highly negative returns in order to transfer or postpone the recognition of these off-balance-sheet liabilities. As a result, a diverse set of restructuring options which fall short of complete closure have developed in the NWE. Two of these options, political and merchant refining deals, have the capacity to alter the outcomes of the must-run scenario (see Chapter 2). By providing struggling refining activities with a new lease of life, both restructuring options constrain the refinery closures foreseen in the must-run scenario.

The presence of significant barriers to exit enables trading-oriented players to acquire struggling refineries and extend their economic life as low-cost flexible producers. The change of ownership and ensuing negotiations surrounding the future of the refinery site allow traditional refiners to restructure political and environmental liabilities, often transferring the liabilities to parties that are more willing and able to carry these into the future.¹²⁹ In absence of the opportunity to sell a struggling refinery as a going concern, political elements in NWE also have the ability to directly impact the economics of refinery restructuring, either by lowering the refinery owner's operational and upgrading costs (e.g. the Grangemouth case) or by raising the cost of alternative restructuring options (e.g. the Total France cases). Accordingly, in both cases struggling refining activities are prevented from closing despite their exposure to direct competition from imports.

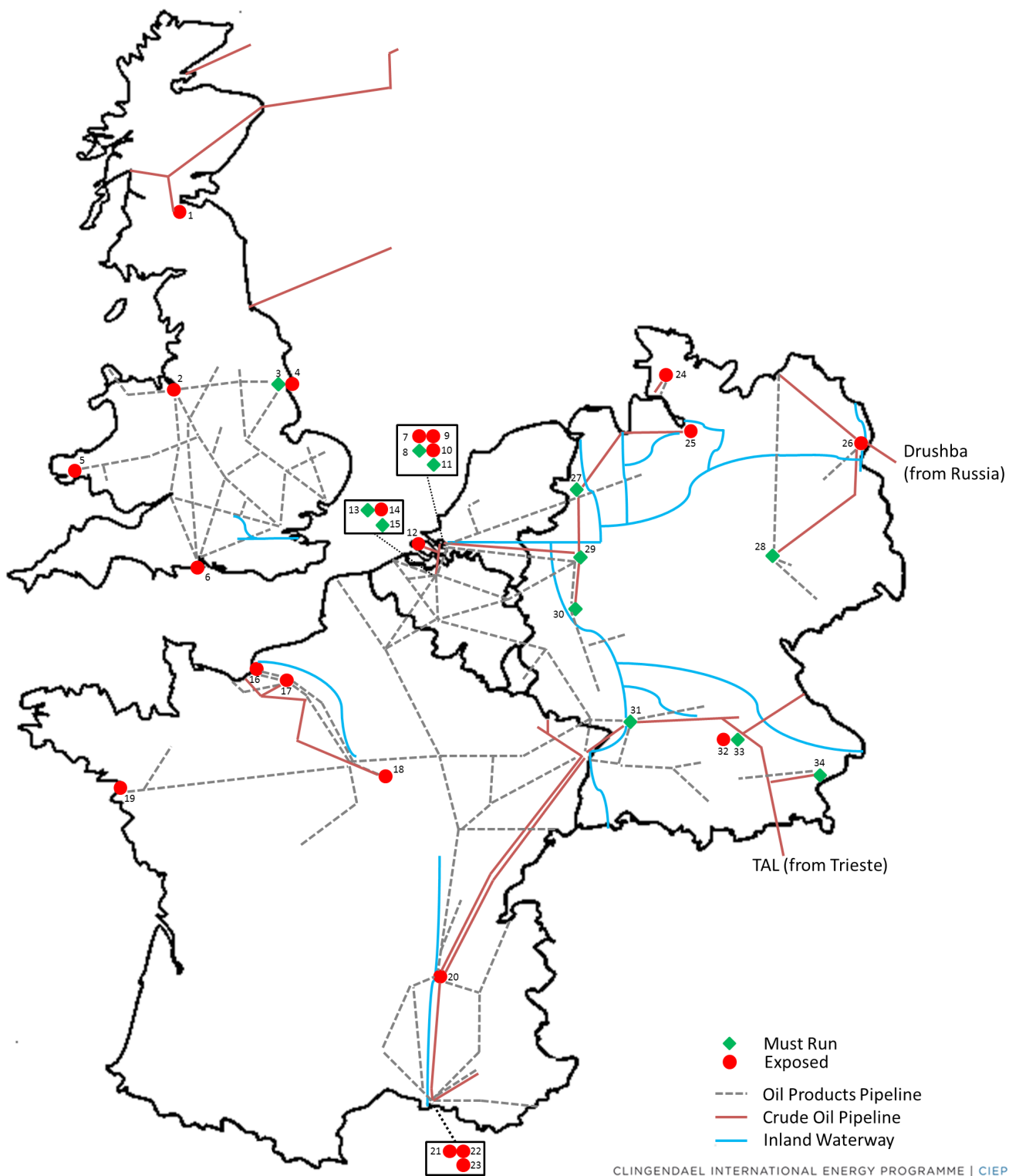
Our review of historical refinery restructuring cases in Chapter 3, however, revealed that the political capital or will is not always present to prevent the closure of refining activities. Likewise, the Petroplus bankruptcy in 2012 has shown that merchant

¹²⁹ The merchant refiner does not necessarily take over all liabilities. In several cases local governments appear to have stepped in and provided guarantees to limit future clean-up cost to acquiring parties.

refining is not a viable alternative for every struggling refinery in NWE.¹³⁰ In the closure-constrained scenario we therefore attempt to identify the exposed refineries that are most likely to obtain a new lease of life on the back of political or merchant refining deals. Estimating the impact of political elements such as union strength and security of supply concerns is not an exact science. Nevertheless, we believe that these factors, however speculative they may be, are part of the reality in NWE refining and cannot be ignored.

In the following sections the closure-constrained scenario is worked out in detail. In section 4.1, the findings from Chapter 3 are used to identify candidates for political or merchant refining deals among the exposed refineries from the must-run scenario (see Figure 4.1). In section 4.2, we use the outcomes of the closure-constrained scenario to describe an alternative outcome, in which must-run conditions are moderated by the barriers to exit in NWE refining, for the post-2025 refining landscape.

130 Some of the Petroplus refineries, such as Antwerp and Ingolstadt, have been purchased by other merchant refiners and are still operational, indicating that the merchant refining model can be viable over long periods. On the other hand, several other former Petroplus refineries, such as Petit Couronne or Teesside, have never found a buyer to continue the refining activities.



UK

- 1: GRANGEMOUTH (PETROINEOS)
- 2: STANLOW (ESSAR)
- 3: HUMBER (PHILLIPS 66)
- 4: LINDSEY (TOTAL)
- 5: PEMBROKE (VALERO)
- 6: FAWLEY (EXXON)

ARA

- 7: ROTTERDAM (GUNVOR)
- 8: ROTTERDAM (SHELL)
- 9: ROTTERDAM (KOCH)
- 10: ROTTERDAM (BP)
- 11: ROTTERDAM (EXXON)
- 12: ZEELAND (TOTAL/LUKOIL)
- 13: ANTWERP (TOTAL)
- 14: ANTWERP (GUNVOR)
- 15: ANTWERP (EXXON)

FR

- 16: GONFREVILLE (TOTAL)
- 17: PORT JEROME (EXXON)
- 18: GRANDPUITS (TOTAL)
- 19: DONGES (TOTAL)
- 20: FEYZIN (TOTAL)
- 21: FOS-SUR-MER (EXXON)
- 22: LAVERA (PETROINEOS)
- 23: LA MEDE (TOTAL)

DE

- 24: HEIDE (KLESCH)
- 25: HOLBORN (TAMOIL)
- 26: SCHWEDT (PCK JV)
- 27: LINGEN (BP)
- 28: LEUNA (TOTAL)
- 29: GELSENKIRCHEN (BP)
- 30: RHINELAND (SHELL)
- 31: MIRO (JV)
- 32: INGOLSTADT (GUNVOR)
- 33: BAYERNOIL (JV)
- 34: BURGHAUSEN (OMV)

FIGURE 4.1: MAP OF MUST-RUN AND EXPOSED REFINERIES

4.1 POLITICAL DEAL CANDIDATES

Political intervention in the NWE refinery restructuring process is a function of the impact that refining activities have on local economic activity and security of supply.¹³¹ Our review of historical refinery restructuring cases emphasises the role of economic considerations for political intervention. But as the rationalisation of NWE's refining sector progresses, we expect security of supply concerns to become an equally important driver for political intervention. The importance governments attach to the last remaining fuel refinery in a region is well illustrated by the 2001 sales agreement for the Irish Whitegate refinery, in which the government stipulated that the refinery had to be kept open for at least another 15 years.¹³²

In similar fashion, we also expect that security of demand considerations by crude long NOCs will play a more prominent role in future refinery restructurings.¹³³ For Russia in particular, the NWE refining sector remains an important crude outlet, averaging 1.3 Mb/d of crude exports to NWE in 2014.¹³⁴ Accordingly, to identify political deal candidates among the 22 exposed refineries, we considered three profiles: (1) an economic footprint profile; (2) a security of supply profile; and (3) a security of demand profile (see Figure 4.2).

(1) The economic footprint profile is likely to include the Total Gonfreville refinery in northern France and the Petroineos Grangemouth refinery in Scotland. The Gonfreville refinery is of strategic value to the Seine Valley cluster, the largest petrochemicals cluster in France (see Figure B.2 in **Annex B**). In the long run, the Seine Valley is expected to be the last remaining petrochemicals cluster in France, and Gonfreville's steam cracker and aromatics capacities are critical to its base chemicals supply. Exxon's Port Jerome refinery is part of the same Seine Valley cluster, but with its smaller steam cracker and modest aromatics production it does not possess the same strategic value as Total's refinery.¹³⁵ Also, we consider it more likely that Total may cut a political deal in France, its home country, to allow for the closure of struggling refining activities at its Donges, Grandpuits,

131 See, for example, UK Department of Energy and Climate Change (2014), "Review of the refining and fuels import sectors in the UK"; Purvin & Gertz (2013), "The role and future of the UK refining sector in the supply of petroleum products and its value to the UK economy"; or Hale & Twomey (2012), "National security assessment: Competitive pressures on domestic refining in Australia".

132 The current owner, Phillips 66, can only close the refinery in 2016. See, for example, www.hydrocarbons-technology.com/projects/whitegate/; or www.irishtimes.com/business/deutsche-bank-to-handle-whitegate-sale.

133 See, for example, Rosneft (2010), "Rosneft Acquires Leading Downstream Position in Germany: 50% of Ruhr Oel"; <http://www.icis.com/resources/news/2009/06/19/9226074/lukoil-buys-dow-s-45-stake-in-total-vlissingen-refinery/>.

134 Based on Eurostat figures.

135 Total's Gonfreville site probably also has significant logistical advantages over Exxon's Port Jerome site.

and Feyzin sites.¹³⁶ In return for keeping a license to operate in France, we would then expect Total to guarantee continued investment in its comparatively advanced and integrated Gonfreville refinery.¹³⁷

Closure Constraint	Refinery Characteristics	Description
Political (Economic activity)	Strategic refinery to economically significant cluster	The refining activity is strategic to an economically important refining/chemicals cluster, and its closure is likely to handicap the chances of survival for the wider cluster. This implies that the economic fall-out from the closure of the refining activity is expected to be significant.
	Last remaining cluster in the country/region	The country/region lacks refining clusters that are expected to be long-term competitive, implying that local government is incentivised to protect the last remaining cluster.
Political (Security of supply)	Last remaining refinery in the country/region	This is expected to be the last operational refinery in the country/region, implying that local government is incentivised to support it on the basis of regional security of supply concerns.
	Connected to military purpose pipeline network	The connection to a military purpose pipeline network ensures that the security of supply concerns around the refinery closure will have a defence angle as well.
Political (Security of demand)	Crude long NOC majority owned	Majority ownership by a crude long NOC ensures that a closure impacts security of demand, because the refinery offers a guaranteed outlet for the NOC's crude oil supplies.
	Direct crude pipeline connection	A direct crude pipeline connection to the crude long NOC's production assets reinforces the importance of the refinery with respect to security of demand.

FIGURE 4.2: OVERVIEW OF POLITICAL REFINERY CLOSURE CONSTRAINTS

Grangemouth is the last remaining refinery in Scotland and is a part of the petrochemicals and North-sea oil cluster on the Scottish east coast. The Grangemouth site is estimated to contribute 4% to Scottish GDP, making up 8% of its manufacturing base and supporting around 10,000 jobs (see Chapter 3).¹³⁸ Even though integration between the Grangemouth refinery and petrochemicals production at the site has diminished, since Q2-2014 the Grangemouth steam

136 This template is more or less comparable to the 2010 Total Mardyc closure deal.

137 This does not mean that Total may not have to invest in the future of the Grandpuits, Donges, and Feyzin sites, but capital requirements for terminal or bio-refinery operations are an order of magnitude lower.

138 See, for example, BBC (2013), <http://www.bbc.com/news/business-24624934>; or www.ineos.com/sites/grangemouth/about

cracker complex runs exclusively on gaseous feedstocks, the refinery is still considered critical to the cluster and the local economy.¹³⁹ As a result, in 2014 Petroineos was able to negotiate more favourable employment terms with local unions, and the petrochemicals cluster received significant government support for a new investment programme. We expect that in future local support for Scotland's last remaining refinery will be forthcoming.

(2) The security of supply profile is likely to include Exxon's Fawley refinery in the south of England and Petroineos' Lavera refinery in southern France. The Fawley refinery is the largest and one of the most advanced refineries in the UK. Also, it serves the economically important greater London region and has direct pipeline connections to Heathrow and Gatwick airports. Proximity to London and integration with all major pipeline networks in England makes it likely that the UK government considers the Fawley refinery critical to security of supply. In fact, between the Fawley refinery on the south coast and the must-run Humber refinery on the east coast, most major urban areas in England could continue to be served in case of local import disruptions, including Manchester and Liverpool on the west coast (see Figure 4.1).¹⁴⁰

The highly integrated Lavera refinery on the Mediterranean coast is expected to be the last remaining refinery in the south of France. Between the Lavera and Gonfreville refineries, most urban centres in France have the option to be supplied by domestic refineries, with the exception of urban centres in the southwest of France (see Figure 4.1).¹⁴¹ This makes it likely that the French government considers the Lavera refinery critical to security of supply. Moreover, unlike Exxon's Fos-sur-Mer refinery, the Lavera refinery is directly integrated with the Naphtachimie JV steam cracker complex, the largest in France, providing additional rationale for local government support.

(3) The security of demand profile is likely to include only the PCK Schwedt refinery in eastern Germany, which distinguished itself from other NOC-owned refineries by its direct access to the Drushba pipeline system. In 2015, Rosneft acquired a majority stake in the PCK Schwedt refinery through equity swaps with

139 The Grangemouth ethylene cracker is mainly fed with ethane and propane instead of naphtha, which has significant commercial advantages. See, for example, Ineos (2015): "Grangemouth" <http://www.ineos.com/businesses/ineos-olefins-polymers-europe/sites>

140 Refinery supply optionality in the north of England is more or less covered between the Grangemouth refinery in Scotland and the Humber refinery on the east coast of England.

141 Today the southwest of France already lacks direct refinery supply.

BP and Total.¹⁴² The equity swaps allowed Rosneft to take control of PCK Schwedt, an exposed refinery exclusively processing Russian crudes (see Figure 4.1). As part of the same deal, Rosneft sold its 50% equity stake in the must-run Gelsenkirchen refinery to BP. This strongly suggests that Rosneft considers the Schwedt refinery a strategic outlet for its Urals crude production, providing a rationale for continued support of refining activities at the Schwedt site.

