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Petrochemicals and climate change: Powerful fossil fuel lock-ins and interventions for transformative change

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Executive Summary

With the risk of climate breakdown, pressure is increasing for all sectors of the economy to break with fossil fuel dependence and reduce greenhouse gas emissions. In this context, the chemical industry requires more focused attention as it uses more fossil-fuel based energy than any other industry and the production of chemicals is associated with very large emissions. Beyond the climate crisis, the chemical industry significantly impacts several critical dimensions of sustainability, including the planetary boundaries for novel entities, bio-sphere integrity, and ocean acidification.

In this report, we focus on the petrochemical sector, which represents the largest share of the chemicals industry and is generally understood to refer to the part of the industry that relies on fossil-fuel feedstocks from oil, gas, and coal. The petrochemicals sector produces chemicals mainly used for plastics and fertilisers, but the products also end up in paints, pharmaceuticals, pesticides, and other applications.

This report provides a critical exploration of the petrochemical sector to strengthen awareness of its relevance to the climate crisis and to provide tools and recommendations for decision-makers in different domains to initiate, support, and accelerate much-needed transformation. The report highlights the rapid expansion of the petrochemical sector as well as the range and growth of economic, infrastructural, and political interlinkages with the fossil fuel extraction sector. It argues that these developments and dynamics are crucial to understanding pathways, strategies, and interventions for a low-carbon transition for petrochemicals.

Key insights

Deep-seated ties exist both within the chemical sector as well as between the petrochemical and fossil fuel industries. These connections exist globally through extensive ownership ties, integrated infrastructure, and business and political collaboration. A large share of the global petrochemical industry is backed by states, many of which have vast fossil fuel reserves and strong interests in creating a future for oil and gas in chemicals as a means of diversification, economic upgrading, and growth. Such dynamics underpin and support the expansion and resilience of fossil-based petrochemical production.

Petrochemical projects attract financing from all regions of the world and investments in the sector have been growing. Baseline estimates indicate that the sector's production capacity will multiply several times in the coming decades. For primary plastics alone, which is the core output of the sector, production is expected to more than double by 2050. While most of the capital invested in the petrochemical sector originates from private investors, this capital is closely tied to support from public financial institutions, which are often used for investments. Finance for petrochemicals is truly global in reach, with much of the credit originating in industrialised countries but increasingly financing petrochemical plants in developing countries. There is limited transparency in the financing trends for petrochemicals or in the financing structure for specific petrochemical projects. This, in turn, complicates efforts that could boost sustainability and reduce the sector's carbon footprint, such as, for instance, requiring that financing be extended only to plants that deliver low carbon production or for conversion of existing facilities to low carbon production. Large strategic investments in renewable energy and new zero-emission production processes remain few in the industry.

Across global petrochemical supply chains, a range of powerful industry actors and states use different avenues to influence policy and institutional arrangements, including lobbying and communication efforts to shape public and political discourse. These actors strategically develop and mobilise particular narratives that cast criticisms of the petrochemical sector and its carbon footprints as misunderstandings and routinely mirror discourses that contribute to climate delay. Given the diversity of countries currently dominating the petrochemical sector and global petrochemical supply chains, the strategies

for devising adequate policy responses, building legitimacy for change, and building pressure for a timely climate transition will likely look very different in the different countries.

As petrochemical production is commonly geographically concentrated, efforts to transform the sector in line with global climate goals must pay close attention to the challenges of a just transition. In many regions and communities, the industry continues to play an important role as a source of employment and tax revenues. Alongside the effort to transform the sector, there is the potential to harness the interest of social movements and fenceline communities, which most directly suffer the negative environmental and health consequences of petrochemical production. These actors have historically been key actors in mobilising efforts to improve the regulation and sustainability of the petrochemical industry.

At the global level, there is no comprehensive international regime for petrochemicals governance, and as a sector, petrochemicals are rarely specifically addressed by existing international regimes. There are opportunities to address the carbon footprint of plastics and the "upstream" challenge of the rising volume of plastics production in the ongoing negotiations for a global plastics treaty. There are also opportunities to focus more on the petrochemical sector in the climate regime, including through initiatives that seek to phase out fossil fuels and support sectoral decarbonisation initiatives. Alongside, there are promising avenues for harnessing global economic governance processes related to trade, development assistance, investment, and finance to regulate better and provide incentives for a shift away from carbon-intensive petrochemical production and toward transitions.

Recommendations

Transforming the industry to shape a development pathway that leads away from fossil fuels, the climate crisis, negative health impacts, and plastic pollution is not an easy task. It will require committed action by a wide range of actors, including chemical producers, financial sector actors, and governments, while acknowledging the principle of common but differentiated responsibilities. Below, we highlight key pathways for immediate action.

First-mover chemical firms could form a leadership group

Chemical industry firms that aim to truly be part of the solution to climate change should break with industry organisations engaged in greenwashing and climate delay rhetoric, adopt the highest standards for net-zero goals and transparent grennhosue gas (GHG) reporting, and form a “beyond fossil chemicals alliance” to show the world that a rapid, low carbon transition is possible and to pressure their competitors. Firms in this group must immediately redirect their investment strategies towards renewable and circular solutions.

Address the logic and structure of the industry through political interventions

Governments could intervene to restrict further expansion of fossil-based petrochemical capacity, ensure a rapid phase-out of the most emissions-intensive facilities, and require all large chemical firms to present transition plans and roadmaps away from the current fossil dependence. They should also work to align development, trade, and investment regimes with the goal of reducing the climate impact of the petrochemicals sector. States with ownership over chemical firms must use their power to push them towards transformation.

Redirect financial flows away from emissions-intensive chemicals

To fulfill the Paris Agreement, financial sector actors must stop financing investments in fossil-based and emissions-intensive petrochemical production. This includes public and private banks, private investors, insurers, and development finance agencies. Public financial institutions must take a leading role by rapidly implementing a moratorium or ban on such projects in their portfolios of loans, bonds, and guarantees. Private investors and asset managers with high ESG ambitions must take action to monitor, track, and address the hidden carbon flows in petrochemical and plastics value chains. Ambitious standards, credible criteria, and accountability mechanisms to drive sustainable investments and transition plans for carbon-intensive sectors are emerging and should be strengthened and used with regard to petrochemicals as well.

Support developing countries and fenceline communities

As part of mobilising action on the climate impact of the petrochemical sector, a key priority should be to address the harm that the petrochemical industry inflicts on fenceline communities in countries and regions where it is already present, and has been sometimes for decades, and to work with local stakeholders and social movements in shaping the transformation of the industry. It will also be vital to understand and address the challenges facing developing countries in the push to decarbonise and control the expansion of the petrochemicals sector, especially for the range of developing countries with oil and gas resources now looking to petrochemicals as an economic diversification strategy. Efforts to tackle the climate impact of the petroleum sector will need to reflect on the principle of common but differentiated global responsibilities and respective capacities embedded in the climate regime. In practice this will mean identifyig ways to ensure that countries with the greatest responsibility for the climate crisis move the fastest and take the strongest action while ensuring that all countries with capacities do more. It will also require concrete action to support countries to pursue sustainable diversification strategies and climate-resilient development pathway strategies with just transitions.

Strengthen the coherence of global governance of the petrochemicals sector to ensure policy action that delivers climate outcomes

Tackling the climate impact of petrochemicals will require efforts to strengthen and integrate a fragmented global governance landscape. This can be advanced by ensuring an ambitious global plastics treaty that includes restrictions on fossil-based upstream plastics production and seizing ongoing efforts at the UN to develop a new global framework for the management of chemicals and science-based environmental policy. Petrochemicals should be one of the key sectors individually outlined in the Nationally Determined Contributions delivered as part of the UNFCCC process under and alongside the convention. Governments must also intensify and coordinate efforts aiming to directly confront and reduce the scale of the fossil fuel industry as a key driver of petrochemical expansion, such as through a Fossil Fuel Non-Proliferation Treaty that also includes petrochemicals, , fossil fuel subsidy reform, and collaboration with the Beyond Oil and Gas Alliance.

Recommendations

ORGANISATION

- Restrict expansion of fossil-based production capacity
- Mandate transition plans for existing companies.
- State-owned chemical firms should be urged to transform.
- Aid oil and gas-dependent developing nations in exploring alternative diversification strategies.

PUBLIC DISCOURSE AND PROTESTS

- Ensure rigorous net zero standards, adhere to best practices for precise corporate GHG inventories, and move passed climate delay rhetoric.
- Recognise the harm the industry does to fenceline communities.
- Include local stakeholders and social movements in shaping the transformation of the industry.

FINANCE

- Ban public financial involvement in fossil-based chemical projects.
- Asset managers aiming to support the transition must recognise the hidden emissions in chemical and plastics value chains.
- Use best available guidance to evaluate and question propositions from firms issuing bonds or requesting loans.

GLOBAL GOVERNANCE

- Bring together the global plastics treaty with global climate efforts and boost global governance of chemicals.
- Petrochemicals should be individually outlined in NDCs delivered as part of the UNFCCC process.
- Confront and reduce the scale of the fossil fuel industry as a key driver of petrochemical expansion.

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1 Introduction

With the risk of climate breakdown mounting as the world is on track for 3 degrees warming[1], pressure is increasing on all sectors of the economy to break with fossil fuel dependence and reduce greenhouse gas (GHG) emissions. Significant efforts have been devoted to studying the possibilities of transitions for the energy and transport sectors, which use the main share of fossil resources to produce heat, power and fuels. Other heavy industry sectors, however, face low-carbon transition challenges, which are somewhat different as their dependence on fossil carbon is embedded in the processes and products themselves[2,3]. Amongst these sectors, the chemical industry, which has been a driver of economic development for decades, is highly dependent on fossil resources for use as feedstock and fuel in its production[4]. Chemical value chains – from fossil resources to consumer products – are long and complex. From the fossil feedstocks, a small number of fundamental primary chemicals are produced. These primary chemicals include the common olefins (ethylene, propylene, and butadiene), aromatics (benzene, toluene, and xylene), methanol, and ammonia. A recent review show that the GHG emissions associated with petrochemicals have tripled in the past 25 years and there are still few signs of a shift in this trend[5]. Despite the dependence on fossil energy and rising emissions, the industry has however not been the focus of much research on climate impact and mitigation as its climate impact has been hidden behind other industries closer to consumers in the global sustainability debate[6].