4.2 MERCHANT REFINING DEAL CANDIDATES

Following the Petroplus bankruptcy in 2012, merchant refining deals did not disappear, but they do seem to have become more disciplined. Recent deals have focused on assets that allow trading houses to leverage existing capabilities and portfolios, providing access to new markets and arbitrage opportunities while limiting capital requirements and potential investment downsides.¹⁴³ We can distinguish between two types of merchant refining deals. The **first type** concerns refining assets with access to a trading hub, in which case a trading house seeks maximum operational flexibility to exploit asset-backed arbitrage opportunities.¹⁴⁴ The **second type** concerns refining assets with access to an inland market (region), in which case a trading house seeks access to new markets with a degree of operational flexibility to exploit asset-backed arbitrage opportunities.¹⁴⁵ Accordingly, to identify merchant refining candidates among the 22 exposed refineries from the must-run scenario, we consider two profiles: (1) a trading hub profile; and (2) a market access profile (see Figure 4.3).

142 See, for example, Gazprombank (2015), "Russia oil and gas equity research note" of June 22, 2015.

143 See, for example, FD (2015), "Gunvor koopt raffinaderij Q8 in Europoort", *Financieele Dagblad*, October 8th 2015; Fyfe (2014), Gunvor presentation Platt's refining summit, "Making sense of European refining: A trader-refinery viewpoint", Brussels September 2014; Chapter 3, "Refinery restructuring in NWE". Additional insights were also gained from discussions with several industry participants.

144 A trading hub is defined as a location that hosts a large independent refining centre, flexible port and terminal infrastructure, and hinterland markets that support significant import and export flows. The ARA region is a good example, having 3 large ports, 8 refineries, and interconnections to the important German, French and even Swiss markets.

145 It should be noted that the Heide refinery sales does not fit either category. That said, we do not understand the rationale for acquiring the Heide refinery, as it lacks access to an inland market or a trading hub and is also not a particularly spot-oriented operation.

Closure Constraint	Refinery Characteristics	Description
Merchant refining (Trading hub)	Direct access to trading hub	A refinery with direct access to a trading hub provides trading-oriented players with a new set of asset-backed arbitrage opportunities, such as location, timing, and commodity transformation arbitrages.
	Operational flexibility (integration)	The ability of refining operations to respond to short-term supply and demand changes is not constrained by upstream or downstream integration, such as crude off-take agreements or speciality production.
	Operational flexibility (complexity)	The ability of refining operations to respond to short-term supply and demand changes is not constrained by complex configurations that favour operational efficiency over flexibility. Accordingly, refineries with advanced cracking or coking refineries are excluded.
	Modest capital outlays	Limiting refinery size, complexity, and future compliance costs has to ensure that the capital outlays can gain access to asset-backed arbitrage opportunities remain modest. Accordingly, refinery size does not exceed 150 Kb/d.
	Oversized storage capacities	Oversized storage capacities ensure that conversion to an oil terminal is a realistic backstop when the merchant refining model succumbs to competitive pressures. Accordingly, refinery storage capacities have to exceed 1M cubic meters or 20% of annualised CDU capacity.
Merchant refining (Market access)	Direct access to inland markets	A refinery with direct access to an inland market provides trading-oriented players with a new set of asset-backed arbitrage opportunities as well as market access.
	Operational flexibility (integration)	The ability of refining operations to respond to short-term supply and demand changes is not constrained by upstream or downstream integration, such as crude off-take agreements or speciality production.
	Logistical flexibility	The inland refinery site needs to have access to at least 3 modes of refined product transportation between pipelines, navigable inland waterways, railroads, and highways.
	Modest capital outlays	Limiting refinery size, complexity, and future compliance costs has to ensure that capital outlays can gain access to asset-backed arbitrage opportunities remain modest. In case of inland refineries, though, this variable is moderated by local market conditions.
	Oversized storage capacities	Oversized storage capacities ensure that conversion to an oil terminal is a realistic backstop when the merchant refining model succumbs to competitive pressures. Accordingly, refinery storage capacities have to exceed 1M cubic meters or 20% of annualised CDU capacity.

FIGURE 4.3: OVERVIEW OF MERCHANT REFINERY CLOSURE CONSTRAINTS

(1) The trading hub profile is likely to include the Gunvor Antwerp and Rotterdam refineries, as well as the Koch Rotterdam refinery.¹⁴⁶ All three refineries have access to the important ARA trading hub, lack significant upstream and downstream integration, and have simple configurations, ensuring they are well-positioned to exploit asset-backed arbitrage opportunities in local spot markets.¹⁴⁷ Moreover, simple refining operations keep capital requirements modest, and access to outsized storage facilities protects the investment's downside (i.e., acts as an insurance or put option) by providing the option to convert the refinery site to a dedicated oil terminal.^{148, 149}

The presence of four large and integrated must-run refineries in the ARA region is likely to ensure the availability of sufficient arbitrage opportunities for the Gunvor and Koch refineries in the longer run, ensuring a bulwark against replacement by refined product imports.^{150,151} Nevertheless, it is worth highlighting that all three candidates are already in the hands of established trading houses, suggesting that opportunities for future merchant refining deals in NWE's trading hubs are scarce. In fact, the only potential candidate that is not yet in the hands of a trading house, Exxon's Fos-sur-Mer refinery located at the heart of the Mediterranean trading hub, disqualifies because of its downstream integration with the Berre L'Étang steam cracker complex.

(2) The market access profile is likely to include only the Gunvor Ingolstadt refinery in Bavaria.¹⁵² The Ingolstadt refinery provides its owner access to the inland southern Germany region, and the relatively simple configuration, lack of upstream and downstream integration, and logistical flexibility of the site allows the refinery to exploit inland arbitrage opportunities in local spot markets.¹⁵³

146 Note that Gunvor's acquisition of KPC's Rotterdam refinery is not yet formally completed.

147 Gunvor has already indicated to suspend lubricants production at the Rotterdam site when they finalise the takeover. See: <http://fd.nl/ondernemen/1122024/personeel-raffinaderij-q8-donderdagmiddag-bijeen>.

148 It should be noted that the Koch Rotterdam refinery does not have storage capacities of its own, it is located on the Vopak Europoort terminal site. This does, however, ensure that an oil terminal conversion would be relatively inexpensive (i.e., the Koch refinery site can easily be connected to the existing infrastructure of the Vopak Europoort oil terminal).

149 In addition, to facilitate the sale of the KPC Rotterdam refinery to Gunvor, local governments are likely to have intervened to limit Gunvor's exposure to environmental liabilities related to past activities on the refinery site.

150 Large and complex refineries are by nature slower and less able to respond to dislocations in spot markets, providing trading opportunities for smaller and more flexible merchant refineries.

151 It should be noted that Gunvor considers the Rotterdam and Antwerp refining activities to be complementary. See: www.reuters.com/article/gunvor-rotterdam-idUSL8N12L3Y320151021#a2KCCVg8oy11K2iI.97.

152 The Bayernoil refinery in Bavaria would probably also fit the 'market access' profile, but this refinery is not exposed in the must-run scenario. In fact, the largest shareholder in the Bayernoil JV is Varo Energy, which is again partially owned by Vitol.

153 In certain cases, for example when Rhine water levels are low, the Ingolstadt refinery is even well-positioned to supply the lucrative Swiss market.

Nevertheless, Gunvor's merchant refining model in Bavaria is exposed to a steep drop in post-2020 German gasoline demand. A 30% drop is expected by 2025, which may pressure the Ingolstadt refinery to find alternative outlets offering a premium over NWE export parity.¹⁵⁴ Consequently, competition for outlets in Switzerland and western Austria is expected to intensify among southern Germany's refiners, requiring Gunvor to run a very nimble and efficient operation to support viable refining activities on the Ingolstadt site.

The Ingolstadt refinery has around 1.1M cubic meters of storage capacity. Combined with the logistical flexibility of the site, this should provide downside protection to the investment by providing an option to convert the site to a dedicated oil terminal.¹⁵⁵ That said, the proximity of the Bayernoil refinery complex could undermine the value of such a conversion. It is worth noting that, again, this merchant refining candidate is already in the hands of an established trading house, suggesting that opportunities for future merchant refining deals in NWE's inland regions are scarce.

4.3 THE POST-2025 REFINING LANDSCAPE

In the must-run scenario, the number of fuel refineries in NWE would drop from 34 to only 12 in the long run, resulting in a reduction of around 4 Mb/d in crude distillation capacity and a decrease in demand cover from over 90% to around 40% (see section 2.2).¹⁵⁶ However, taking the barriers to exit in NWE refining into account significantly impacts the outcomes of the must-run scenario. Of the 22 exposed fuel refineries in the must-run scenario, 9 are expected to be 'closure-constrained' because they are plausible candidates for political or merchant refining deals (see Figure 4.5). Accordingly, under closure-constrained scenario conditions, only 13 out of 34 fuel refineries in NWE are expected to be exposed. This leaves 9 closure-constrained and 12 must-run fuel refineries which together operate around 4.5 Mb/d of crude distillation capacity in NWE, covering close to 70% of overall demand (see Figure 4.4).^{157, 158}

154 Based on BP (2016), "Energy outlook 2035"; Exxon (2015), "The outlook for energy"; IEA (2015), "World Energy Outlook" and Wood Mackenzie 2025 refined product demand outlook figures from July 2015.

155 See, for example, Petroplus annual report 2010.

156 Based on BP (2016), "Energy outlook 2035"; Exxon (2015), "The outlook for energy"; IEA (2015), "World Energy Outlook" and Wood Mackenzie 2025 refined product demand outlook figures from July 2015.

157 Ibid.

158 Note that merchant refiners in a bid to simplify operations could further reduce crude distillation capacities.

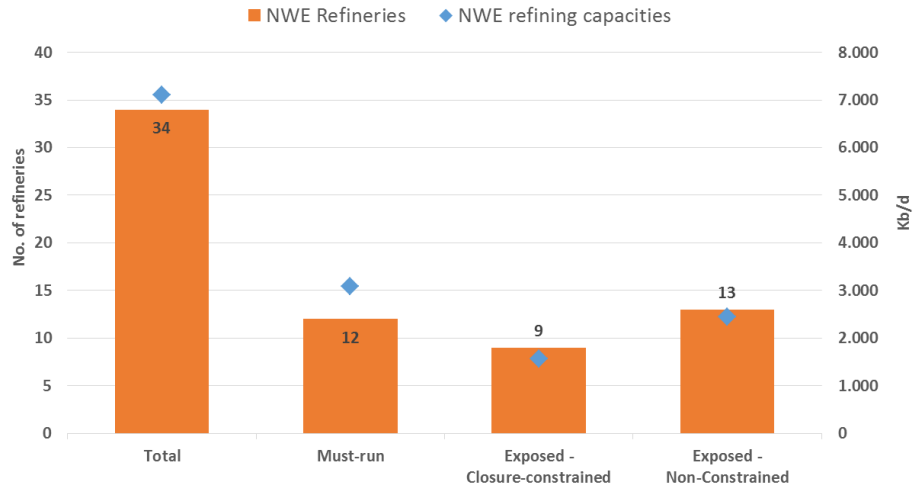
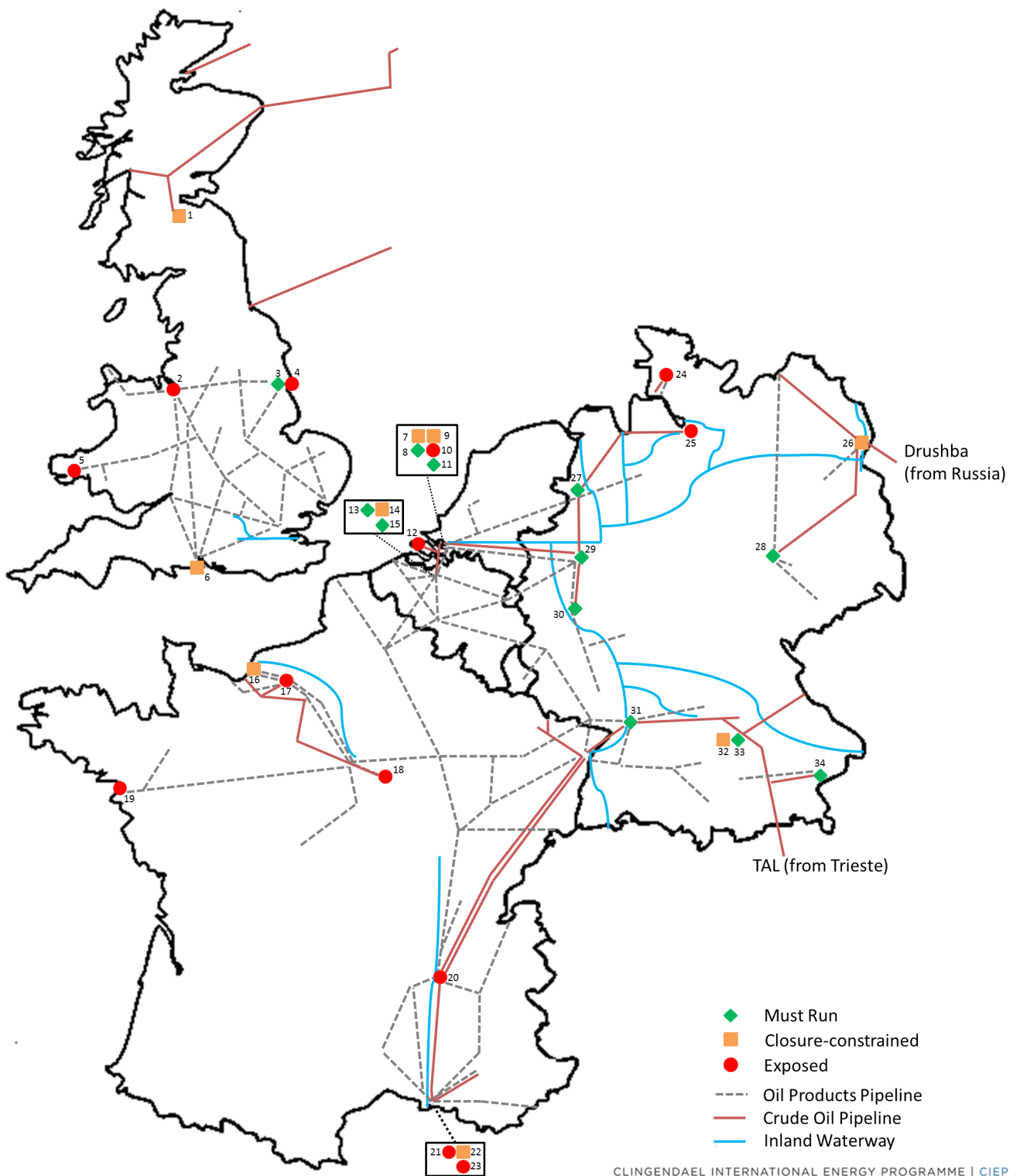


FIGURE 4.4: NWE REFINING LANDSCAPE UNDER CLOSURE-CONSTRAINED CONDITIONS

Unsurprisingly, the majority of the political deal candidate refineries can be found in the regions that are hardest hit in the must-run scenario (see Figure 4.6). The UK and French regions show a particularly high number of political deal candidates, because government intervention is expected to intensify for refinery closures that threaten the future of economically important clusters or entirely eliminate crude vs product import optionality for a key economic region. There is a clear consensus in the industry that political intervention will play an increasingly important role in future NWE refinery restructurings. It is far from clear, though, as to how local governments will intervene and whether they will ensure a level playing field within the industry and respect the framework of the EU internal market and the Treaty principles of state aid.¹⁵⁹

¹⁵⁹ Based on various discussions and personal interviews with industry players.