Anticipating a long-term downturn in traditional markets following efforts to combat climate change, fossil fuel extraction companies are increasingly diversifying their business portfolios into petrochemicals[7,8]. This is further fuelled by an expected exponential growth in demand for plastics - tripling by 2050 unless our way of using plastics is significantly changed[9–11] and coupled with considerably higher profit margins for petrochemicals products than transport fuels. Evidence of this shift has already materialised. Plastics and other petrochemicals are forecasted to be the largest driver for growth in oil demand from 2025[7]. A prime example of this shift is that in 2019 Saudi Aramco, the Saudi Arabian state-owned oil firm and largest oil producer in the world, bought a majority stake in one of the biggest plastic producers in the world - the Saudi Arabian firm SABIC - and later the same year bought a 20% stake in Reliance Industries - the largest Indian petrochemical company. Oil refineries, all over the world, are increasingly being retrofitted to boost their share of petrochemical production capacity. Some are even maximising the output of chemicals in new so-called 'crude-to-chemicals' complexes, a development spearheaded by an ExxonMobil investment in Singapore in 2014, but now followed by many others, primarily in Asia-Pacific and the Middle East[12].

Short-term impacts on the petrochemical industry include both the Covid-19 pandemic which hit in 2020 and led to significant market volatility, leading to questions about central assumptions about the stability of the industry and its projections for ever-growing demand. The global energy crisis that followed as a consequence of the pandemic and the Russian invasion of Ukraine has also sent shockwaves through the industry. Skyrocketing gas prices in Europe led to the production of key petrochemicals dependent on gas being ramped down and even completely shut down during parts of 2022 as production became uneconomical and the future of the industry in the region – where the modern chemical industry originated in the 19th century – is being questioned. BASF – the world's largest chemical company that has had a leading position in the industry for more than a century – has announced that they are likely to permanently downsize their activities in Europe[13], pointing to a redrawing of the map where this historically important region may lose its role and other regions could take the lead in shaping the future of the industry. At the same time, major firms in the industry are making record profits by hiking prices beyond increased costs[14,15].

Powerful actors and authorities are taking an increasing interest in the politics and economies of

petrochemicals. While governments are committing to action on climate change and have signed up to initiatives tackling global plastic pollution, massive investments are being made to expand the production capacity in the petrochemical sector, not least in the Middle East, China, and the USA. However, as the industry is far removed from the daily lives and thoughts of consumers this has to a large extent flown under the radar of the public and political discourse. While the fossil fuel extraction sector has been the topic of numerous analyses, much fewer studies have provided critical insight into the petrochemical sector. Similarly, most policy-focused studies on plastics target waste management and pollution rather than drivers for production and consumption[16,17]. It is clear that policymakers engaging with the important policy domains of climate change or plastics focus little on the petrochemical value chains and their key role in these questions.

The chemical industry demands petroleum fractions such as naphtha and petroleum gases as feedstocks to produce organic building block chemicals and polymers, such as benzene and polyethylene, and natural gas, e.g., for the production of methanol and ammonia. Further, the use of coal for the production of chemicals is large and increasing, mainly in China, where it is used for primary chemicals and plastics. The high level of complexity and the substantial share of emissions embodied in feedstock makes the petrochemical sector a challenging area to reduce emissions, compared to other industrial sectors with far simpler production processes such as the iron and steel or paper industry. It is becoming clear that there are pathways to transforming the industry and its value chains to break the dependence on fossil resources and reach close to zero emissions[18,19]. However, roadmaps outlined by chemical industry firms and interest groups are limited in scope and tend not to consider demand-side changes to mitigate the climate impact of petrochemical life cycles[20]. Aside from the climate impact the chemical industry is also heavily implicated in other issues related to environmental sustainability, such as emissions of pollutants to surface and groundwater, production and diffusion of endocrine disruptors, persistent organic pollutants, and other chemical compounds that negatively affect the human health, the ozone layer, and ecosystems[21]. While this report focuses on climate change, it is imperative that GHG emission reductions are addressed together with these other issues in the transformation of the industry towards more sustainable modes of production and use of chemical products.

The rapid expansion of the petrochemical sector and the growing interlinkages – economic, infrastructural, and political - with the fossil fuel extraction sector, necessitates a deeper understanding of its dynamics. Furthermore, given this sector's ability to deflect the public gaze, it is crucial to provide an extensive understanding of how development in this sector can be turned towards a low-carbon transition, as well as explore interventions for how to achieve this. This report aims to provide a much-needed investigation into the petrochemical sector to strengthen awareness of its relevance to the climate crisis and to provide tools and recommendations for decisions makers as well as other stakeholders on how to approach change in the sector.

The next chapter maps the key structural aspects of the industry on a global level to highlight the power structures, lock-ins, and restraints that must be overcome to facilitate a transformation of the sector. Chapter 3 presents an analysis of how intertwined flows of capital, originating in both the private and public spheres of the international financial economy, support and enable the expansion of petrochemical production. Chapter 4 explores contestation around the industry and its developments, as well as key avenues of influence through which firms in the industry act to shape conditions supporting its growth. Chapter 5 presents the fragmented nature of international chemicals governance and its connections to environmental and climate governance. Finally, in chapter 6 we synthesise our findings and provide recommendations for how to address some of the key issues highlighted by our analysis. In so doing, our aim is for this report to contribute to strengthening the field of petrochemicals in climate change governance.

2 Actors, ownership structures, infrastructure expansion, and regional trends

2.1 Changing geography of the sector

The modern chemical industry emerged in Europe following the industrial revolution, which enabled the industrial use of coal as an energy source and soon also as a feedstock for synthetic materials[22]. In the decades after the second world war, which saw great technological and industrial progress in processing petroleum – a development led by US firms with the support of the government to globalise its market and export technologies – the industry found itself in a new era with North America as another central region for the industry[23]. Japanese firms also successfully entered the industry and became the leading chemical hub in Asia. However, the contemporary map of the industry is very different from this historical situation. China now dominates it but the 10 countries that have the largest production capacities make up more than 75% of global capacity[24], see Figure 1.

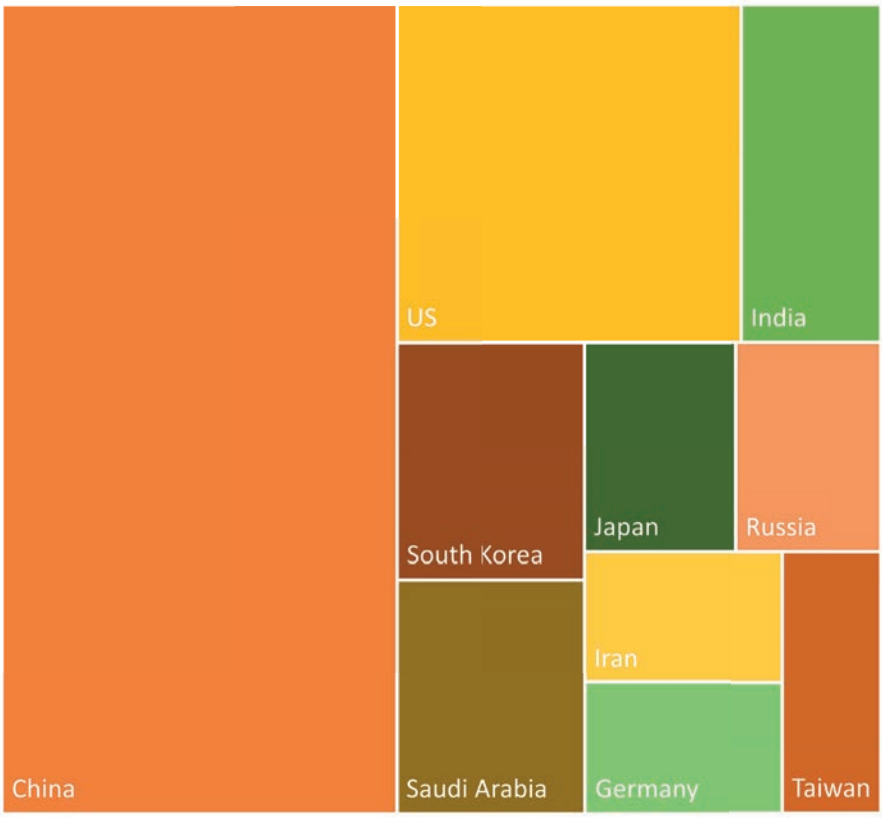


Figure 1. *Share of global petrochemical production capacity of the 10 countries with the highest active petrochemical capacity in the world (China (33%), United States of America (here US) (12%), India (5%), South Korea (5%), Saudi Arabia (5%), Japan (3%), Russia (3%), Iran (3%), Germany (3%) and Taiwan (3%)). The combined production capacity in these 10 countries is estimated to 1605.2 Mt/yr.*

(Global Data, 2021).

While Japan and the Tiger economies of South Korea and Taiwan have maintained strong positions in the global petrochemical industry, the development in Asia-Pacific has been dominated by China in the 21st century. Public and private actors have supported and enabled an industrial policy focused on domestic investments in petrochemical production, as petrochemicals are central to many essential value chains such as textiles and automotive. State-owned firms such as Sinopec and ChemChina have acquired and partnered with overseas firms and invested in domestic production. Further, international firms have also invested in new facilities in China to meet the rapidly growing demand from the manufacturing industry in the country. As shown in Figure 2, in the past decade, production in China has grown more rapidly than in any other country or region in the world. The country now has about one-third of the total global production capacity. Also, chemical production increased significantly in India, although from low volumes at the start of the millennium.

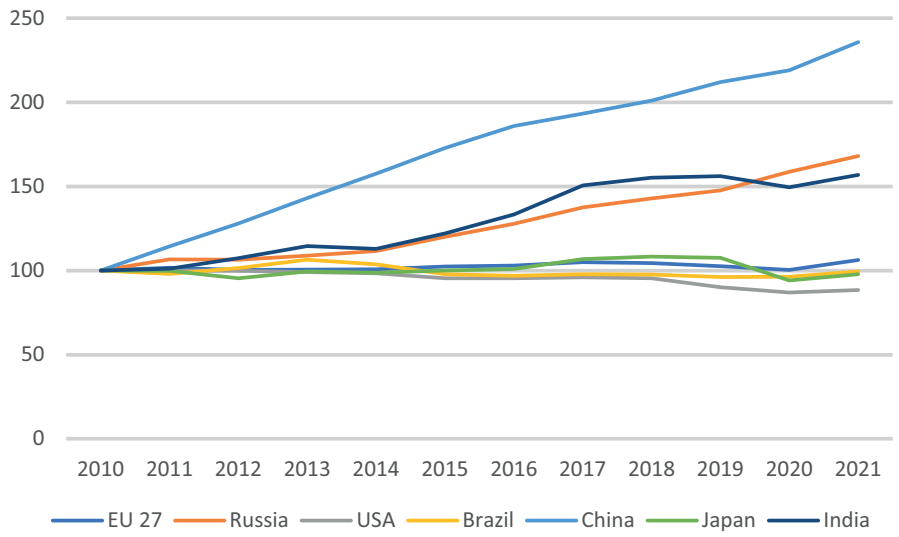


Figure 2. *Petrochemical production index in key countries and regions, with production in the year 2000 as index 100. Based on data from VCI[25].*

Intending to capture a larger share of the value of the extracted resources and to diversify the economies, oil firms in the Middle East have developed their petrochemical industry. This has been done both independently, as in the case of the Saudi Arabian firm SABIC which has become one of the largest chemical firms in the world, and through partnerships, mergers, and acquisitions, as in the case of the Emirati acquisition of a large ownership share of the European firm Borealis through its International Petroleum Investment Company, later transferred to the state-owned oil company ADNOC. Acquisitions abroad have been paralleled by large investments in new production capacity close to the oil and gas resources in the Middle East. The Sadara chemical cluster in Saudia Arabia became the largest greenfield chemical project ever when announced (see Chapter 3 for more details) and Saudi Arabia has now become one of the countries in the world with the largest petrochemical production capacity. The low cost of energy and feedstocks has provided an advantage for the industry in the region compared to competitors in other regions.

Development in the traditional strongholds of Europe and North America has been slower in the past decades. Following the US fracking boom, the petrochemical industry has benefited from access to cheap ethane – a byproduct from natural gas produced through fracking – leading to a new boom for chemicals and plastics production[8,26]. With new technologies for exports being developed, this ethane has also become available for other markets, with producers in Europe being early to pick up ethane imports[27]. The European industry has found itself struggling to meet competition from regions with low energy costs and low labour costs, making it less attractive for new investments. Following the energy crisis caused by high natural gas prices and limited supply after the Russian invasion of Ukraine, the industry is now struggling to maintain production, and large firms are even permanently downsizing their operations in the region[13].

While the industry is a fully integrated part of the fossil fuel value chain, the choice of feedstocks for petrochemical production differs between regions. Europe remains committed to the traditional naphtha fraction, while ethane has become more important in North America and the Middle East. China stands out as the largest user of coal for chemicals production. Also, elsewhere in Asia-Pacific, coal is a major energy source – although not used as a feedstock – which results in much higher emissions from the industry in Asia-Pacific than other regions, as shown in Figure 3.

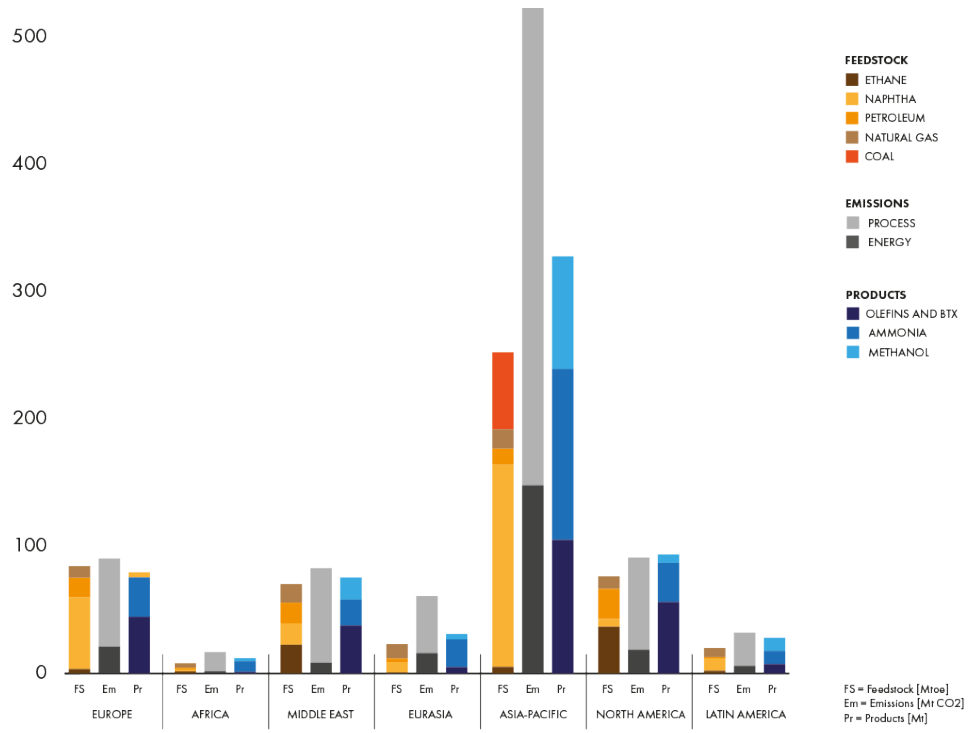


Figure 3. *Feedstocks, main products, and CO_2 emissions from petrochemicals production in key regions. Source: Bauer et al.[5]*

2.2 Ownership and organisation

2.2.1 Who are the "petrochemical majors"?

The largest companies working mainly upstream from petrochemical production to extract fossil fuels are often referred to as the "oil majors"[28,29]. But which companies are the petrochemical equivalent? In other words, who are the petrochemical majors? To a large extent, the oil and gas and the petrochemical majors are the same. Some of the world's largest fossil fuel companies are also among the biggest petrochemical producers such as ExxonMobil and Shell. In addition to international majors, national and state-owned oil companies such as the Chinese Sinopec and PetroChina are also key petrochemical producers. The petrochemical majors also count companies which have the bulk of their sales from chemicals such as publicly listed Dow and BASF, privately-owned INEOS as well as major state-owned petrochemical producers such as SABIC and SinoChem (see Section 2.1).

Some of these companies are owned by national or international oil companies but have been constituted as separate firms (e.g. SABIC, ChevronPhillips, PTT Global). In this way, these firms are connected to and born out of the interest of their owners and/or parent companies, illustrated by how petrostates invest in petrochemical production (see Box 1). The classification of petrochemical majors along the lines of state involvement and connections to fossil fuel extraction are summarised in Table 1.

Table 1. *Classification of petrochemical producers.*

	Recognised chemicals firm	***Recognised O&G firm***
Strong state influence or SOE	State-owned petrochemical producers (e.g., SABIC, SinoChem)	National oil companies (e.g., PetroChina, Sinopec, Abu Dhabi National Oil Company)
Weak direct state influence	Private and publicly listed chemical companies (e.g., Dow, BASF)	International fossil fuel companies (e.g., ExxonMobil, Shell)

The industry magazine Chemical & Engineering News – an outlet of the American Chemical Society – publishes a global top 50 ranking of all chemical-producing companies according to their size as measured by chemical sales every year. Table 2 reports this top 50, and the data on chemical sales that it is based on, as well as company ownership, ties to states and fossil fuel interests in line with the classification above. A glance at these major producers shows that many have direct and strong ties to different forms of vested interests, standing in the way of a just low-carbon transition for the industry. The list of petrochemical majors helps illustrate various dynamics and changes in the sector over time. The top 50 includes the actors that dominated the industry in the 20th century, i.e. long-standing producers which have existed since the emergence of the chemical industry in Europe (e.g. BASF and Bayer) or the petroleum-based chemical production which rose to power in the US (e.g. ExxonMobil and Dow) around the time of, and in relation to, the Second World War[23]. The list also counts companies from different parts of Asia which emerged as petrochemical producers in the decades after the war (e.g. Formosa, LG Chem, Mitsubishi) as well as the major firms in regions which have seen the largest growth in the 21st century (see Section 2.1), namely the Chinese state-owned fossil fuel and chemical companies (e.g. Sinopec, PetroChina, ChemChina and Saudi Arabian SABIC.