UK

- 1: GRANGEMOUTH (PETROINEOS)
- 2: STANLOW (ESSAR)
- 3: HUMBER (PHILLIPS 66)
- 4: LINDSEY (TOTAL)
- 5: PEMBROKE (VALERO)
- 6: FAWLEY (EXXON)

ARA

- 7: ROTTERDAM (GUNVOR)
- 8: ROTTERDAM (SHELL)
- 9: ROTTERDAM (KOCH)
- 10: ROTTERDAM (BP)
- 11: ROTTERDAM (EXXON)
- 12: ZEELAND (TOTAL/LUKOIL)
- 13: ANTWERP (TOTAL)
- 14: ANTWERP (GUNVOR)
- 15: ANTWERP (EXXON)

FR

- 16: GONFREVILLE (TOTAL)
- 17: PORT JEROME (EXXON)
- 18: GRANDPUITS (TOTAL)
- 19: DONGES (TOTAL)
- 20: FEYZIN (TOTAL)
- 21: FOS-SUR-MER (EXXON)
- 22: LAVERA (PETROINEOS)
- 23: LA MEDE (TOTAL)

DE

- 24: HEIDE (KLESCH)
- 25: HOLBORN (TAMOIL)
- 26: SCHWEDT (PCK JV)
- 27: LINGEN (BP)
- 28: LEUNA (TOTAL)
- 29: GELSENKIRCHEN (BP)
- 30: RHINELAND (SHELL)
- 31: MIRO (JV)
- 32: INGOLSTADT (GUNVOR)
- 33: BAYERNOIL (JV)
- 34: BURGHAUSEN (OMV)

FIGURE 4.5: MAP OF CLOSURE-CONSTRAINED SCENARIO

4.3.1 NWE REFINING ASSET BASE BY REGION

In contrast to political deal candidates, merchant refining candidates are exclusively found in regions which, even under must-run scenario conditions, are expected to maintain a healthy refining asset base, such as ARA and southern Germany (see Figure 4.6). Merchant refineries likely benefit disproportionately from a high concentration of crude and product flows and liquid spot markets, which are supported by the survival of a healthy refining centre. The presence of relatively large and more complex must-run refineries is also likely to support the availability of arbitrage opportunities, because they are by design slower to respond to spot market dislocations.¹⁶⁰

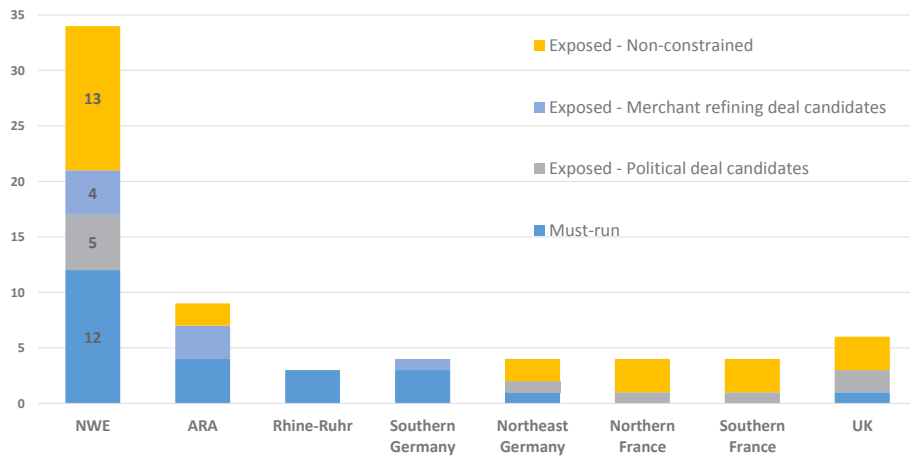


FIGURE 4.6: CLOSURE-CONSTRAINED SCENARIO OUTPUT BY REGION

4.3.2 NWE REFINING ASSET BASE BY OWNERSHIP CATEGORY

The dominant position of IOCs in the NWE refining sector comes back in their share of both must-run and exposed refineries. Among closure-constrained refineries, however, the IOCs are underrepresented. On the face of it this is rather surprising, because the home countries of 3 out of 4 active IOCs are in NWE (see Figure 4.7). Nonetheless, only Total is expected to be involved in a political deal around the restructuring of its refining footprint in France. BP and Shell have either already exited the refining business in their home country, or have concentrated their investments in a single must-run refining complex.¹⁶¹

¹⁶⁰ Significant upstream and downstream integration makes it unlikely that a refinery operator will sacrifice operational optimisation and stability to exploit (temporary) spot market dislocations.

¹⁶¹ Note that Shell is considered an Anglo-Dutch company with a dual home market.

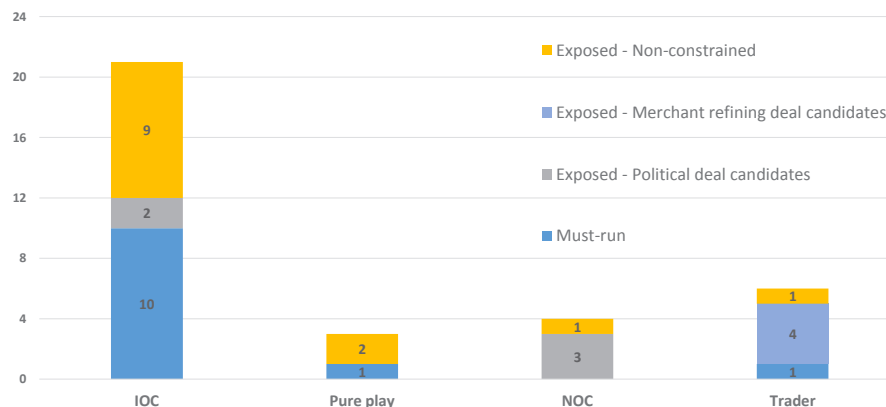


FIGURE 4.7: CLOSURE-CONSTRAINED OUTPUT BY OWNERSHIP CATEGORY

On the other hand, NOC-owned refineries are expected to benefit disproportionately from politically motivated deals that constrain closure. These NOCs, however, are not of NWE origin, which is not surprising because IOCs have always occupied a dominant position in NWE. Rather, the political deal candidates concern NOCs from outside NWE which consider a foothold in the NWE refining sector to be strategic.¹⁶² Nevertheless, with the exception of the Rosneft-owned Schwedt refinery, the strategic value of these refineries is not considered sufficient to guarantee continued investment in the long run. In fact, we expect concerns around local economic activity and security of supply to motivate political deals for the Grangemouth and Lavera refineries, in spite of their ownership by foreign NOCs. This may further complicate the role of local governments, though, if local resources are spent on propping up the assets of foreign state-owned entities.¹⁶³

Merchant refiners already own all four merchant refining deal candidates. This strongly suggests that opportunities for future merchant refining deals in NWE are expected to be scarce, and such deals are not likely to play an important role in NWE refinery restructurings in the future. It is interesting to highlight, though, that despite its trading-oriented owner the Klesch Heide refinery is not considered a merchant refining candidate. In fact, its refinery characteristics could not be more different from those of a merchant refining profile. The Heide refinery does not provide access to a trading hub or premium inland market, nor is it a particularly flexible and

¹⁶² See, for example, Gazprombank (2015), "Russia oil and gas equity research note" of June 22, 2015; and <http://www.reuters.com/article/petrochina-ineos-idUSTOE70905Q20110110>.

¹⁶³ The UK government granted a loan guarantee to Ineos (NOC) for an investment at its Grangemouth chemical site.

spot-oriented operation. It is a small but highly complex refinery with significant downstream integration.

All in all, the closure-constrained scenario provides valuable insight into how barriers to exit play a critical role in shaping the post-2025 refining landscape. Even though they are hard to quantify and it is even harder to predict in detail how they may influence the refinery restructuring process, this chapter demonstrates that barriers to exit cannot be ignored in any study of the NWE refining sector.

5 NWE ENERGY TRANSITION – A POTENTIAL MISMATCH IN TIMING

COP-21 has made it clear that fossil fuel related CO₂ emissions have been put on notice.¹⁶⁴ Particularly in NWE, the policy focus has decisively shifted towards achieving a transition to a low-carbon economy, suggesting increased pressure on fossil fuel industries to tackle emissions. The phase-out of fossil fuels, however, will not happen overnight and certainly not everywhere at the same pace. For the next 25 years at least, fossil fuels are expected to maintain their leading position in the world's energy mix.¹⁶⁵ Despite inroads of new fuels into the transportation fuels market, the role of oil will remain very large indeed in the decades to come. For example, both BP and Exxon still expect oil to serve close to 90% of world energy demand in transportation by 2035 and 2040 respectively.¹⁶⁶

Regionally, though, demand for petroleum-based transportation fuels could widely differ, removing the cushion of a growing or stable domestic market for some refiners. Given the policy initiatives in Europe, demand for petroleum-based transportation fuels may decline faster than global demand, changing the outlook for NWE refiners. This is reflected in our must-run (see Chapter 2) and closure-constrained (see Chapter 4) scenarios, which show that it is likely that without upgrading investments a significant portion of NWE's refining capacity may close long before regional oil demand is replaced by low-carbon alternatives.

Given the possible mismatch between unco-ordinated refinery closures and demand switching to new transportation fuels or technologies, it seems likely that the transition towards a low-carbon economy will include a stage in which a significant portion of NWE's oil demand may have to be satisfied by refined product imports. In the interim, NWE may cease to enjoy the full benefits of a thriving refining sector (GDP, jobs, know-how, security of supply, etc.), while still grappling with the external costs of a fossil-fuelled economy (GHG emissions, carbon leakage, stranded assets,

¹⁶⁴ COP-21 is the 21st yearly session of the Conference of the Parties (COP) to the 1992 United Nations Framework Convention on Climate Change (UNFCCC).

¹⁶⁵ See, for example, IEA WEO (2015), "World energy outlook 2015 executive summary"; The UK Department of Energy and Climate Change (2014), "Review of the Refining and Fuel Import Sectors in the UK".

¹⁶⁶ Exxon expects oil to serve >30% of world energy demand and close to 90% of world energy demand in transportation by 2040, Exxon (2015), "The outlook for energy"; and BP expects an approx. 30% share of oil in world primary energy demand and an 88% share for oil in energy demand in transportation by 2035, BP (2016), "Energy outlook 2035". BP and Exxon are no exceptions among oil companies; the IEA and OPEC outlooks show comparable scenarios for oil demand over the next 20 years.

etc.).¹⁶⁷ In this section we therefore aim to discuss the strategic implications of the potential mismatch in timing between changing demand for oil products and the reduction of NWE refinery capacity. In particular, we highlight the implications for security of supply as well as the costs of prematurely abandoning NWE's refining legacy.

5.1 SECURITY OF SUPPLY

One of the strategic issues surfacing in a scenario in which there is a mismatch between changing demand for oil products and a reduction of NWE refining capacity revolves around the state's role in providing security and protecting the rule of law. These security functions remain overwhelmingly dependent on oil-based infrastructure, equipment, and appliances, ensuring that secure oil and oil product supplies must continue to be a top priority for NWE's governments.¹⁶⁸ The dominance of the market refining model in NWE since the 1950s has implied that security of supply discussions historically have focused almost exclusively on crude oil. The IEA as an organisation, and its International Energy Programme in which the strategic oil reserves are organised, bear witness to this focus. Only a few IEA member states dedicate, in addition to crude oil reserves, part of their strategic reserve to refined oil products storage. A wholesale return to a source-refining model would require the discussion to shift to refined products instead. Undoubtedly, in terms of energy trade balances, a transition from crude to product imports may have little to no impact on strategic import dependence. But security of supply is not only a function of the degree of import dependency; it is also a function of the flexibility of supplies and the ability to switch to alternatives.¹⁶⁹

167 See, for example, Foundation for Economic and Industrial Research (2014), "Refining Sector in Greece: Contribution to the Economy and Prospects"; or Europa (2010), "White Paper on EU Refining".

168 See, for example, CIEP (2004), "Study on energy supply security and geopolitics", section 1.1.

169 See, for example, CIEP (2004), "Study on energy supply security and geopolitics", section 2.2.6.

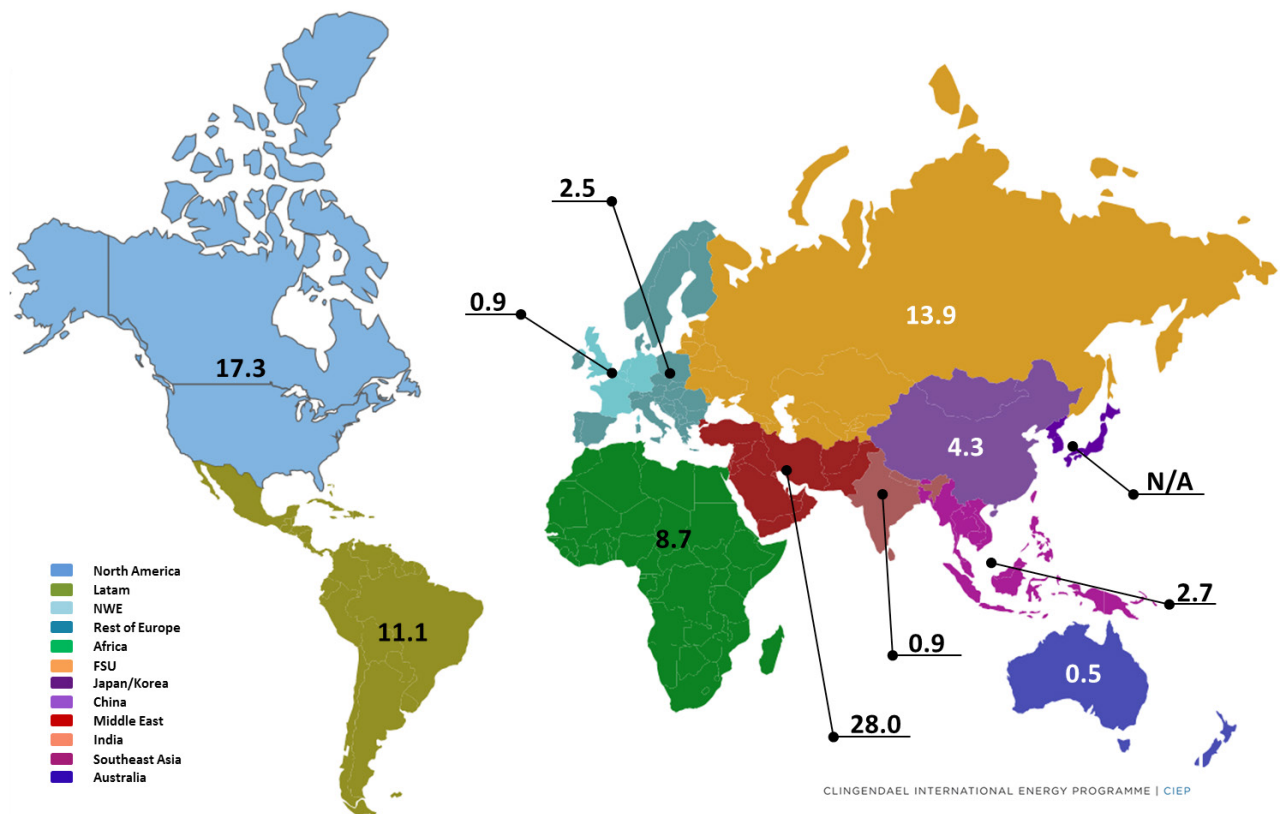


FIGURE 5.1: GLOBAL DISTRIBUTION OF CRUDE OIL PRODUCTION (Mb/d)¹⁷⁰

The security of supply impact of closing NWE's refineries before oil demand is replaced by low-carbon alternatives thus depends on the relative flexibility of the global crude oil and refined product supply chains. The flexibility of a supply chain is again primarily a function of the diversity and stability of its origins.¹⁷¹ Figures 5.1 and 5.2 illustrate that when it comes to diversity and stability of global production, refining capacities are neither more nor less favourably distributed than crude oil capacities. In addition, the inverse Herfindahl-Hirschman (HHI) index numbers show that a shift from crude to refined product imports might even have a slightly positive impact on the diversity and flexibility of NWE's oil supplies.¹⁷² Nevertheless, a wholesale move towards refined product imports would require an adjustment in

170 Based on BP Statistical Review (2015) and UK Department of Energy and Climate Change (2015) figures.

171 Shipping cost differentials between crude and products have historically also played an important role, but the emergence of multi-product supertankers has been somewhat of a game changer.