Table 2. *The world's major petrochemical producers.*

Company	*Headquarter*	*State ownership*	*Chemical sales % of total sales 2021*	*Chemical sales 2021 (M USD)*
BASF	Germany	-	100.0	92 982
Sinopec	China	State-owned (CN)	15.9	65 848
Dow	US	-	100.0	54 968
SABIC	Saudi Arabia	State-owned (SA)	92.7	43 230
Formosa Plastics	Taiwan	-	72.2	43 173
INEOS	UK	-	100.0	39 937
PetroChina	China	State-owned (CN)	9.8	39 693
LyondellBasell Industries	US	-	84.5	38 995
LG Chem	South Korea	-	100.0	37 257
ExxonMobil	US	-	13.3	36 858
Mitsubishi Chemical Group	Japan	-	84.8	30 719
Hengli Petrochemical	China	-	91.1	27 961
Linde	UK	-	90.7	27 926
Air Liquide	France	-	98.3	27 148
Syngenta Group	Switzerland	State-owned (CN) (a)	81.1	24 900
Reliance Industries	India	-	21.1	22 583
Wanhua Chemical	China	-	100.0	22 561
Braskem	Brazil	State minority (b)	100.0	19 575
Sumitomo Chemical	Japan	-	76.2	19 176
Shin-Etsu Chemical	Japan	-	100.0	18 885
Covestro	Germany	-	100.0	18 813
Toray Industries	Japan	-	88.0	17 856
Evonik Industries	Germany	-	100.0	17 692
Shell	UK	-	6.5	16 993
DuPont	US	-	100.0	16 653
Yara	Norway	State minority (c)	100.0	16 617
Rongsheng Petrochemical	China	-	58.3	16 001
Lotte Chemical	South Korea	-	100.0	15 827
Mitsui Chemicals	Japan	-	100.0	14 681
Indorama Ventures	Thailand	-	100.0	14 626
Chevron Phillips Chemical	US	-	100.0	14 104
Umicore	Belgium	-	47.7	13 567
Solvay	Belgium	-	100.0	13 527

Table continues on next page

Table 2, continued from previous page

Bayer	Germany	-	24.4	12 743
Mosaic	US	-	100.0	12 357
Nutrien	Canada	-	41.8	11 590
Arkema	France	-	100.0	11 261
Asahi Kasei	Japan	-	48.7	10 908
DSM	Netherlands	-	100.0	10 888
Hanwha Solutions	South Korea	-	86.6	10 888
Eastman Chemical	US	-	100.0	10 476
Johnson Matthey	UK	-	47.2	10 412
Air Products	US	-	100.0	10 323
EuroChem Group	Switzerland	-	100.0	10 202
Borealis	Austria	State minority (d)	100.0	10 164
PTT Global Chemical	Thailand	State majority (TH)	62.0	9 084
Sasol	South Africa	-	65.9	9 011
TongKun Group	China	-	100.0	8 996
Lanxess	Germany	-	100.0	8 940
Hengli Petrochemical	China	-	44.3	8 858
ChemChina	Germany	State-owned (CN)	-	-
SinoChem	China	State-owned (CN)	-	-

Source: *Chemical & Engineering News Global Top 50 2022 (see Tullo30 for details on sales data) and the ORBIS database. a) Ownership through ChemChina which acquired Syngenta Group in 2020. b) Partly owned by Brazilian state through the national oil company Petrobras. c) The largest shareholder of Yara is the Norwegian government (36.2%). d) 25% owned by the Emirate of Abu Dhabi through Abu Dhabi National Oil Company.*

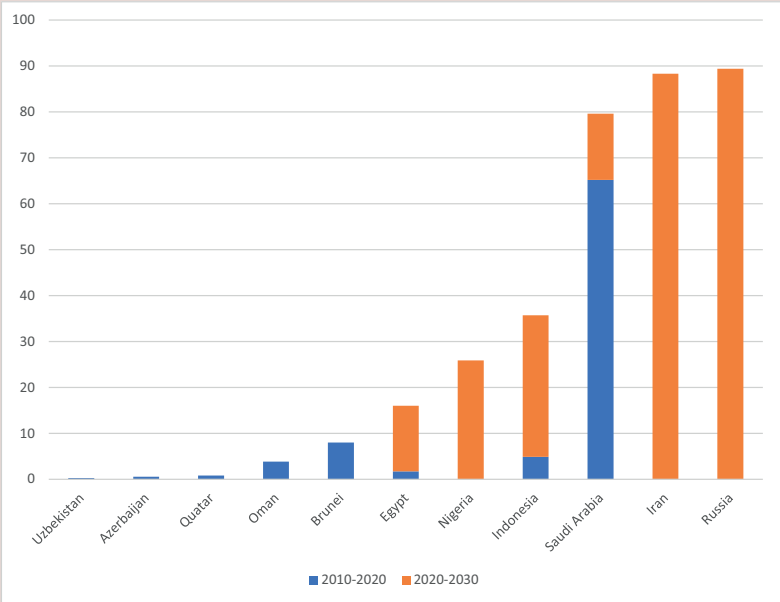
Box 1: Petrostates and the growth of petrochemicals

The global production of petrochemicals is anticipated to increase from 2,198 Mt/y to 3,072 Mt/y between 2020 and 2030[24]. A large part of these huge investments is financially and politically supported by states with a strong dependence on the revenues from oil and gas, so-called petrostates, as a way to future-proof and diversify their economies.

Petrostates, here defined as states with >10% of GDP coming from the combined revenues of oil and gas, face several long-term challenges in a decarbonising world. Oil and gas demand from traditional end-use sectors of oil and gas, such as transport, power, and heating, is projected to decline rapidly in the coming years (IEA 2021). Such development could seriously destabilise petrostates financially and also politically.

Several petrostates began investing in petrochemicals investment in the 2000s, and this trend increased after 2010 as oil and gas prices declined. In Figure B1, investments in petrochemicals by petrostates from 2000 up to 2030 are given. Saudi Arabia has been the main investor with its mega-project in Jubail but Brunei, Indonesia, Qatar and Oman also made large investments. Iran, Iraq, Russia, Indonesia, Nigeria, and Egypt are petrostates that aim to invest significantly in petrochemicals in the coming decades[24]. This assessment, however predates the Russian invasion of Ukraine, that might have repercussions, especially on the role and use of gas and planned international investments in Russia.

Figure B1: *Petrochemical capacity additions by petrostates between 2010 and projected up to 2030. Sources: 2010 to 2020: OGJ Database. From 2020 to 2030: GlobalData*[24]



More than 25% of all anticipated new capacity additions between 2020 to 2030 are located in petrostates[24]. The rest of the investments are mainly located in China (25%) and India (15%), two big countries with a rapid increase in domestic demand, and also from the US (7%). Even if not defined as "petrostates" here, the expansion in both China and the US (7%) has strong connections to access to fossil resources. China is utilising ample coal resources to produce methanol; access to low-cost shale gas is a driver for the US. Several investments in both China and India are furthermore developed in cooperation with chemical and oil companies from the MENA-region, most notably SABIC (Saudi Arabia) and ADNOC (UAE).

Petrostates frame their petrochemical investments as part of a wider diversification strategy to insulate them against weaker oil- and gas-markets and to create much-needed domestic jobs. Petrochemicals as large scale mega-projects also fit well with a centralised petrostate logic as a way to diversify the economy compared to e.g. economic liberalisation that would require more difficult institutional changes[31]. Government involvement is strong in these large mega-projects and includes both domestic and international financial support, as will be discussed in more detail in the next chapter. There is a high risk that large investments in petrochemicals will not lead to a properly diversified economy in these petrostates, but rather simply entrenches their carbon lock-in further.

2.2.2. A globally interconnected industry

The chemical industry is materially, organisationally, and institutionally connected to the fossil fuel industry. Material integration exists in industrial petrochemical clusters (which often include petroleum refining) through economies of scope[32], while organisational ties are most evident in the form of vertically integrated oil, gas, and chemicals companies (see Section 2.2.1). Institutionally, the oil, gas and chemical industries have a shared knowledge base in chemical engineering[33,34] and also share markets for technology because key process technologies are available through licences[35–37]. The interdependence between fossil energy and chemicals – and the "special relationship" it has given rise to – dates back to the origins of the industry, and has evolved as the main form of fossil feedstock has changed[23,38]. Globally, stability has long been a keyword to describe the sector, and historical continuity remains important[37,39].

Today, the petrochemical industry is characterised by certain geographical "hotspots", where most of the largest and most dominant firms are present (both Western and non-Western firms). These include major world cities like Singapore, London, and New York as well as lower-ranked global cities like Amsterdam and Houston[39]. Amongst these so-called hotspots, Houston is the top meeting point in terms of subsidiary networks, wherefore it has recently been dubbed "the petrochemical capital of the world"[39]. Many factors influence the territorial configuration of the industry[40]. These include historical path dependencies and geopolitical considerations as well as location-based advantages such as links to global production networks[41,42], resource availability, and market access. In addition, financial and tax-related considerations also play in[43], with multiple companies present in places such as Kuala Lumpur, Singapore and Amsterdam as well as Bermuda and the British Virgin Islands[39].

In addition to geographical meeting points, research on corporate networks considers many other forms of integration. This includes so-called interlocking directorates, where corporate members associated with one organisation sit on other companies' boards[44,45], ownership networks[46,47], corporate networks arising from career hubs[48] and more. These different forms of interlocks create different forms of interdependencies and mutuality and arguably reflect power and agency in the global economy[39,46,49]. In this context, research on the chemical industry has focused on the cartels and strong corporate networks that have characterised the chemical sector historically, and less on the importance of networks for sustainability transitions in this century[49,50].

A key question is thus what the extent and form of integration are beyond industry "hotspots". Corporate networks and ties between chemicals and fossil fuels are important for the prospects of transforming the sector and which strategies might be the most effective (see Chapter 6). If the industry is dispersed and disintegrated, the industry holds fewer interests in common on a global scale. If, conversely, the largest actors globally are highly interlocked with strong ties to fossil interests, and we can meaningfully talk of a globally integrated industry, a higher degree of collective and coordinated efforts to steer a transition in a fossil-friendly direction is likely. In the following, we draw from the analysis in Tilsted and Bauer[51] to explore this issue.

2.2.3 Ownership interlocks connect petrochemical producers

2.2.3.1 Approach and method

To analyse overlapping interests and integration in the global petrochemical industry, we focus on joint ownership. We do so because we want to highlight shared material and economic interests. By focusing on ownership ties between lead firms, we map relations that are materially anchored. These relations reflect collaboration and joint ventures, which often work to further different forms of lock-in given the current configuration of the industry. If firms collaborate on projects with investment horizons of several decades and substantial 'committed' emissions[52], the profitability hinges on utilising production facilities until the end of their lifetime. The alternative is that current and previous commitments end up as stranded assets. This, in turn, means a continuing reliance on fossil fuels to remain profitable. Ownership ties and the collaboration they reflect help illustrate the extent to which firms are contractually connected and hold

shared economic interests. This is important, as they can arguably hint at the extent to which there is a common interest in dictating that reconfigurations of the global petrochemical industry respect the fossil-based investments that characterise the sector.

Given the role of large multinational companies in the sector described above, our analysis remains centred around the largest companies in the industry as measured by chemical sales at the time of analysis. This includes public, private, and state-controlled entities and vertically integrated oil, gas, and chemical companies deeply rooted in the fossil fuel energy order. We rely on data from the Orbis (Bureau van Dijk) database. Its compilation of data from various sources is the most comprehensive of its kind in terms of providing information on companies from around the world and widely used for analysing corporate networks[53].

From the sample of 52 major chemical corporations listed in Table 2 we identified almost 30'000 subsidiaries. Using statistical and visualising software (all details of the analysis are available elsewhere[51]) we created a network, where petrochemical majors are nodes and ties between them represent joint ownership in a given subsidiary. The identified subsidiaries are involved in different activities along the petrochemical value chain. Table 3 shows an overview of subsidiaries divided according to their main activity based on NACE industry codes. Amongst the 52 major petrochemical producers we consider here, many are engaged in extraction and refining of fossil fuels. Subsidiaries whose main activities revolve around extraction, refining and selling oil, gas and coal are measured in terms of both assets and turnover around the same size as the chemical, plastics and fertiliser entities combined. Given the amount of vertically integrated companies involved in petrochemical production, this is hardly surprising. In addition to the entities

Table 3: *Overview of subsidiaries owned by 52 petrochemical producers included in the network analysis.*

	Fossil fuels	*(Petro)-chemicals*	*Plastics*	*Fertiliser*	*Financial entitites*
# of entities	966	3 831	1 134	366	1 783
Total assets (m 2021 USD)	1 108594	721 480	271 392	144 396	2 040 298
Share of chemical assets	154%	100%	38%	20%	283%
Total turnover (m 2021 USD)	955 192	530 643	207 857	79 882	327 919
Share of chemical turnover	180%	100%	39%	15%	62%

Source: *Analysis based on data from Orbis (Bureau van Dijk). Note: The categorisation is based on NACE-codes related to respectively i) extatraction, refining and sale of fossil fuels, ii) chemicals manufacturing, iii) plastics manufacturing, iv) fertiliser manufacturing and distribution, and v) financial sector activities.*

directly involved in actions "on the ground", 1 783 subsidiaries are engaged in activities associated with the financial sector. This relatively large number of entities with assets of more than 2 trillion USD in assets owned by petrochemical producers reflect broader processes of financialisation associated with the rapid expansion of the financial sector and the era of financialised capitalism.

2.2.3.2 Network analysis

From our analysis arises the network graph depicted in Figure 3. Together, they show that ownership ties exist across the largest petrochemical producers. On average, a producer holds ownership in 76 subsidiaries also partly owned by 11 other companies and only three firms are not linked to any other in the network (which are all outside the top 30). More than 20% of all possible ties exist and a maximum of four ties relate all petrochemical companies in the network to each other. The most central firms in the network count SABIC (the Saudi state-owned petrochemical major), a number of large Japanese producers and the North American firms with the highest chemical sales namely Dow, ExxonMobil and LyondellBasell. These all have connections to 20 or more of the other corporations in the sample, as shown in Table 4.

Using an algorithm for community detection[54–57], the network graph depicts different clusters with various colours. From this analysis, a couple of different clusters are particularly noteworthy. Most prominently, there is a strongly connected Japanese cluster (in pink). All Japanese firms in the sample are part of that cluster with many direct ties between the different companies. The integration through ownership of the Japanese petrochemical majors illustrates territorial embeddedness, meaning that the geographical context influences industrial organisation, which fits with the extensive and long-standing corporate networks characterising the Japanese economy[58,59]. Another internally related but however more peripheral cluster is the Chinese cluster in blue. What is interesting about the Chinese cluster is not the few linkages that show up between different state-owned oil and petrochemical companies in the Orbis data. Rather, it shows how the Chinese companies, which have grown to take up 36% of global production (see Section 2.1), are somewhat isolated in the ownership network of petrochemical majors. In fact, joint ventures between international and Chinese petrochemical majors are generally located in China[39]. The findings from our network analysis thus illustrate the Chinese industrial strategy of self-sufficiency and corporate networks that are integrated on a national level[60].

Table 4: *Top 25 most central firms in the network.*

Company	*No. of other chemical majors with which they are connected (Degree)*	*No. shared ventures with other chemical majors (Weighted degree)*
SABIC	28	128
Mitsui Chemicals	27	236
Toray Industries	26	133
Sumitomo Chemical	22	69
Asahi Kasei	22	128
LyondellBasel	22	243
Exxon Mobil	21	28
Dow Inc.	20	67
Borealis Ag	19	29
Evonik	19	196
BASF SE	19	66
Air Products & Chemicals	19	28
Bayer Ag	18	34
Lanxess Ag	18	189
Arkema	18	21
PTT Global	17	184
Mitsubishi Chemical	15	65
Eastman Chemical	15	15
INEOS	14	50
Solvay Sa	13	37
ChemChina	13	268
Syngenta Ag	12	276
Covestro Ag	12	29
Shin-Etsu	10	100
Tosoh	10	57

Note: *Degree – number of ties to other firms in the network; weighted degree – number of subsidiaries with shared ownership; Betweennes – importance in relating other actors to each other through the shortest path possible; Closeness – centrality in terms of the average distance to other firms; Eigenvector centrality – centrality measured in terms of the centrality of connected nodes.*

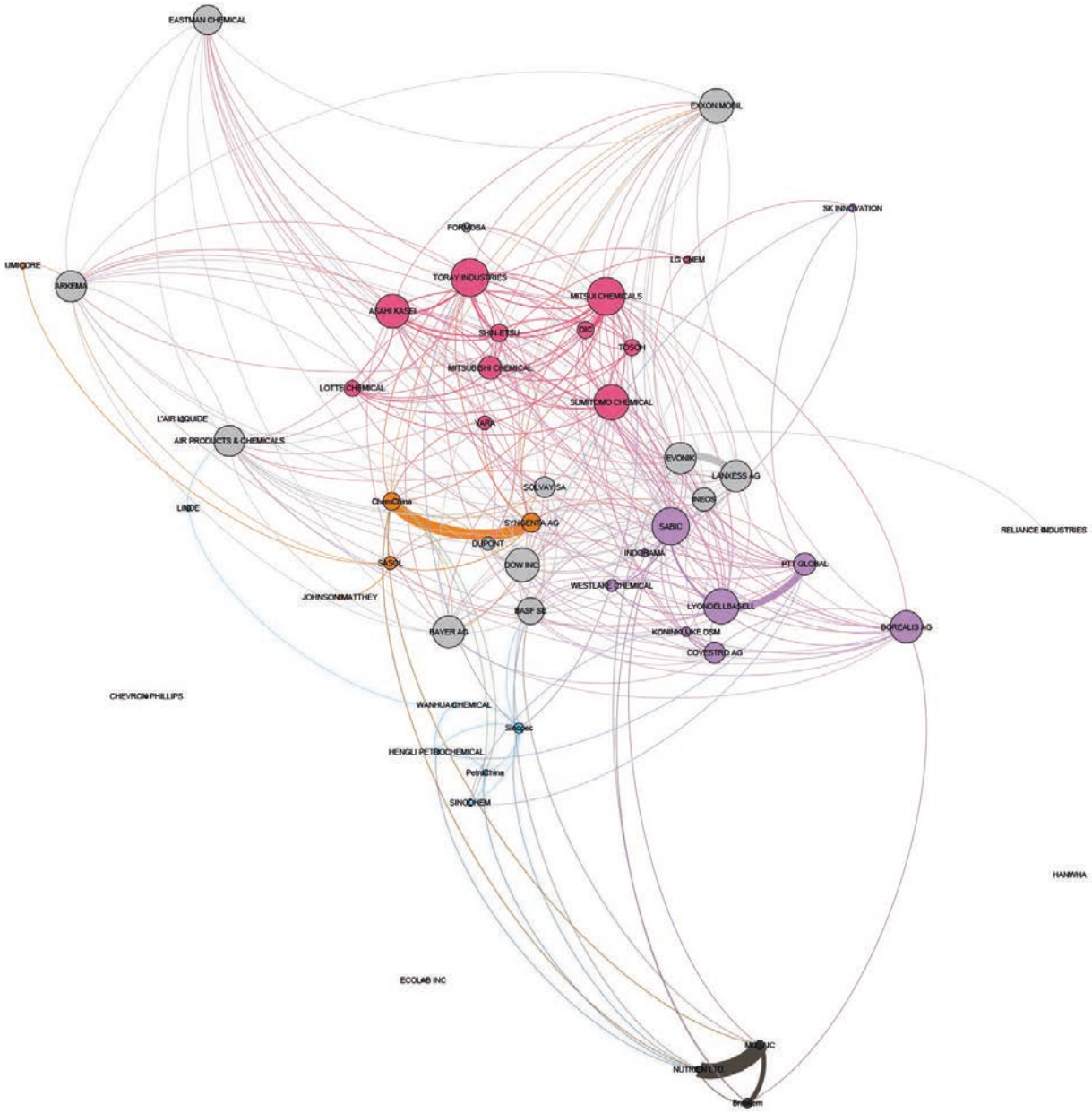
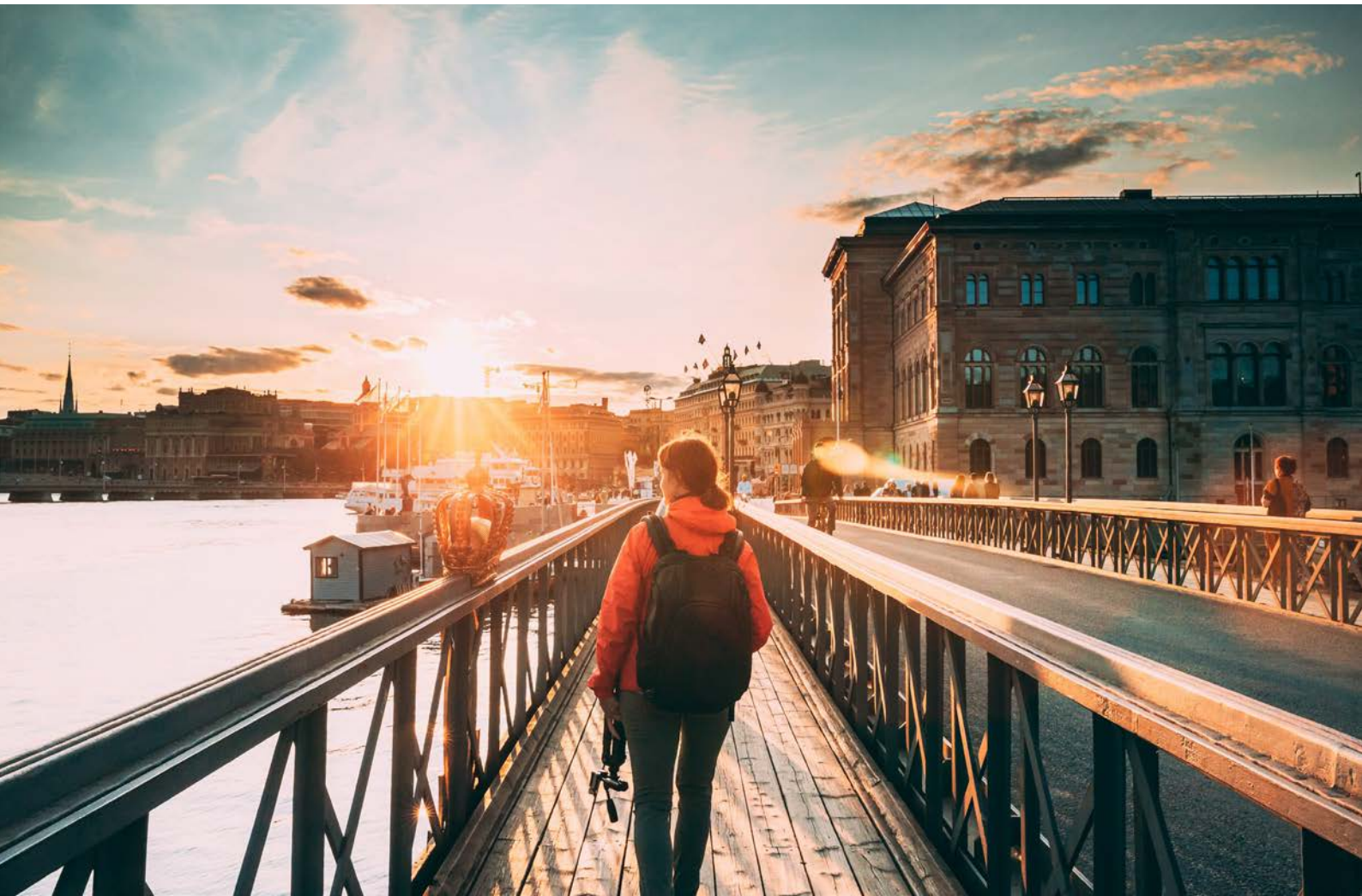