172 The inverse HHI provides an effective number of suppliers in a market, given the number of active origins and their respective market shares. The inverse HHI index for crude oil production is 14.6, and that for refining capacities is 15.3. Based on figures from BPSR (2015) and UK Department of Energy and Climate Change (2015).

strategic stockpiling policies to reflect the diminished role of crude in NWE markets.¹⁷³ More importantly, however, crude has historically been more actively traded than its refined components, and its deep and liquid markets have often been instrumental in absorbing supply disruptions and managing the adverse effects of price volatility. It remains to be seen whether global refined product markets will be able to follow this act and rival the reliability and liquidity of crude markets.

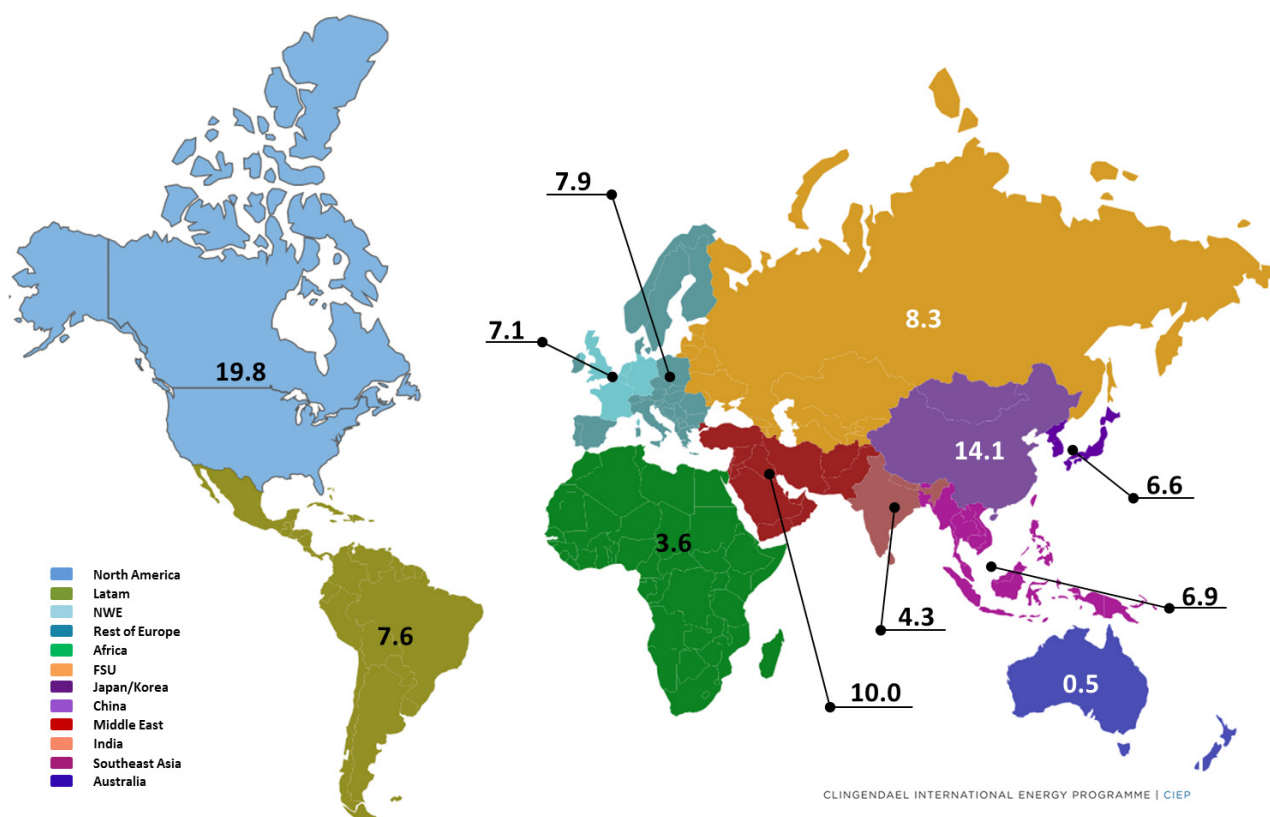


FIGURE 5.2: GLOBAL DISTRIBUTION OF REFINING CAPACITIES (Mb/d)¹⁷⁴

The above analysis also fails to consider the ability of refineries to switch between crude oil and refined product imports. In other words, a refinery offers the optionality between importing crude oil and refining it, or to skip the refining step and directly import the end product from elsewhere.¹⁷⁵ In the case of refinery closures in NWE,

¹⁷³ Holding refined product instead of crude oil stocks in strategic storage has some practical implications as well. For example, the quality of refined oil product stocks will deteriorate much faster than that of crude oil stocks.

¹⁷⁴ Based on BP Statistical Review (2015).

¹⁷⁵ Department of Energy and Climate Change (2014), "Review of refining and fuel import sectors in the UK", Chapter 3.

the ability to switch between crude oil and refined product imports may be severely constrained. It is hard to quantify the contribution of this optionality to NWE's security of supply, but as long as critical state functions are dependent on oil there is a strategic rationale to maintain an additional layer of security in the form of a domestic refining sector.¹⁷⁶ In this light, small and nimble merchant refineries might be particularly well positioned to provide security of supply at the lowest possible cost to NWE's economies. However, chances are that NWE refining economics may continue to deteriorate, and even nimble merchant refiners may no longer be able to provide a measure of supply security without some form of state support. This suggests that the return of a source-refining model would in time require the state to play a more active role in the NWE refining sector.

5.2 REFINING LEGACY: MANAGING TRANSITION

After nearly a decade of continuous restructuring, the NWE refining legacy still consists of 34 active fuel refineries with a combined capacity of 7.1 Mb/d, serving regional demand for transport fuels and chemical feedstocks, and actively engaging in trade with refining centres across the world.¹⁷⁷ The refining legacy also directly supports over 30,000 highly skilled jobs and contributes significantly to regional GDP.^{178,179} Accordingly, closing refining capacities before regional oil demand is replaced by low-carbon alternatives might prematurely expose NWE's economies to both social (jobs and know-how) and clean-up costs associated with restructuring the domestic refining industry (see Chapter 3).

Nevertheless, in the face of a relentless push by NWE governments to lead the world into an unknown process towards a low-carbon energy transition, the reluctance of the private sector to maintain a sustainable level of refinery investments is not surprising.¹⁸⁰ As a result, during the transition there is a real possibility that energy demand in NWE's transport sector will be served by two incomplete business models, neither of which can function independently without state support. On the one hand, the capital-intensive refining business model is undermined by growth and policy support for low-carbon alternatives. On the other hand, low-carbon

176 Strategic sectors include, but are not limited to, the military, police, and, for example, diesel-driven back-up power systems of hospitals.

177 Based on Joint Organisations Data Initiative (JODI) global refined product trade flows for 2015.

178 In France the refining sector supports 7,500 direct jobs (UFIP), in Belgium the sector supports 6,500 direct jobs (Petrofed), and in Germany it supports close to 17,000 direct jobs (MVV). This averages to at least 900 direct jobs per fuel refinery, implying that there are at least 30,000 direct jobs supported by the NWE refining sector.

179 For example, the UK refining sector alone accounts for about 0.15% of GDP, and the Grangemouth complex is said to account for about 4% of Scottish GDP. On the continent, the Dutch refining sector accounts for about 0.2% of GDP.

180 The recent developments in the European electricity markets loom large in this respect. See, for example, CIEP (2014), "Sunset or Sunrise? Electricity Business in Northwest Europe".

alternatives may not be able to fully satisfy energy demand in NWE's transport sector for decades to come, ensuring lasting demand for refined oil product supply.

This leaves NWE governments with two options: they can step in and aggressively accelerate the introduction of low-carbon alternatives to oil, or they can make certain refinery investments more attractive for the private sector to co-ordinate both transition processes. Unfortunately, COP-21 has shown that even the most ambitious plans for phasing out fossil fuels fall well short of achieving such a demand switch the coming 20 years.¹⁸¹ Therefore, NWE governments may either have to face the cost of replacing a large part of the domestic refining industry by imports or engage with the industry to improve the refinery investment climate and address the liabilities inherent in an energy transition that could make much of today's infrastructure obsolete in the longer term.

The long-term reduction in NWE refining capacity is not in question, but the must-run and closure-constrained scenarios illustrate that this reduction has to be managed carefully. NWE not only requires a policy framework to support the introduction of low-carbon alternatives; it also requires a policy framework to promote a responsible contraction of its refining sector, ensuring that it maintains the capabilities to deliver secure and adequate refined oil product supplies during the long-term energy transition.

181 The EU estimates that over 50% of final energy consumption will remain fossil based until 2050: European Commission (2013), "EU Energy, Transport and GHG Emission Trends to 2050". JRC projects the 2020 share of petroleum products in the transport sector over 90%: Joint Research Centre (2014), "EU Renewables Energy Targets in 2020".

6 CONCLUSION

The NWE refining sector faces structural demand contraction, an early transition to a low-carbon economy, and increased competition from advanced export-oriented source refineries. This non-level playing field undermines the investment case in NWE refineries and may pave the way for imports to assume a dominant role in NWE refined product supply. The must-run and closure-constrained scenarios have presented possible states of the post-2025 NWE refining landscape while accounting for structural competitive advantages and barriers to exit in NWE refining. The must-run scenario in particular presents an extreme or worst-case outcome, but with the traditional role of NWE market refineries in flux we believe this scenario provides the boundary conditions to guide a discussion about the future role of this sector.

Under must-run conditions, 12 of the 34 operational NWE refineries may have the structural competitive advantage to withstand the competition of refined product imports and continue to secure upgrading investments. Post-2025, this would leave NWE with about 3 Mb/d of refining capacity to serve close to 7 Mb/d of refined product demand.¹⁸² Critical to note is that this so-called must-run refining capacity is all but evenly distributed across NWE. The ARA, Rhine-Ruhr, and Southern German refining centres come out relatively unscratched, whereas UK and French refining centres are almost entirely exposed to refined product imports.

The closure-constrained scenario shows that economic efficiency is likely to be blunted by the presence of significant barriers to exit in NWE refining. A significant proportion of NWE refineries, especially in hard-hit France and the UK, will be shielded from closure by political support and pressure on the grounds of their impact on regional security of supply and local economy. On the other end of the spectrum, some NWE refineries are likely to be shielded from closure by minimising full-cycle environmental clean-up costs by transforming into low-cost and nimble merchant refineries. All in all, barriers to exit in NWE refining may constrain the closure of up to 9 refineries, accounting for around 1.5 Mb/d of refining capacity. Post-2025, this would leave NWE with about 4.5 Mb/d of refining capacity to serve close to 7 Mb/d of refined product demand.

¹⁸² Based on BP (2016), "Energy outlook 2035"; Exxon (2015), "The outlook for energy"; IEA (2015), "World Energy Outlook" and Wood Mackenzie 2025 refined product demand outlook figures from July 2015.

Post-2025, NWE countries may find that refining capacity reductions have raced ahead of changes in refined oil product demand, raising significant security of supply concerns and prematurely bequeathing a refining legacy of stranded assets and polluted refinery sites. Given the long-term nature of refining investment cycles, we believe it is necessary for stakeholders in the NWE refining sector to start discussing a responsible path for refining capacity reductions, ensuring that the NWE refining industry preserves the capabilities to deliver reliable, affordable and adequate refined oil product supplies during the upcoming energy transition. Hence, this study might kick-start the discussion on near future implications of unco-ordinated refinery restructurings due to market circumstances and government policy priorities demanding a different timing. In this light, we also hope that this study will inspire follow-up studies that more closely examine the strategic implications of a contraction in the NWE refining sector.

In particular, we would call for an expansion of the scope of this study to include Mediterranean, Scandinavian, and eastern European countries. This may provide an excellent starting point for a more detailed examination of the security of supply impact and the future clean-up costs related to a shrinking European refining footprint in the wider EU-28. In addition, future research that can find a way to incorporate measures of internal refinery performance when assessing the competitive advantages of a refinery complex is of particular interest. Another topic for a potential spin-off study could be an in-depth assessment of the specific added value of the Dutch refining sector to its economy. Overall, we think more research into the strategic importance of the European refining sector is needed, also in terms of security of supply, to provide policy-makers with a better understanding of its legacy and role during the upcoming energy transition. A more elaborate assessment of the barriers to exit and potential policy recommendations regarding EU-wide regulation would give the European refining sector a foothold for strategic choices in times of turmoil.