Figure 4: *One mode ownership network graph. Note: Nodes (MNCs) are scaled by eigenvector centrality (captures the centrality of related actors) while edges (instances of common ownership) are scaled by the number of subsidies in which two MNCs share ownership. Colours represent internally strongly connected communities. Source: Tilsted and Bauer*[51]

The entities which are listed as subsidiaries in the Orbis database and link the different petrochemical producers together play different roles. The vast majority of the subsidiaries in the sample connect two companies in a dyadic relation. These include, e.g., joint ventures, production entities and niche projects that are set up in a way which leads to common ownership in a given subsidiary between two firms. In addition to these subsidiaries, a range of entities which connect multiple companies is also evident. These include organisations such as industry interest associations and think tanks. For example, the Singapore Chemical Council connects 15 petrochemical producers in the sample (as well as a long list of other member companies of different sizes) while the German plastic industry think tank BKV connects 7 companies in the network. These organisations play different but rather policy-oriented functions, seeking to influence decision-making processes either directly or through "coordinative discourses" and the supply of "policy-relevant" knowledge[61,62].

The integration along the fossil fuel-chemicals-plastics value chain as well as the ownership interlocks across petrochemical producers underline that petrochemical production is rooted in the fossil energy regime. Noticeably, the most central actor in the network is SABIC, which is owned by one of the largest oil producers in the world, Saudi Aramco. The pervasive economic and legal ties that this form of integration represents show how industry actors for structural reasons cannot be relied on to secure a rapid and just transition beyond fossil fuels[63]. Strong economic interests in upholding and expanding current levels of consumption of products derived from petrochemicals to secure both the recent wave of investments as well as maintain fossil fuel demand, means that industry actors overall are likely to work towards continued expansion. Ensuring genuinely transformative solutions that challenge fossil fuel dominance in the petrochemical industry, therefore, requires a new global plastic and chemicals governance.



3 Webs of finance

The financial sector has become increasingly important in the discussion about transforming key industrial sectors. From early initiatives among special groups of asset owners, such as religious groups, who wanted to ensure that their assets reflected their convictions, the idea has grown to include calls that the financial sector should be at the forefront of enabling the green transition. Through its power as the mediator of capital, the financial sector is envisioned to allocate capital towards green transformation and away from emissions-intense investments using different tools and instruments. The key role of finance is also highlighted in the central Article 2 of the Paris Agreement, which states that one of the three central aims of the agreement is to make "finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development". Through policy interventions such as the EU sustainable finance package with its taxonomy on green economic activities, as well as private governance initiatives in the ESG domain, the pressure is increasing on actors in the financial sector to become part of the green transformation of the economy.

A primary focus area has been the role of equity, primarily stocks, and the possibilities for asset managers and owners to influence companies or divest from them if the firms do not show clear plans and strategies for the transition. However, what enables investments in new petrochemical production facilities is not primarily the value of stocks, but rather different forms of credits and direct project finance instruments that are used to invest in new assets. Thus, we here focus mainly on how private and public financial institutions support and enable continued investments through credits such as loans, bond markets, and guarantees.

Globally, the chemical industry has made massive investments in the past decade – funnelling capital into fossil-dependent technology and infrastructure. As shown in Figure 5, investments in China have grown to become much larger than anywhere else in the world. This chapter explores the different types of financial institutions that have made this expansion possible, as well as the role of the bond market and of public financial institutions. It does so with reference to global financial flows as well as four case studies of the financing of recently constructed petrochemical plants.

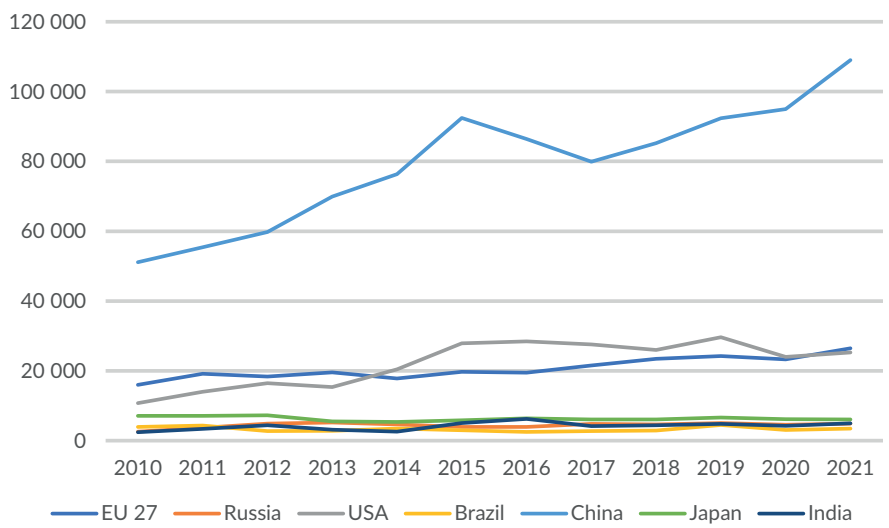


Figure 5. *Investments by the chemical industry in key countries and regions. Over the past decade investments in China have outpaced investments in other regions and countries. Figure based on data from VCI*[25].

3.1 Types of financial institutions involved in petrochemicals and their roles

A range of different public and private institutions provide finance for petrochemical infrastructures. We distinguish between public and private financiers in terms of whether they are respectively established "to benefit or promote a specific national interest" or "(a) carrying out or established for business purposes and (b) financially and managerially autonomous from nationals or local government", a definition developed by the Multilateral Development Banks[64].

Finance from public institutions often intends to increase the amount of private finance, an effect referred to as mobilising, leveraging and catalysing[65–67]. Such leveraging may be direct through bringing the "risk-adjusted rate of return on investment in line with the market, increasing the allure of the investment from a private commercial investor perspective"[68]. It may also be indirect, by sending a signal to private financiers that the project meets their standards or is less exposed to political risk stemming from government policy, e.g. since governments are involved[69].

3.1.1 Public institutions

Among the public institutions, some belong to one state, whereas others are multilateral. Starting with those belonging to one state, first, National Development Banks have been established to support domestic industrial development, today mainly in emerging and developing countries, through the provision of loan guarantees, credit and fixed income instruments. Second, state-owned companies, particularly within the fossil fuel or petrochemical sectors, often provide equity for petrochemical infrastructures both within and beyond their own country. The Sadara and Lake Charles petrochemical plants discussed in detail below show instrumental state-owned fossil fuel companies (in the two cases respectively SaudiAramco and Sasol) can be in financing petrochemicals. Third, Sovereign Wealth Funds, which are particularly prominent in fossil-fuel producing countries, and provide equity for investments both within and beyond its own country. The fact that Sovereign Wealth Funds often derive their funds from fossil fuel revenues and are tied to state interests (especially those of state oil and gas companies and agencies) means that their investments have been used to secure long-term demand for fossil fuels by expanding petrochemicals production, as has been the case in Saudi Arabia (see Sadara case study below).

Fourth, central banks in industrialised and emerging economies have provided finance by purchasing bonds that fund petrochemical companies in general or infrastructure in particular. These purchases have mainly been part of quantitative easing bond-buying programmes. For instance the European Central Bank has purchased bonds from the petrochemical sector that can be (conservatively) estimated at €14-15 billion[70]. Fifth, export credit agencies support domestic companies by promoting the export of their goods and technologies, mainly by providing guarantees, credits or fixed income instruments for foreign purchases of such goods and services beyond what the market can offer, e.g. because the purchase is deemed too risky or costly[71]. The direct financing for petrochemicals from such export credit agencies has been estimated at $31 billion for the period 2000-mid 2021, while loan guarantees from such agencies amount to $23 billion for the same period[70]. Finally, bilateral development agencies and banks promote development in developing countries by providing grants, (often concessional) credit, guarantees, and in rare cases equity for projects or budget support. Often bilateral development finance is influenced by the interests of the donor's domestic industries[72]. The financing of the Surgil plant in Uzbekistan, as discussed in more detail below, to a large degree came from South Korea and was tied to the interests of the Korean petrochemical industry.

Multilateral development banks (MDBs) arguably constitute the most important public multilateral financiers of petrochemical infrastructures. Similarly to bilateral development agencies they provide grants, (often concessional) credit, guarantees, and in rare cases equity for projects or budget support in developing countries, but are less influenced by national political or industry interests, although the interests of their largest donors may influence their

financing decisions[73]. As Figure 6 shows, MDBs have provided billions in direct financing to petrochemicals, with the International Finance Corporation (the private arm of the World Bank Group), the European Investment Bank and the Asian Development Bank all providing more than $ 1 billion.

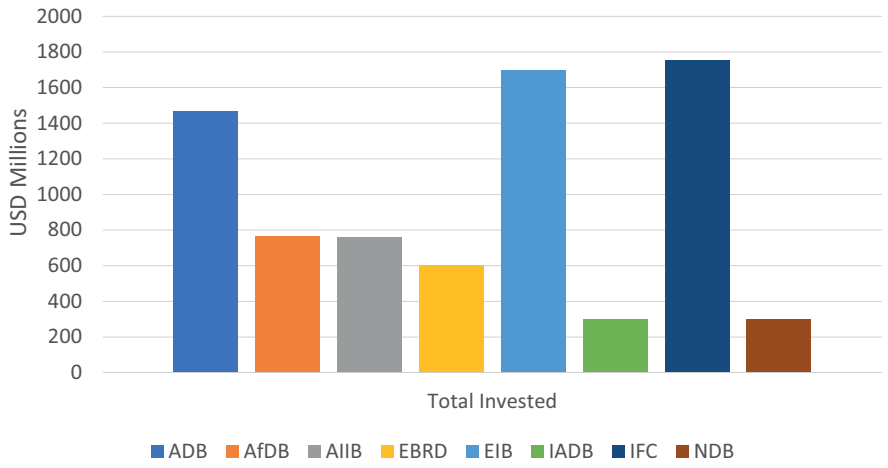


Figure 6. *Direct financing for petrochemical projects by major multinational development banks in the period 2010 to 2020. Acronyms: ADB - Asian Development Bank, AfDB - African Development Bank, AIIB - Asian Investment and Infrastructure Bank, EBRD - European Bank for Reconstruction and Development, EIB - European Investment Bank, IADB - Interamerican Development Bank, IFC - International Finance Corporation - World Bank, NDB - BRICS New Development Bank.*

3.1.2 Private financial institutions

The most important private financiers are banks, fossil fuel (primarily oil and gas) and petrochemical companies. Whereas banks mainly provide credit, but also are involved in issuing and purchasing bonds, petrochemical and fossil fuel companies mainly provide equity. When it comes to the different kinds of companies, there are often close ties between petrochemical and fossil fuel companies, often with the latter owning large shares of the former or the former being subsidiaries of the latter. This is the case with SABIC, which is owned by SaudiAramco, and the chemical division of Shell which owns nearly seventy petrochemical companies.

De facto the boundaries between public and private companies are often blurred.

Although Western governments in the 1990s started to sell off shares in their state-owned petrochemical companies, in many cases, they still hold substantial shares. For instance the state is the major equity owner of four of the 50 largest petrochemical companies (by chemical sales), Braskem (Brazil), Sinopec (China), Saudi Aramco/SABIC (Saudia Arabia), Sasol (South Africa). While state equity holdings are a small proportion of total equity for the petrochemical companies, the numbers are substantial. For the mentioned top 50 petrochemical companies, state holdings are worth around $179 billion (close to the GDP of New Zealand).

Even when governments are not directly involved, states are often indirectly involved through their sovereign wealth funds and public pension funds with equity holdings. This is the case for the funds

of states such as South Korea, Sweden, and Thailand which hold equity investments in several petrochemical companies. Most notably, the Norwegian state has equity holdings in just over half of the top 50 petrochemical companies, through its state pension funds. Even if a state only holds a few percent of the total equity, this adds legitimacy to the company and means that the state has an interest in the financial performance of the company[74]. These connections can also constitute informal channels for company influence.

3.2 Bonds as an important source of capital

One of the key sources of financial capital for new large investments is the global bond market. Corporate bonds allow businesses to borrow money from investors. The buyer of a corporate bond makes a fixed-term loan to the firm at a fixed interest rate against the promise that they will receive regular interest payments from the corporation until the bond matures, at which point the holder will get the face value of the bond. Overall, the industries that are most active in the corporate bond markets are those that require significant capital investment to fund growth and development, which is typical for the oil and gas industries as well as petrochemicals and other heavy industries. While the role of the global bond market for the climate transition receives less attention than that of the stock market, it can potentially be important for pushing and accelerating the transition as bonds and loans directly enable investments[75].

Many types of financial actors are active on bond markets. Institutional investors such as pension funds, insurance companies, and mutual funds are among the largest investors in the corporate bond market. They often have a long-term investment horizon and can invest large sums of money in corporate bonds. Hedge funds and other alternative investors may also invest in corporate bonds to complement investments with higher risk profiles. As mentioned above, sovereign wealth funds, central banks, and other public investors, also invest in corporate bonds, and it can be argued that central banks play a special role. Central banks invest in corporate bonds for a variety of reasons, e.g. to support the functioning of financial markets and ensure that credit is available to businesses. By investing in corporate bonds, central banks can lower borrowing costs for firms and provide liquidity to financial markets. This can help to stimulate economic growth and job creation, which was the primary motive for central banks to invest large volumes of capital in corporate bonds in the immediate crisis management following the outbreak of covid-19. As much of these investments were supposed to be market neutral they did not discriminate against investments in high-emitting industries such as the petrochemical industry[70].

The global chemical industry commonly uses bonds to finance their investments and other activities. Our analysis of Bloomberg data on global bonds showed that in late 2021 there were more than 2300 active bonds issued by firms in the chemical industry (the data source does not specifically identify petrochemicals), with a total held value of 135 billion USD indicating the scale of capital flowing into the industry. Of these only 13 were identified as green bonds, indicating that there is still a very low interest in the industry in green investments.

Among those supporting the industry are a limited number of banks and and financial actors that direct large flows of capital to the industry through the bond market as well as through loans. As there is no formal registry of bond holders transparency is limited, but for 24% of the bonds we could identify the managing firms, among which we find some of the most well-known banks and investment companies in the world as shown in Table 5. These findings complement earlier analyses which identified the international banks that were the strongest supporters of investments in plastics[76].

Table 5: *Largest managing firms with registered holdings of bonds issued by chemical firms.*

Managing Firm Name		*Total (million USD)*
Total	100%	135003
Blackrock	6.67%	9005
Vanguard Group	4.84%	6530
Prudential financial Inc	4.16%	5612
JP Morgan Chase & Co	2.85%	3854
Allianz Se	2.27%	3068
Capital Group Companies Inc	2.27%	3062
Goldman Sachs Group Inc	1.60%	2160
Fmr Llc	1.54%	2082
Metlife Investment Management Ll	1.29%	1743
Alliance Bernstein	1.15%	1547

3.3 Integrated flows of capital from public and private financial institutions

In this section, we present findings that display the geographical distribution of public and private flows of capital into major infrastructural projects in the petrochemical industry, tracking trends in output as well as identifying key financiers. We identified transactions behind 56 petrochemical projects with a total capital expenditure (CAPEX) of more than 1bn USD in the period 2010-2020, with the purpose of understanding the capital dynamics behind large investments in new or expanded production capacity. With data from IJ Global, we could map the flows of capital from both private and public financial institutions to these large investments. These flows of capital are outlined in Figure 7 below.

It becomes clear from our analysis that while private finance is much larger than public finance, both forms and sources of capital are intertwined[77]. Support from public financial institutions is likely to be used strategically as leverage to gain trust and support from private financial actors. The capital is mainly directed towards Asia-pacific and the MENA region, which aligns with research showing that these are the two key regions where the industry is growing. The data shows that the investments are mainly in greenfield sites. If we had been able to also include projects with CAPEX below $ 1 billion, it is likely that brownfield projects would have taken up a larger share. Yet, the large investment in greenfield projects shows how capital is not only used to retrofit and build on existing facilities but also continues to lock in completely new facilities to the existing business model built on fossil fuels. This is important given that these petrochemical facilities are typical of industrial infrastructure in that they are constructed with the plan to operate for decades. Lastly, while the details about final material output type are often not transparently reported, it is beyond doubt that plastics are the main driver for these investments.