7 ANNEXES

ANNEX A – DETAILED MUST-RUN REFINERY DECISION TREES

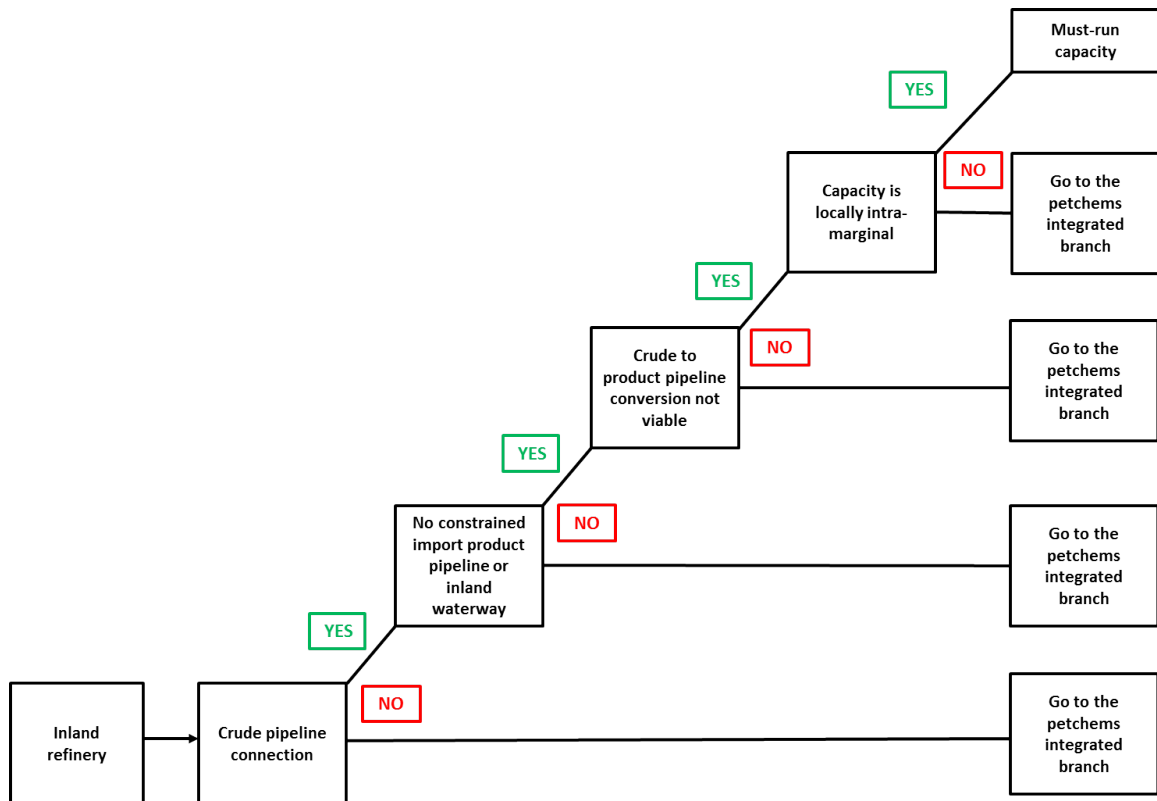


FIGURE A.1: CAPTIVE DEMAND REFINERY DECISION TREE

CAPTIVE DEMAND REFINERIES¹⁸³

The first branch of the binary decision tree concerns captive demand refineries (see Figure A.1). A refinery that serves an inland market, has direct access to a crude pipeline and lacks exposure to non-constrained refined product pipelines or inland port facilities enjoys the benefit of a captive market for its products.¹⁸⁴ As long as it is not viable to convert the existing crude pipeline to a product pipeline and refining capacity is intra-marginal to local demand, we assume that the refinery has strategic value to the inland region. Investments in upgrading to maintain a match between

183 For more details on pipeline and inland waterway connections see Mineralölwirtschaftsverband (2015), "Jahresbericht 2014"; IEA (2014), "Netherlands, Belgium, Germany, France, and UK energy supply security"; EFIP (2014), "European inland waterways map"; UN economic commission for Europe (2012), "European inland waterways"; Tebodin (2009), "Vopak terminal Eemshaven"; NATO (2008), "Central European pipeline system"; and ECSP (2007), "European pipeline infrastructure networks"; TRAPIL (2006), "Le Havre-Paris pipeline network"; www.mwv.de; www.trapil.fr; www.rpwweb.nl; www.binnenvaart.be; www.interrijn.nl

184 Note that this assumes that refined product imports by rail or truck will not be competitive over a distance exceeding 250 Km.

refinery output and local demand are expected to continue, avoiding costly exports of refined product surpluses.¹⁸⁵ Accordingly, such a refinery will be considered 'must-run' capacity and remain competitive vis-à-vis refined product imports.

PETROCHEMICALS INTEGRATED REFINERIES

The second branch of the binary decision tree concerns petrochemicals integrated refineries (see Figure A.2). A refinery that is integrated into a petrochemicals cluster through various pipeline connections will benefit from reduced transport intensity (i.e., lower freight costs, reduced hazardous products transport risk, and reduced emissions), more effective utilisation of raw material inputs and assets, and more efficient use of working capital.¹⁸⁶

When integrated with world-scale steam crackers with feedstock flexibility exceeding 20%, the refinery augments naphtha supply with significant volumes of gaseous or specialty feedstocks, such as refinery off-gas or hydrowax, for which third party alternatives are comparatively expensive.¹⁸⁷ Considering the importance of steam cracker feedstock flexibility, it is also important that refineries are able to deal with surplus petrochemical feedstocks (i.e., when the steam cracker is optimised toward one or the other feedstock). This suggests the importance of readily available outlets for commoditised feedstocks such as naphtha and LPGs. When integrated with world-scale aromatics production, the refinery plays an important role as a source of hydrogen, directly by supplying hydrogen or indirectly by supplying sulphur-free naphtha, or in other cases by supplying refinery off-gas as a cheap feedstock for hydrogen production.¹⁸⁸ By-products from steam cracking and aromatics production are returned to the refinery for use in fuels productions.¹⁸⁹ Accordingly, refineries that are directly integrated with world-scale steam cracking or aromatics production are expected to be of strategic value to a petrochemical cluster.¹⁹⁰

185 Note that constraints on crude to product pipeline conversions are not technical or financial, but a function of the number of inland refineries served by a crude pipeline, the ownership structure, and the lack of incentive for refiners that own the crude pipeline to make it available for refined product transports. The TAL crude pipeline is a case in point: it is owned by a consortium of oil companies that all own refineries in captive demand regions in Germany, Austria, and the Czech Republic (owners include OMV, Shell, BP, ExxonMobil, Phillips 66, Gunvor, and MIRO).

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

187 20% has been chosen as threshold, because traditional naphtha-based steam crackers can switch up to 20% of their capacity to alternative feedstocks such as LPGs. In order to be able to switch above the 20% threshold level, steam crackers require significant upgrading.

188 Aromatics production includes hydrogenation stages, making it a hydrogen intensive production process.

189 A steam cracker by-product, pygas, is also used as a feedstock for aromatics production, which makes integration between steam cracking and aromatics productions an important aspect of a competitive cluster.

190 For more details on refinery steam cracker and aromatics integration in Europe see Petrochemicals Europe (2014), "Facts and Figures"; "Oil & Gas Journal (2014), "International survey of ethylene from steam crackers"; Infra Leuna (2013), "Regional network"; ExxonMobil (2013), "Esso actualités printemps 2013"; Association of petrochemicals producers in Europe (2011), "Refineries and steam crackers in EU-27"; Al Qahtani, K. and A. Elkamel (2010), "Planning and integration of refinery and petrochemical operations"; Total (2008), "Synergies between refining and petrochemicals: Today and tomorrow"; and various company publications.

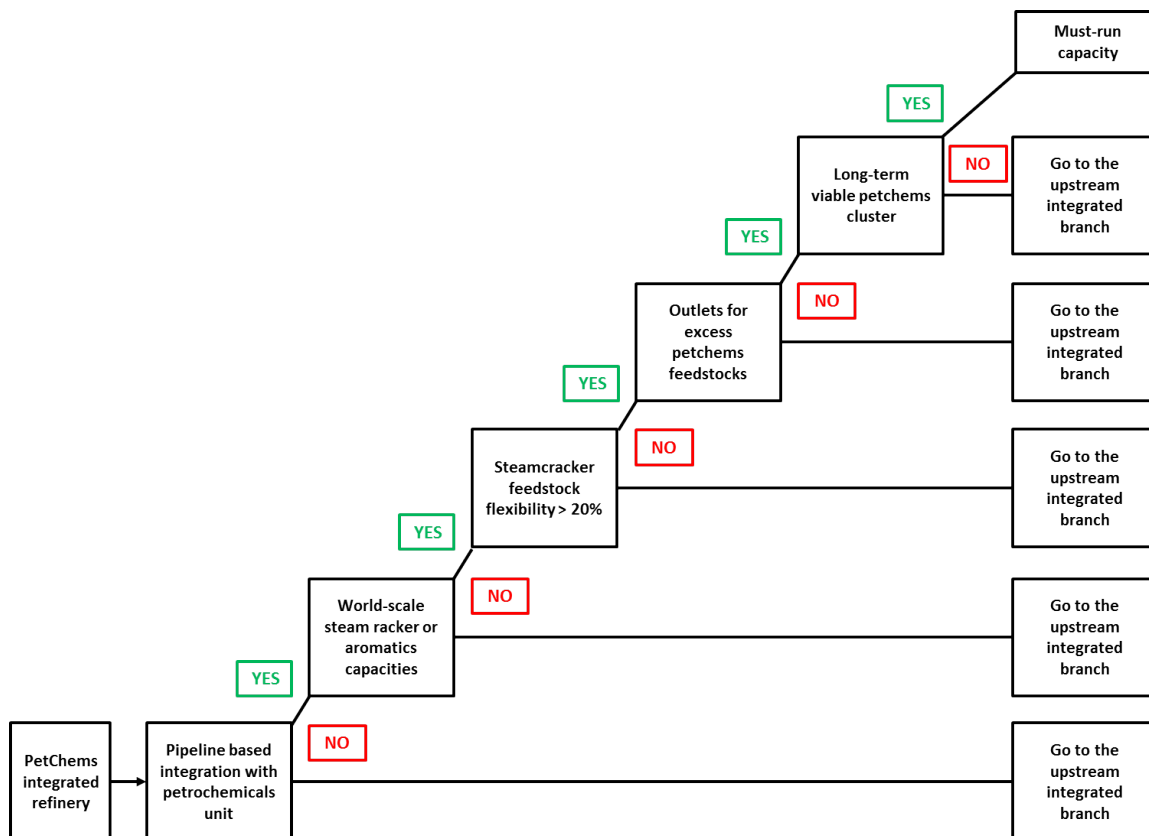


FIGURE A.2: PETROCHEMICALS INTEGRATED REFINERY DECISION TREE

Finally, petrochemicals integrated refineries need to be part of a cluster that is expected to remain competitive in the long run. Three criteria are critical for long run competitiveness: (1) availability of several world-scale steam crackers and aromatics plants; (2) significant downstream olefins and aromatics integration; and (3) availability of ethylene and propylene pipelines. Where the cluster exhibits these criteria, we assume it is large and diversified enough to remain competitive for the foreseeable future.^{191, 192}

When a refinery has strategic value to a petrochemicals cluster that is expected to remain competitive in the long run, we expect it to secure continued investment in refinery upgrades to remain competitive vis-à-vis refined product imports.

191 For more details on industrial gas networks in Europe, which we have used to delineate clusters, see Perrin, J. et al. (2007), "European hydrogen infrastructure atlas"; and ECSPP (2007), "European pipeline infrastructure networks".

192 For more details on European petrochemical clusters and refinery integration, see Port of Antwerp (2015), "A case of success for the management of chemical maritime logistics"; Germany Trade & Invest (2015), "Chemical parks in Germany"; Cefic (2014), "Landscape of the European chemical industry"; Oil & Gas Journal (2014), "International survey of ethylene from steam crackers"; Infra Leuna (2013), "Regional network"; ExxonMobil (2013), "Esso actualités printemps 2013"; Port of Rotterdam (2010), "Energy port and petrochemicals cluster"; Total (2008), "Synergies between refining and petrochemicals: Today and tomorrow"; EPCA (2007), "A paradigm shift: Supply chain collaboration and competition between Europe's chemical clusters".

UPSTREAM INTEGRATED REFINERIES

The third branch of the binary decision tree concerns upstream integrated refineries (see Figure A.3). A refinery that has a pipeline connection to a crude long region with no alternative premium outlets for its crude oil enjoys a strategic position. This is particularly true if it is not viable to convert the crude pipeline to a refined product pipeline. There will be a mutual interest in supporting profitable refinery operations and ensuring continued investment in upgrading.¹⁹³ As long as production in the crude long region is viable in the long term, a refinery with these characteristics will be considered 'must-run' capacity with continued investments to remain competitive vis-à-vis refined product imports.

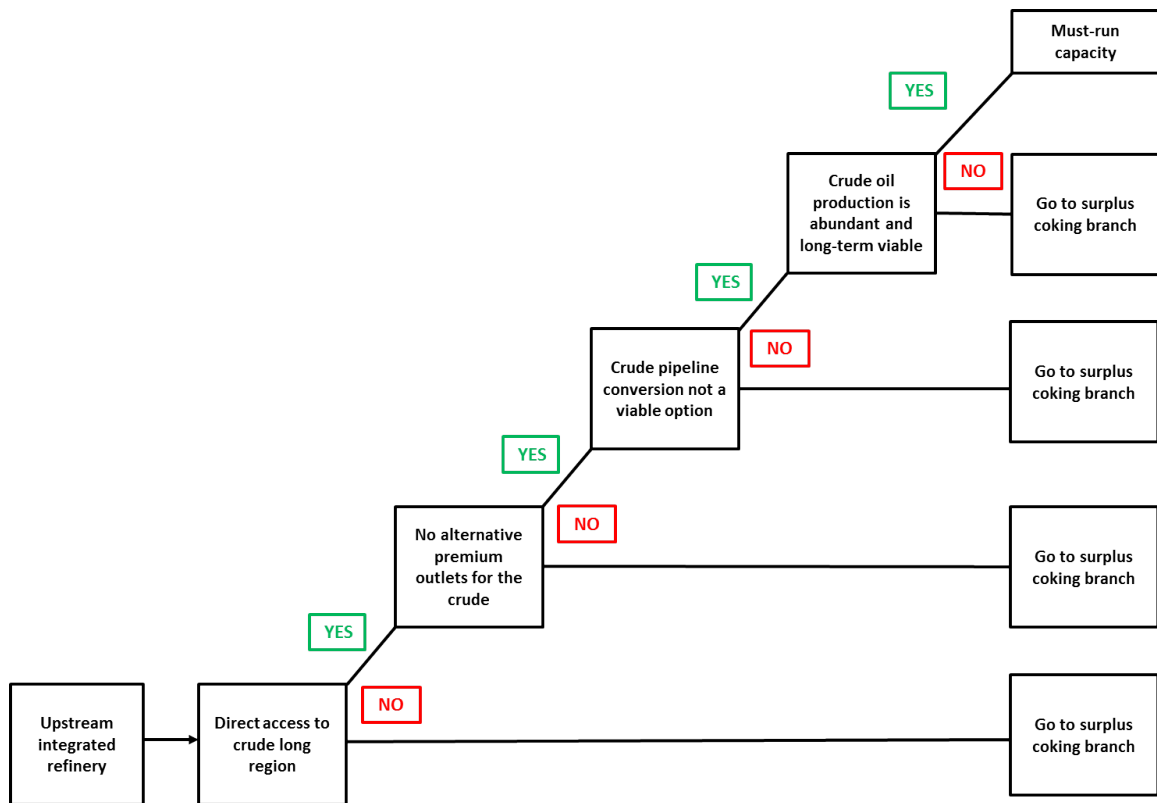


FIGURE A.3: UPSTREAM INTEGRATED REFINERY DECISION TREE

¹⁹³ Often this mutual interest drives a crude long company to take an ownership stake in the refinery. The Rosneft ownership stake in the German Schwedt refinery is a prime example.

SURPLUS COKING REFINERIES

The fourth branch of the binary decision tree concerns surplus coking refineries (see Figure A.4). The strategic position of surplus coking refineries stems from the gradual tightening of refined product specifications, in particular for heavy fuel oil (HFO) outlets such as bunker fuels, and the limited availability of coking capacity in NWE to upgrade bottom of the barrel streams to low-sulphur transport fuels.¹⁹⁴ This suggests that NWE refineries with available coking capacities are in a strong position and that refineries with significant surplus coking capacities will be able to provide an HFO outlet for coking deficit refineries. Under must-run scenario conditions it is critical, though, that a surplus coking refinery maintains access to HFO feedstock. Accordingly, a surplus coking refinery that serves must-run refineries with deficit coking capacities is expected to enjoy continued investment in refinery upgrades and remain competitive vis-à-vis refined product imports.

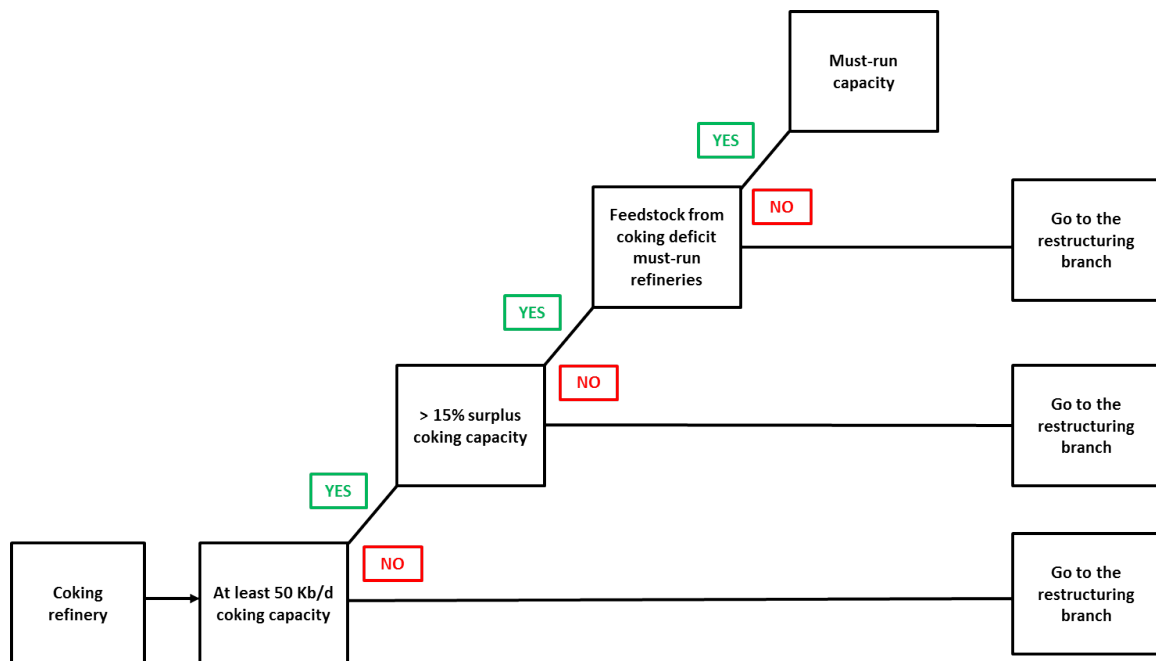


FIGURE A.4: SURPLUS COKING REFINERY DECISION TREE

¹⁹⁴ For more details on changing HFO sulfur specifications, see, for example, Concawe (2013), "Oil refining in the EU in 2020, with perspectives in 2030". Also, note that residue gasification capacities, an alternative to coking to upgrade HFO streams, are even more limited in NWE.

ANNEX B – MUST-RUN REFINERIES BY CATEGORY

CAPTIVE DEMAND REFINERIES

More than 800 Kb/d of refining capacity is expected to be of strategic value to captive demand regions in NWE, ensuring continued investment in upgrading and sheltering it from direct competition with imports. All of this capacity is located in the south and east of Germany. In Bavaria the combination of the TAL crude pipeline system (a constrained and interruptible refined product pipeline network) and a lack of inland waterways ensures that the OMV Burghausen, Varo Energy Bayernoil, and Gunvor's Ingolstadt refineries remain competitive vis-à-vis imports (see Figure B.1).¹⁹⁵ Nevertheless, the ability of the large and complex must-run MiRO refinery in neighbouring Baden-Württemberg to supply part of Bavaria's refined product demand is expected to make the Gunvor Ingolstadt refinery extra-marginal in the long run.¹⁹⁶

The MiRO Karlsruhe refinery, located close to the Stuttgart demand region, benefits from access to both the TAL and SPSE crude pipeline systems, a constrained and interruptible refined product pipeline network, and the Rhine bottleneck west of Frankfurt, at Kaub (see Figure B.1). During 2013 and 2014, Rhine water levels at Kaub were below 2m on 40% of the days, significantly constraining the draft and tonnage of tanker barges heading to southern Germany and Basel.¹⁹⁷ In theory, the SPSE crude pipeline could be converted to a refined product pipeline when the Feyzin refinery succumbs to competition from imports. In practice, however, both Exxon and Shell, who together own a majority stake in MiRO, hold ownership stakes in the SPSE pipeline company, allowing them to restrict refined product transports to Karlsruhe and protect their investments in the MiRO refinery.¹⁹⁸

The last captive demand refinery is Total's Leuna refinery located west of Leipzig and south of Berlin. Access to the Russian Drushba crude pipeline system (a single refined product pipeline limited to 90 Kb/d and focused on supplying petrochemical feedstocks), a lack of inland waterways, and an absence of competing refineries in a 300Km radius ensure a captive market for the Leuna refinery (see Figure B.1).¹⁹⁹ This contrasts with the position of the Schwedt refinery north of Berlin. First, it faces a

195 For more details on pipeline and inland waterway connections in Germany, see Mineralölwirtschaftsverband (2015), "Jahresbericht 2014"; IEA (2014), "Netherlands, Belgium, Germany, France, and UK energy supply security"; UN economic commission for Europe (2012), "European inland waterways"; NATO (2008), "Central European pipeline system"; and ECSPP (2007), "European pipeline infrastructure networks".

196 Some forecasts see gasoline demand in Germany falling between 20-30% post-2020.

197 This assumes that the normal draft of a fully loaded 2,000 DWT tanker barge heading to Basel is around 2.5m. For more details on Rhine-Kaub water levels, see: www.interrijn.nl.

198 A change in third party access to privately owned NWE oil pipelines is obviously a threat to this set-up.

199 The Litvinov refinery is only 200 Km from Leuna, but a lack of rail infrastructure connecting it to Germany ensures that competition from this refinery is constrained.

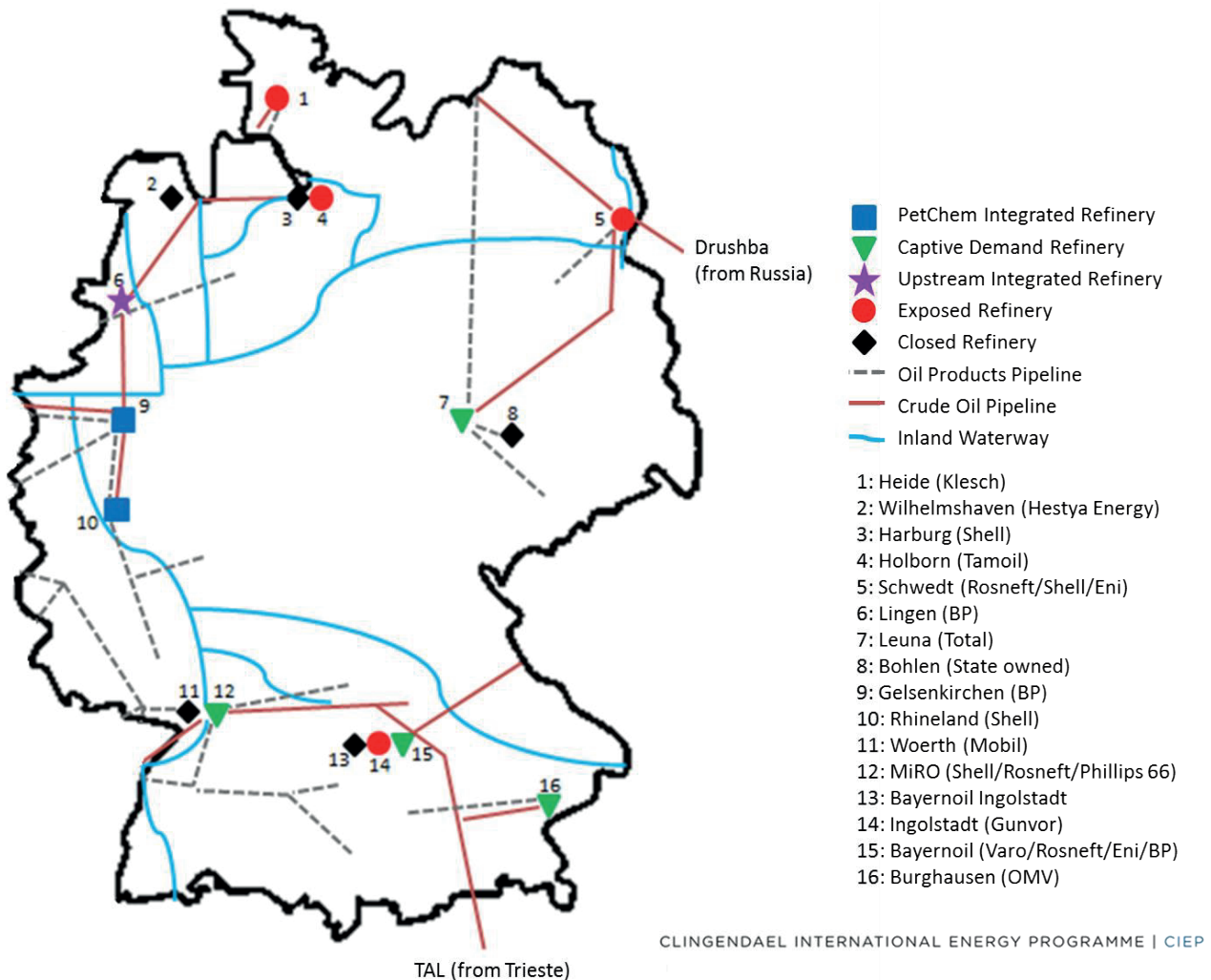


FIGURE B.1: GERMAN REFINERIES AND OIL INFRASTRUCTURE

potential threat from imports supplied from the Swinoujscie-Szczecin port over the Oder inland river system. Second, an upgraded Rostock-Berlin railway connection leaves the refinery exposed to competition from imports supplied directly from the Rostock port.²⁰⁰

Finally, it is worth noting that coking and asphalt production capacities in southern Germany are likely to be sufficient to process local vacuum residue streams, and avoid the need for HFO exports under must-run scenario conditions. If Gunvor's Ingolstadt refinery remains operational, though, southern Germany's HFO slate would look somewhat less favourable. At the same time, Total's Leuna refinery in eastern Germany appears to rely on residue gasification capacity to avoid an HFO surplus.²⁰¹

²⁰⁰ Rostock-Berlin is served by a new double-track railway that is suitable for heavy duty freight transportation, and the distance between Rostock and Berlin is under 250 Km. Refined product imports through the Rostock-Schwedt pipeline are unlikely, because the pipeline is directly owned by the PCK Schwedt consortium.

²⁰¹ Note that this assumes a vacuum residue yield of around 40%. Moreover, Leuna's residue gasification capacity might not be sufficient to eliminate all of its HFO output, although, traditionally the Leuna refinery has also processed some vacuum residue in their hydrocracking units and supplied vacuum residue to local methanol and POX units.

PETROCHEMICALS INTEGRATED REFINERIES

Five refineries in NWE are expected to be of strategic value to competitive petrochemical clusters, ensuring continued investment in upgrading and sheltering them from direct competition with refined product imports. Close to 1.0 Mb/d of petrochemicals integrated must-run capacity can be found in the Antwerp-Rotterdam cluster, and circa 0.6 Mb/d in the Rhine-Ruhr cluster. In total 22 NWE refineries are integrated with petrochemicals production, but in most cases downstream petrochemicals units are sub-world scale and part of clusters for which long run competitiveness is doubtful (see Figure B.2).^{202, 203}

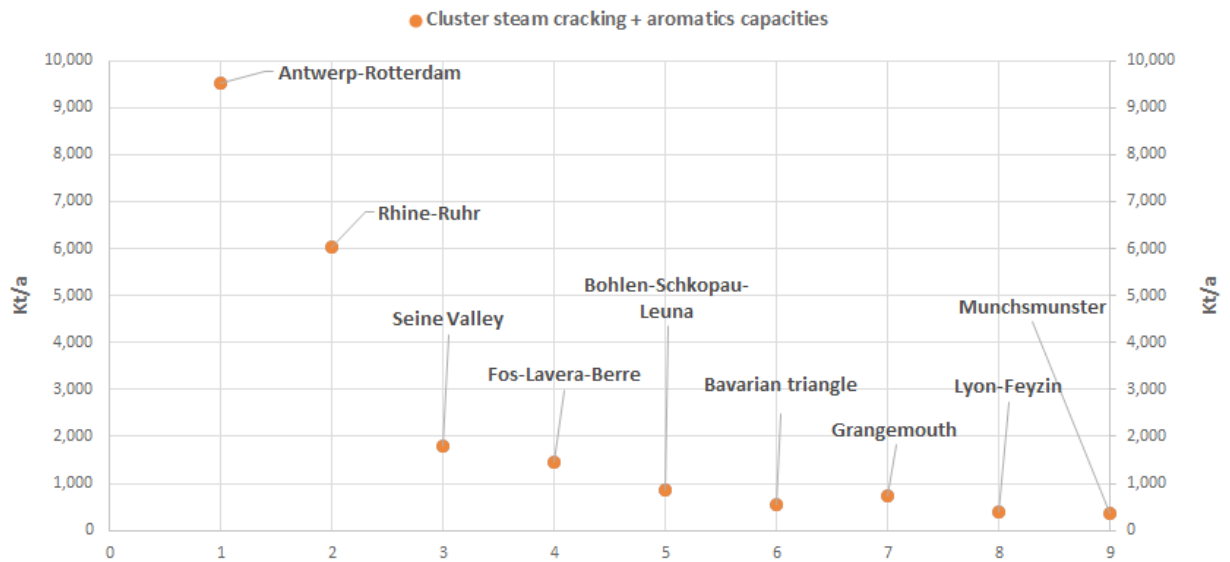


FIGURE B.2: NWE PETROCHEMICAL CLUSTERS – STEAM CRACKING AND AROMATICS CAPACITIES²⁰⁴

202 See Figure 2.7 for more details around the criteria we have used to determine the long run competitiveness of a petrochemicals cluster.

203 For more details on European petrochemical clusters and refinery integration, see Port of Antwerp (2015), "A case of success for the management of chemical maritime logistics"; Germany Trade & Invest (2015), "Chemical parks in Germany"; Cefic (2014), "Landscape of the European chemical industry"; Oil & Gas Journal (2014), "International survey of ethylene from steam crackers"; Infra Leuna (2013), "Regional network"; ExxonMobil (2013), "Esso actualités printemps 2013"; Port of Rotterdam (2010), "Energy port and petrochemicals cluster"; Total (2008), "Synergies between refining and petrochemicals: Today and tomorrow"; EPCA (2007), "A paradigm shift: Supply chain collaboration and competition between Europe's chemical clusters".

204 The Antwerp-Rotterdam cluster includes Dow's Terneuzen site, but excludes Sabic's Geleen site. The Rhine-Ruhr cluster excludes BASF's Ludwigshafen site. For more details on industrial gas networks in Europe, which we have used to delineate clusters, see Perrin, J. et al. (2007), "European hydrogen infrastructure atlas"; and ECSP (2007), "European pipeline infrastructure networks".

The Total Antwerp and Shell Rotterdam refineries enjoy direct integration with world-scale steam crackers that exhibit significant feedstock flexibility (see Figure B.3). This allows the refineries to optimise the supply of multiple feedstocks, including refinery by-product streams such as refinery off-gas (Total) and hydrowax (Shell), and add value to its steam cracker backflows as well.²⁰⁵ Such optimisation ensures that both refineries have direct strategic value to the Antwerp-Rotterdam cluster. The third strategic refinery is the Exxon Rotterdam refinery, which is directly integrated with the Botlek Aromatics plant and constitutes a critical source of sulphur-free naphtha and hydrogen (see Figure B.4).²⁰⁶

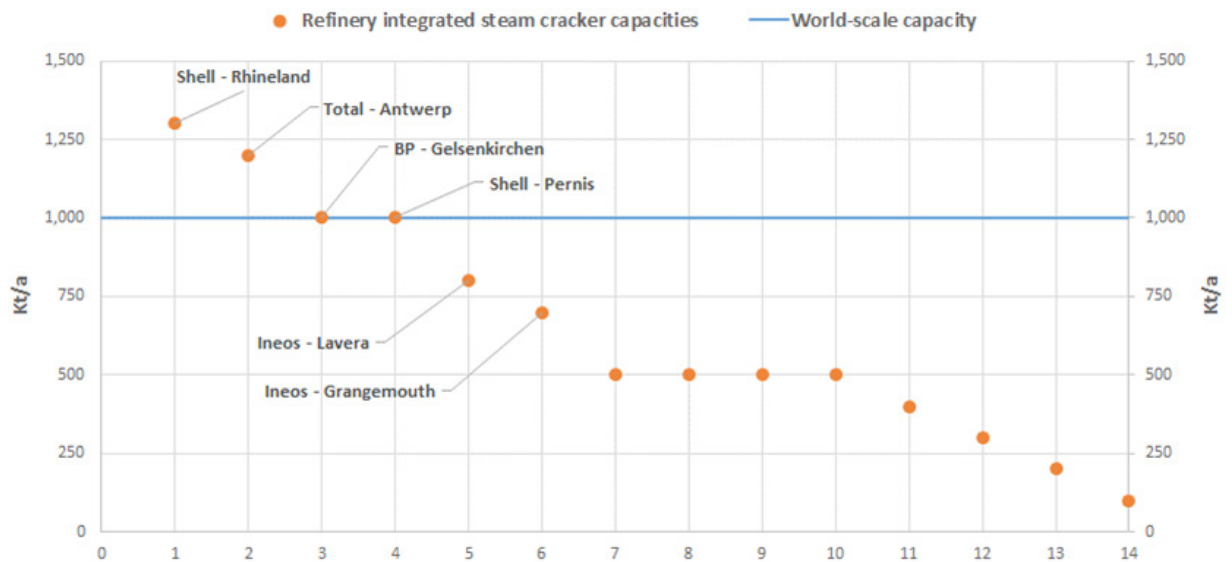


FIGURE B.3: NWE PETROCHEMICALS INTEGRATED REFINERIES – STEAM CRACKER ETHYLENE CAPACITIES²⁰⁷

205 For more details on refinery steam cracker and aromatics integration in Europe, see Petrochemicals Europe (2014), “Facts and Figures”; “Oil & Gas Journal (2014), “International survey of ethylene from steam crackers”; Infra Leuna (2013), “Regional network”; ExxonMobil (2013), “Esso actualités printemps 2013”; Association of petrochemicals producers in Europe (2011), “Refineries and steam crackers in EU-27”; Al Qahtani, K. and A. Elkamel (2010), “Planning and integration of refinery and petrochemical operations”; Total (2008), “Synergies between refining and petrochemicals: Today and tomorrow”; and various company publications.

206 Note that to ensure adequate hydrogen supply to the Exxon-owned Botlek aromatics plant, it is integrated with the Air Products hydrogen plant, which again uses excess refinery gas as a feedstock and returns its excess steam production to the refinery.

207 See 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”; and various company publications.

The BP Gelsenkirchen refinery derives its strategic value to the Rhine-Ruhr cluster from close integration with world-scale steam crackers that also have the ability to switch between various refinery produced feedstocks. Together with Total Antwerp, the Shell Rhineland complex is the only NWE refinery that enjoys both direct integration with world-scale steam cracking and world-scale aromatics capacities. It should be noted, though, that Shell Rhineland, alone among its peer group, does not own all the steam crackers directly integrated with its refinery.²⁰⁸

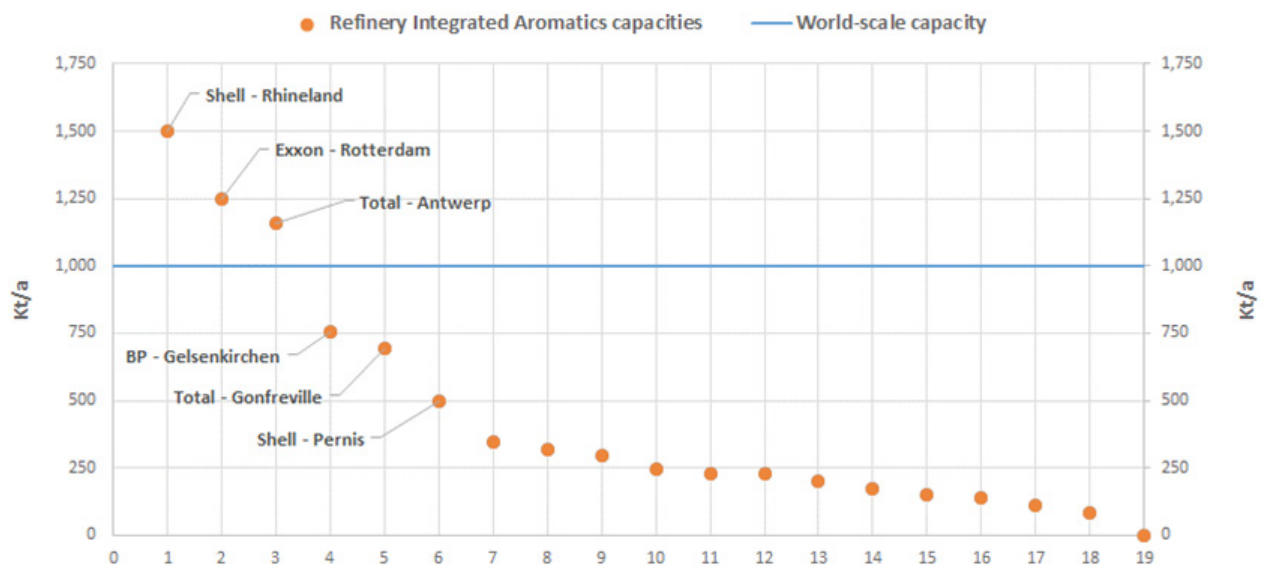


FIGURE B.4: NWE PETROCHEMICALS INTEGRATED REFINERIES – DISTRIBUTION OF AROMATICS CAPACITIES²⁰⁹

UPSTREAM INTEGRATED REFINERIES

Only one refinery in NWE is expected to be of strategic value to a crude long region, safeguarding continued investment in refinery upgrades to remain competitive vis-à-vis refined product imports. Surprisingly, it is not one of the eastern German refineries connected to the Drushba pipeline that derives a must-run status from its upstream integration (see Figure B.5).²¹⁰ Rather, the 95 Kb/d BP Lingen refinery in the northwest of Germany enjoys this position. Located in the midst of the German

208 LyondellBasell owns the two largest steam crackers on the Wesseling site.

209 Note that only benzene, toluene and xylene capacities have been considered. See Petrochemicals Europe (2014), "Facts and Figures"; Association of petrochemicals producers in Europe (2011), "Refineries and steam crackers in EU-27"; and various company publications.

210 Increased Russian crude oil export optionality has diminished the strategic value of the Schwedt and Leuna refineries in eastern Germany. In particular, the extension to the Ust-Luga oil terminal in the Gulf of Finland that was commissioned in 2012 has increased Russia's crude export optionality.

Emsland oilfields and with a direct pipeline connection to the Dutch Schoonebeek field, it sources around a third of its crude oil requirements locally, with its remaining crude requirements being supplied via the Wilhelmshaven crude pipeline (see Figure B.6). Moreover, large hydrocracking and coking units ensure that the BP Lingen refinery is well adapted to local crude diet, consisting primarily of very heavy (< 25° API) crude oil.²¹¹

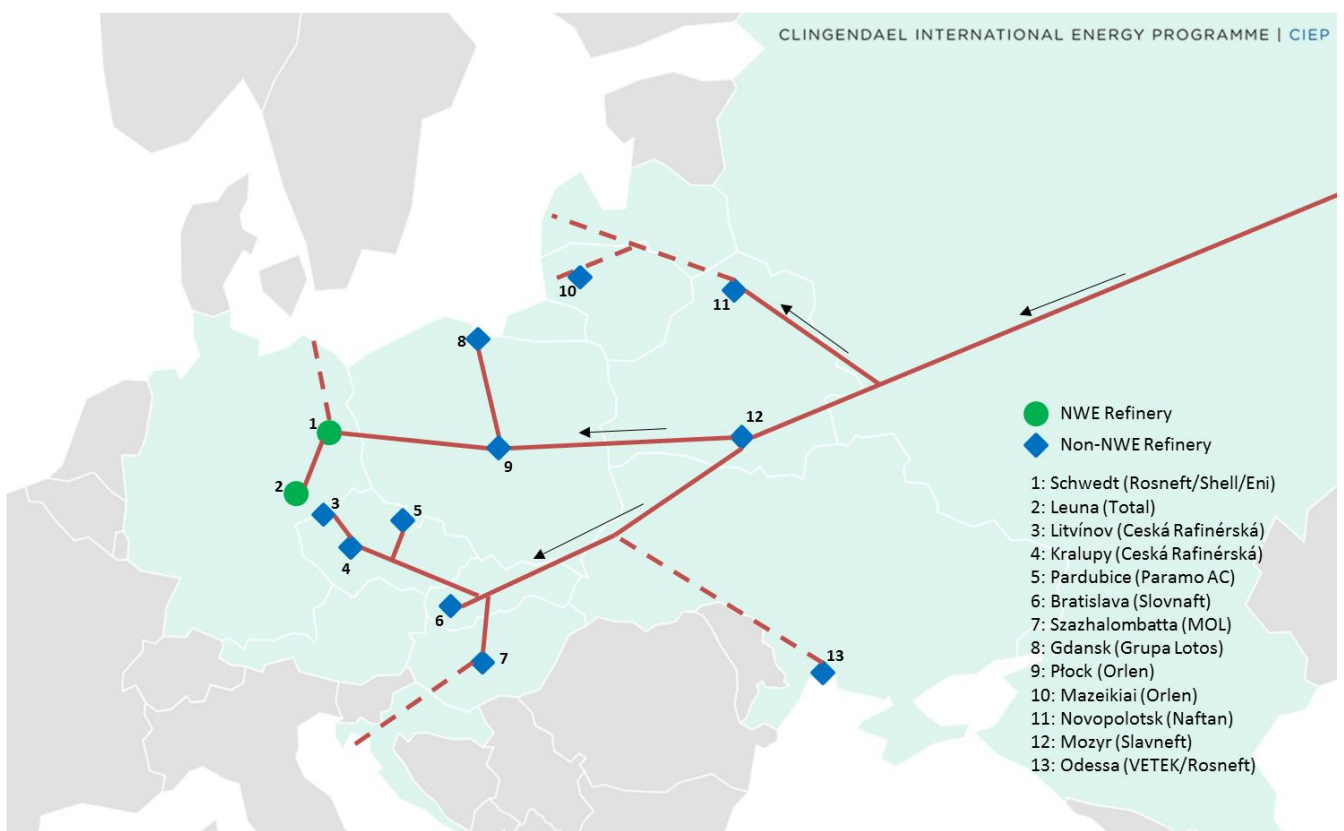


FIGURE B.5: DRUSHBA PIPELINE SYSTEM²¹²

211 The most recent reference to Emsland oil reserves suggested that the production to reserves ratio was ~15 years, see Ferdani, M. (2006), "Oil and gas in Germany". In the meantime the Lingen refinery has also been connected to the Dutch Schoonebeek field, which adds around 15 Kb/d of crude oil supply for ~25 years and is supported by a 20-year supply contract, see: www.nam.nl/nl/our-activities/schoonebeek/about-schoonebeek.html; and Shell (2006), "MER rapportage Schoonebeek".

212 See, for example, ILF Consulting and Purvin&Gertz (2010), "Study on the Technical Aspects of Variable Uses of Oil Pipelines Coming to the EU from Third Countries", or Clingendael International Energy Programme (CIEP) "Factsheet: Russia-Europe: The Liquid Relationship often Overlooked", or http://eurodialogue.eu/files/fckeditor_files/Druzhiba-Pipeline-Map.jpg.

The 100 Kb/d Total Grandpuits refinery also benefits from direct access to local crude supply from the Basins Parisien. This source of local crude supply, however, only represents circa 10% of its crude oil requirements, providing only limited incentive for continued investment in the Grandpuits refinery. Other refineries with direct access to North Sea crude, such as Grangemouth in Scotland or Humber in England, do not derive strategic value from upstream integration. The presence of unilateral asset specificity is a critical ingredient for an upstream integrated refinery to enjoy a strategic position, and North Sea crude can all too easily be loaded onto tankers and delivered to an Atlantic Basin refining centre of choice. This flexibility is coincidentally also one of the main reasons that North Sea crude oil spot markets emerged as the global benchmark and to this day dominate crude oil pricing around the world.

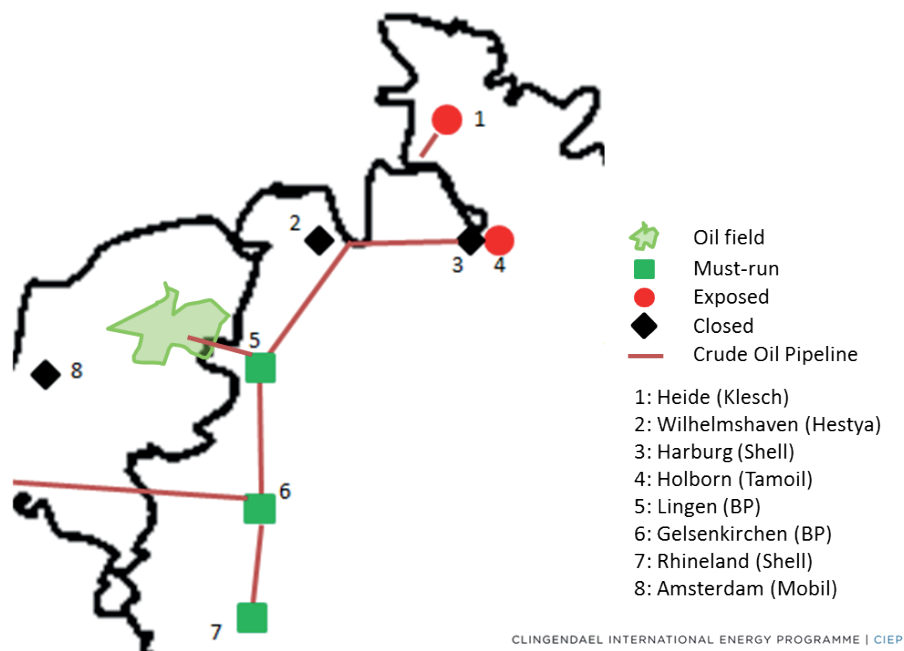


FIGURE B.6: SCHOONEBEEK OIL FIELD AND NWE REFINERY CONNECTIONS²¹³

213 It must be noted that Figure B.6 reflects a schematic representation of the Schoonebeek oil field; in reality the proportions of the field differ. The figure is based on information on the northwest German Basin. See, for example, The US Geological Survey, or NAM (2006), "Mileueffectrapportage: Herontwikkeling Olieveld Schoonebeek".

SURPLUS COKING CAPACITY REFINERIES

NWE has very limited coking capacities available to upgrade residual fuel oil streams (see Figure B.7).²¹⁴ In fact, 3 out of 5 petrochemicals integrated must-run refineries lack coking capacities altogether. The Shell Pernis and BP Gelsenkirchen refineries partially compensate for the lack of coking capacity with residue gasification capabilities. Nevertheless, under must-run scenario conditions we still expect the Phillips 66 Humber and Exxon Antwerp refineries (once its new coking capacity comes online) to have access to sufficient quantities of residue oil to leverage their surplus coking capacities. Considering coking deficit must-run refineries in the ARA and Rhine-Ruhr regions (e.g., Total Antwerp and Shell Rhineland), it seems likely that Phillips 66's Humber and the closely co-ordinated Exxon coking refineries in ARA will enjoy a strategic position. Accordingly, continued investments for upgrading seem secure for these refineries, ensuring their competitiveness vis-à-vis refined product imports.

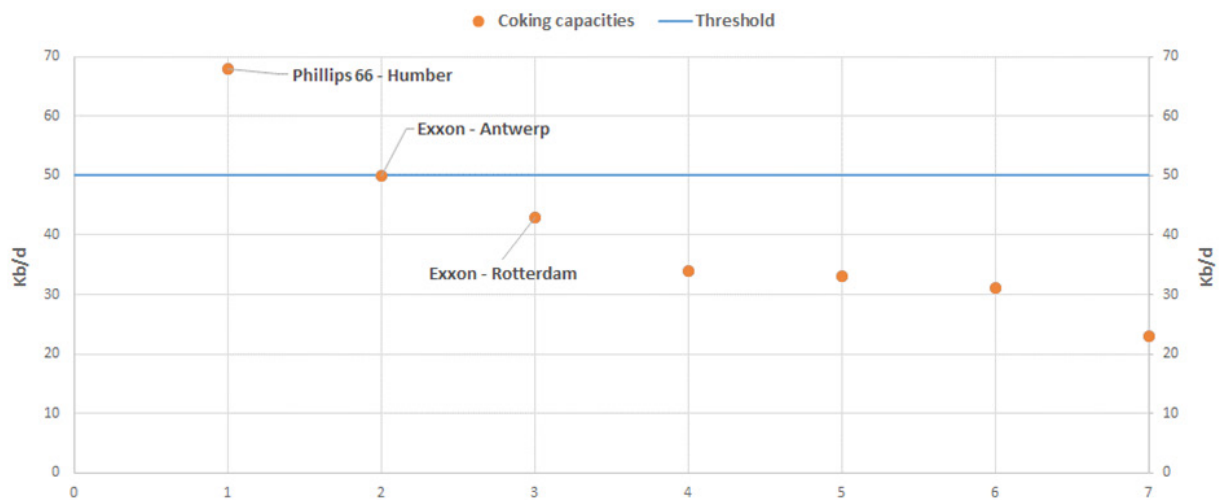


FIGURE B.7: NWE REFINERIES – DISTRIBUTION OF COKING CAPACITIES²¹⁵

214 Residue gasification provides an alternative to coking for the upgrading of vacuum residue oil, but the NWE refining sector does not have a single refinery with surplus residue gasification capacities.

215 See ExxonMobil (2012), "MER voor uitbreiding Esso raffinaderij"; and various company publications.

ANNEX C – MUST-RUN COMMENTS BY REFINERY

Refinery	Region	Capacity (Kb/d)	Ownership category	Status	Must-run comments
Antwerp (Gunvor)	ARA	110	Trader	Exposed	A coastal refinery with a simple configuration that could, all else equal, be replaced by imports.
Antwerp (ExxonMobil)	ARA	323	IOC	Surplus coking	A 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 Exxon's European solvents plant.
Antwerp (Total)	ARA	350	IOC	PetChems integrated	The refinery is closely 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.
Rotterdam (Shell)	ARA	425	IOC	PetChems integrated	The refinery is 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.
Rotterdam (Exxon)	ARA	201	IOC	PetChems integrated	The refinery is closely integrated with Exxon's world scale aromatics plant in Rotterdam Botlek, which is again an integral part of the competitive Antwerp-Rotterdam petrochemicals cluster. The refinery fulfills an especially important role as a source of sulfur-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 Exxon aromatics plant.
Rotterdam (BP)	ARA	377	IOC	Exposed	A coastal refinery with a relatively simple configuration and limited downstream integration, which in spite of its size and considerable flexibility could, all else equal, be replaced by imports.
Rotterdam (Koch)	ARA	80	Trader	Exposed	A coastal refinery with a simple configuration that could, all else equal, be replaced by imports.
Rotterdam (Kuwait)	ARA	88	Trader	Exposed	A coastal refinery with a simple configuration that could, all else equal, be replaced by imports.
Zeeland (Total, Lukoil)	ARA	149	IOC	Exposed	A coastal refinery that in spite of its beneficial configuration (i.e., an outsized hydrocracker) and some downstream integration, could, all else equal, be replaced by imports.
Gonfreville (Total)	Northern France	247	IOC	Exposed	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.
Port-Jerome (Exxon)	Northern France	248	IOC	Exposed	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)	Northern France	101	IOC	Exposed	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 could, all else equal, be replaced by imports.
Donges (Total)	Northern France	230	IOC	Exposed	A coastal refinery that in spite of its recent commitments to upgrade its desulphurisation capacity could, all else equal, be replaced by imports.
Feyzin (Total)	Southern France	117	IOC	Exposed	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 could, all else equal, be replaced by imports.
Fos sur Mer (Exxon)	Southern France	136	IOC	Exposed	A coastal refinery that is closely integrated with the Berre steamcracker, but this steamcracker is sub-world scale. Accordingly, the refinery could, all else equal, be replaced by imports.
Lavera (Petroineos)	Southern France	210	NOC	Exposed	A coastal refinery that is closely integrated with onsite steamcracker and aromatics capacity, but both are sub-world scale. Accordingly, the refinery could, all else equal, be replaced by imports.
La Mede (Total)	Southern France	158	IOC	Exposed	Total has already announced plans to convert the refinery to a bio-refinery.

Refinery	Region	Capacity (Kb/d)	Ownership category	Status	Must-run comments
Gelsenkirchen (BP)	Rhine-Ruhr	266	IOC	PetChems integrated	The refinery is closely integrated with world scale steamcracking capacity, and the site an integral part of the competitive Rhine-Ruhr petrochemicals cluster.
Rhineland (Shell)	Rhine-Ruhr	344	IOC	PetChems integrated	The refinery is closely integrated with world scale on-site steamcracking and aromatics capacity. The site is also an integral part of the competitive Rhine-Ruhr petrochemicals cluster.
Lingen (BP)	Rhine-Ruhr	95	IOC	Upstream integrated	The inland refinery is located in the midst of Germany's largest mainland oil fields and it has a 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.
MiRO (Shell, Rosneft, Phillips 66)	Southern Germany	322	IOC	Captive demand	An inland refinery that is connected to the TAL and SPSE crude pipelines and serves a high 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.
Burghausen (OMV)	Southern Germany	78	IOC	Captive demand	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.
Bayernoil (Varo, Rosneft, Eni, BP)	Southern Germany	218	Trader	Captive demand	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.
Ingolstadt (Gunvor)	Southern Germany	110	Trader	Exposed	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 we expect the Ingolstadt refinery to be handicapped by its relative small-scale and simple configuration.
Holborn (Tamoil)	Northeast Germany	105	NOC	Exposed	A coastal refinery with a simple configuration that could, all else equal, be replaced by imports.
Heide (Klesch)	Northeast Germany	91	Trader	Exposed	A coastal refinery that in spite of some cracking capacity and petrochemicals integration could, all else equal, be replaced by imports.
Leuna (Total)	Northeast Germany	227	IOC	Captive demand	An inland refinery connected by the Drushba crude pipeline and directly serving the Leipzig and southern Berlin regions. The petrochemical feedstock pipeline has only limited capacity (~ 90 Kb/d) and there is a lack of inland waterways.
Schwedt (Rosneft, Shell, Eni)	Northeast Germany	239	NOC	Exposed	An inland refinery that is connected to the Drushba pipeline, in which Rosneft holds majority ownership. 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-Berline railway system.
Fawley (Exxon)	UK	274	IOC	Exposed	A coastal refinery that in spite of some petrochemicals integration could, all else equal, be replaced by imports. It is worth noting that the chemical plants on the Fawley site already import a significant portion of their feedstock requirements.
Grangemouth (Petroineos)	UK	210	NOC	Exposed	A coastal refinery that 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).
Humber (Phillips 66)	UK	233	Pure play	Surplus coking	A 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)	UK	221	IOC	Exposed	A coastal refinery with a simple configuration that could, all else equal, be replaced by imports.
Pembroke (Valero)	UK	220	Pure play	Exposed	A coastal refinery that in spite of some cracking capacity could, all else equal, be replaced by imports.
Stanlow (Essar)	UK	296	Pure play	Exposed	A coastal refinery that in spite of some aromatics integration, could, all else equal, be replaced by imports. Essar has also put the refinery up for sale.

ANNEX D – EXPOSED REFINERY CHARACTERISTICS

Comparing some characteristics of today's exposed refineries with post-2008 restructuring cases reveals a similar distribution of acreage (site) and operational years, whereas the throughput and number of employees are larger among the exposed refineries (see Figure D.1). In general, it should be noted that on average an exposed refinery has been operational for 60 years, occupies 364 Ha of land, produces 183 Kb/d and employs 728 people.²¹⁶

These numbers provide a sense of the magnitude of the local impact of a refinery. It indicates that both the environmental and economic footprints of exposed refineries is substantial, potentially compromising their restructuring. Factors such as security of supply, complexity and indirect employment further deepen the impact of refinery restructurings and are likely to have an impact similar to that of the historical cases. Inevitably, these factors give rise to substantial barriers to exit, which may tamper with restructuring processes. Given the similarity of both historical restructuring cases and today's exposed refineries, it is safe to assume similar plurality among restructuring developments as has been witnessed over the last decades.

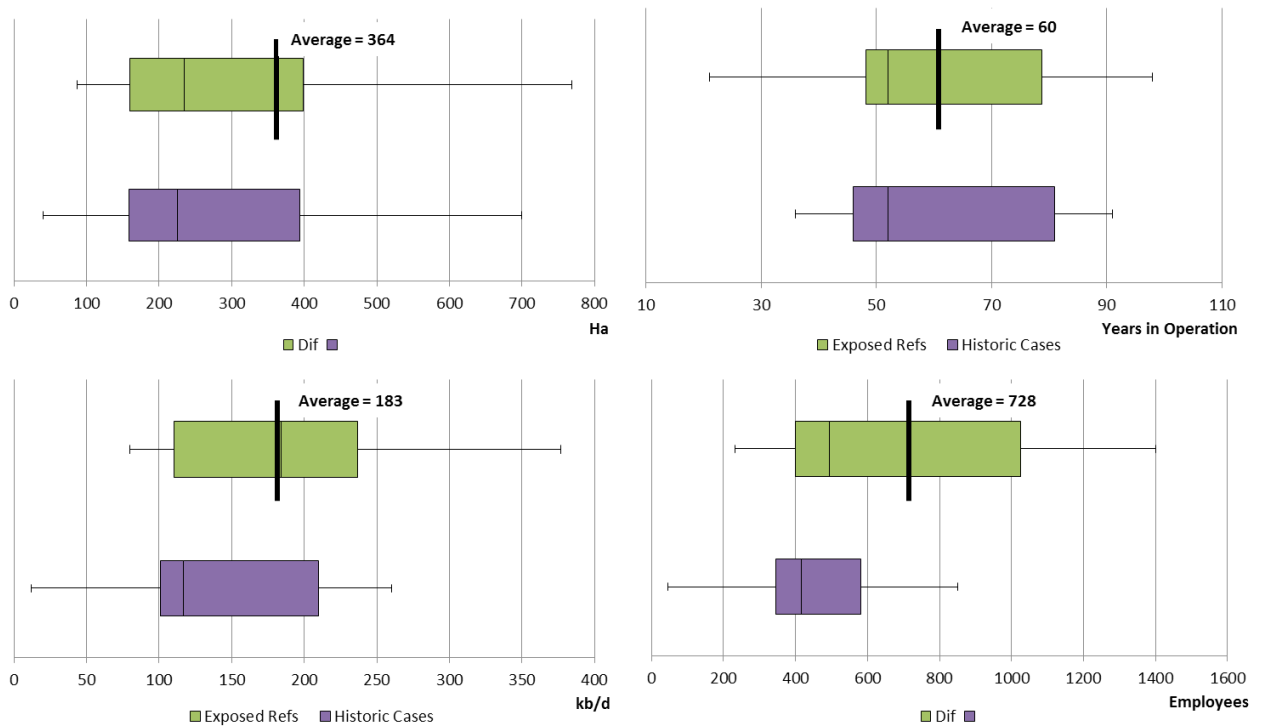


FIGURE D.1: EXPOSED REFINERIES VS HISTORICAL CASES (POST-2008)

²¹⁶ All data has been retrieved from public sources: company profiles, brochures, news articles, press releases, public statements, etc.

ANNEX E – ADDITIONAL COMPLETE CLOSURE CASES

On average, a complete closure case consists of four stages. First, when refining operations are halted, the entire site has to be maintained (i.e., cleaning pipes, containing leakages, etc.). Second, the demolition of the refinery itself can commence, which usually grants a positive net present value, depending on the presence of asbestos and scrap prices. Third, the underground structures (e.g. foundations, pipelines, etc.) need to be removed, which are usually not recyclable and hence are costly. The fourth step is generally the most cost intensive, as the soil/water pollution needs to be addressed. Depending on the future destination clause of the site, soil structure, and specific type of pollution, the remediation of the site may take up to several decades and cost up to several hundred million euros. The complete closure of the BP Llandarcy refinery and the partial closure of the Shell research facility in Amsterdam provide additional insight in overall refinery restructuring.

The BP facility in Llandarcy (Wales) comprised 1,060 acres, hosting a refinery and chemicals plant. Large-scale contamination was expected, as the plant has been in operation since 1921. After its 1998 closure, the entire site was bought by St. Modwen in 2008, with the intention of complete remediation and rebuilding of the land.²¹⁷ Despite heavy contamination, the site now hosts a university campus, industrial sites and a 30 acre solar park.²¹⁸ With further construction of residential areas (COED Darcy), commercial districts, and an extension of the Swansea University, the project is nearing completion.²¹⁹ The transformation of the industrial brownfield area into a commercial/residential area significantly increased its economic value. Although no direct subsidies were awarded, the involvement of the Prince's Foundation allows for substantial credibility from a (semi-)public source.²²⁰

Shell operated a 27 ha research facility on the northern edge of Amsterdam, the Netherlands. In 2002, Shell decided to rationalise its operations, selling off 20 ha of land. In a real estate deal with private parties and the local municipality, it was agreed that following remediation the land would be sold for €141 mln.²²¹ Altering the destination clause allowed for residential and commercial areas to be developed,

217 St. Modwen is a specialised development company active mainly in the UK. It currently operates the largest brownfield portfolio of the UK, aiming at developing former industrial sites.

218 Chapple, Martin – URS Corporation Ltd. (2004), "Assessment and Restoration of the BP Llandarcy Refining Landfill".

219 St. Modwen – Baglan Bay. See: <http://www.baglanbay.com/>

220 Source: <http://www.bbc.com/news/uk-wales-south-west-wales-20287810>

221 Volkskrant (28-02-2002), "Amsterdam koopt terrein van Shell".

raising the economic value of the land.²²² Total remediation costs were not disclosed, but it is likely that the land value covered clean-up costs. The city of Amsterdam has also aided in the financing of the development of the terrain, minimising market risk.²²³ Today, the Shell NTC remains operational on the remaining 7 ha of land, and the remediated site harbours both commercial and residential areas.

222 Geurst & Schultze Architecten (2004), "Stedenbouwkundig plan Shellterrein" and Gemeente Amsterdam (2005) "Concept MER Herinrichting Shellterrein en Buiksloterham te Amsterdam".

223 Both the Film museum EYE and the residential area located on the Shell-NTC site benefit from a guarantee of the municipality. See: <http://www.volkskrant.nl/vk/nl/2676/Cultuur/article/detail/3240133/2012/04/13/EYE-Filmmuseum-is-nog-niet-open-of-er-is-ruzie.dhtml>



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