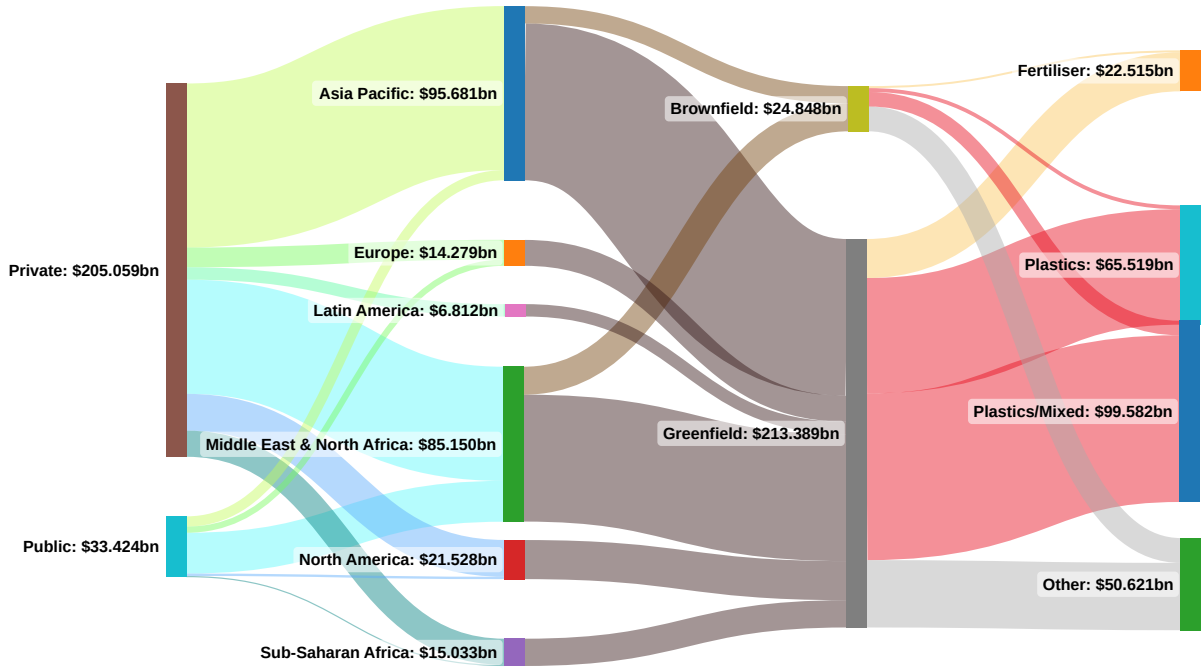


Figure 7 . *Finance flows to petrochemicals projects with a CAPEX above 1bn USD between 2010 and 2020. Source: Data derived from IJ Global database. All geographical, types of project, and final material outputs are defined by the classifications used in the IJ Global database. Authors' own calculations.*

If we shift the lens towards the financiers, it is evident that while private finance dwarfs public finance, the latter still accounts for 14% of the total finance provided. Moreover, while most of the projects were located in Asia-Pacific and the Middle East and North Africa regions, Europe and North America constituted respectively the largest and third-largest regions in terms of where the finance comes from. Although public financing only represents 14% of the total financing in Figure 8, the manner in which this financing is influential in each of the transactions could in fact be instrumental as public financing has a leveraging power in getting large infrastructural petrochemical projects off the ground[77]. The usage of public financing in the purchasing of tranches in a commercial bond can act in a similar leveraging way, reassuring corporate lenders of the validity and assuredness of a bond or special purpose vehicle that has been issued for the purpose of financing a new project or for all-encompassing financial instruments such as refinancing and additional facility. Despite the comparably low quantities stemming from the public coffers, they can act as an extended vote of confidence in each individual transaction and, more generally, the industry as a whole[70].

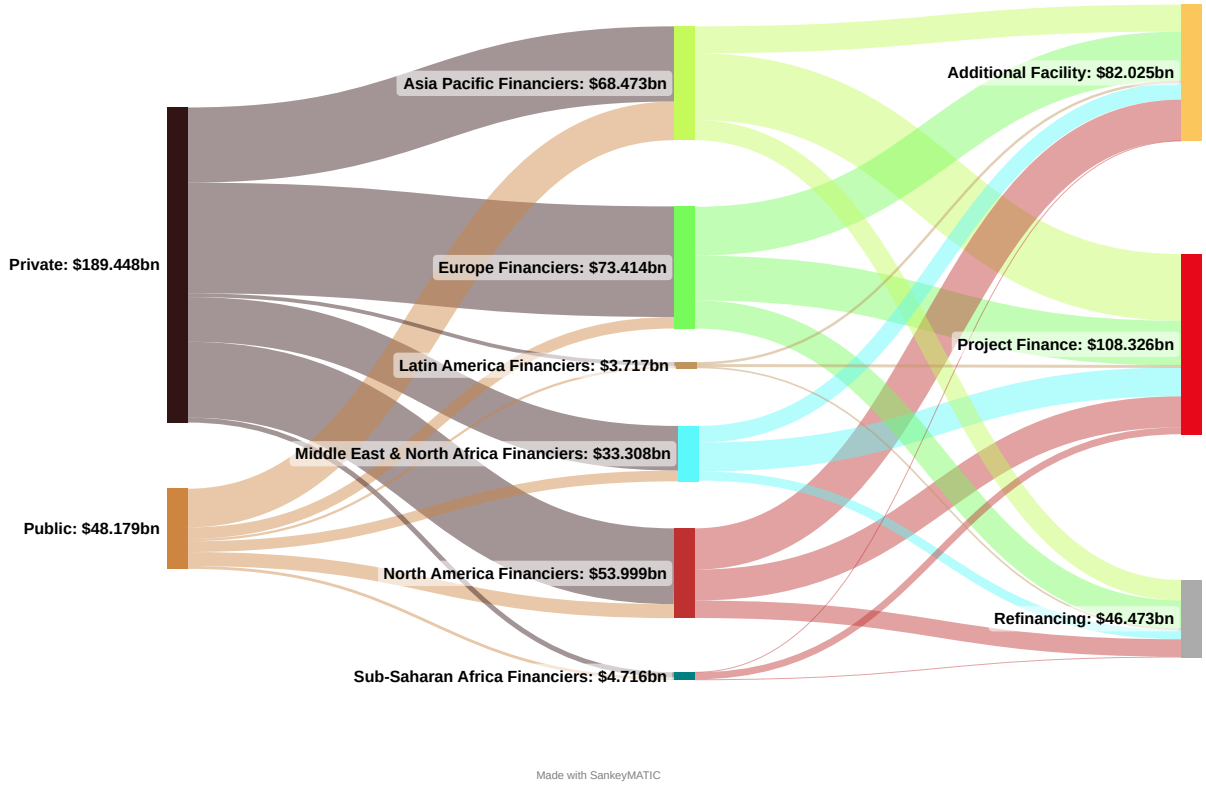


Figure 8. *The flows of state and private debt into financing the infrastructural related operations of the petrochemical from December 2009 to June 2020. Finance flows from left to right with values equating to the convergence of flows into each solid node. 'Source of Financing' displays the division between the start-points of financing, from either state or private interests. 'Location of Financiers' shows the geographical distribution of financing based on the company/institutions' HQs. 'Usage of Funds' depicts the purposes for which the financing is used, all related to either new or existing infrastructural projects. Data derived from IJ Global. Authors' own calculations.*

From the 269 infrastructural related deals tracked across the period from December 2009 to June 2020, there were 553 debt providers with some familiar names[76]. The 11 banks that executed more than 50 each of the individual transactions within the 269 deals are laid out in Table 6. These individual finance flows can take the form of multiple financial tranches, including but not limited to; a commercial bond tranche, term loan, cash equity, bridge facility, revolver loan, working capital and so forth.

Table 6: *International banks with the most provided transactions for petrochemical projects 2010-2020.*

Company	Debt Provided Transactions
JP Morgan	148
HSBC	117
Citigroup	115
BNP Paribas	111
Bank of America / Merrill Lynch	110
Sumitomo Mitsui Banking Corporation	103
MUFG Ban	92
Credit Agricole Group	89
Societe Generale	84
Standard Chartered Bank	59
Barclays	54

3.4 Deepdive: four large petrochemical projects and their financing

To illustrate how the webs of private and public finance enable and support the expansion of fossil-based petrochemicals, we briefly present four cases of large investments from the past decade. The cases are from different continents and involve different actors, but they show how the large capital investments exemplary of the industry attract direct investment capital as well as different forms of credits and guarantees from public financial institutions that enable a continued lock-in in carbon-intensive, fossil-based petrochemical production. They do so despite pledges from many governments and institutions to redirect financial flows to be aligned with the Paris Agreement.

3.4.1 Sadara petrochemical complex (Saudi Arabia)

The Sadara petrochemical complex in Saudi Arabia constitutes the largest petrochemical facility ever built in a single phase incorporating "26 manufacturing units, a mixed-feed steam cracker and an aromatics plant"[78]. The joint venture between state-owned oil giant Saudi Aramco (65%) and chemicals major Dow (35%) was announced in 2011[79]. Saudi Aramco and Dow provided initial capital of $4.39 and $2.37 billion respectively. Sadara is central in the effort of Saudi Aramco to diversify downstream from oil production and become a stronger global actor in the petrochemicals industry: "it is the cornerstone of our downstream strategy to become a leading global integrated energy and chemicals enterprise"[80]. Material output from Sadara will be dominated by value-added chemicals, as well as plastics for use in the energy, transportation, construction, electrical, and electronics sectors. The set of facilities is capable of producing 1.5 million metric tons of ethylene and 400,000 metric tons of propylene per year. The ethylene and propylene will serve as feedstock for multiple downstream production lines, producing materials that can later end up in market segments such as plastic packaging, textiles or toys.

The Sadara has the largest ever project financing in the Middle East and received financing from a range of financiers and guarantors. There was a $1.3 billion injection from Saudi Arabia's own Public Investment Fund. Public money also took the form of direct loans from Export-Import Banks of South

Korea, Spain and the US, as well as loan guarantees from export credit agencies in Germany, France, South Korea, and the UK. Altogether, public finance from other (predominantly Western) countries dwarfed private finance, headed by a $5 billion loan from the US Export-Import Bank, the largest in the history of the bank. The project also benefitted from a $2 billion Sukuk bond issuance by SABIC's parent company Saudi Aramco. The Sukuk bond issuance was listed alongside a private consortium of commercial banks that mustered $1.8 billion between them.

3.4.2 Surgil gas and chemical project (Uzbekistan)

The Surgil gas and chemical project is worth approximately $4 billion and can annually process 4.5 billion cubic meters of natural gas and produce 3.7 billion cubic meters of marketable gas, 387 000 tons of polyethylene, 83 000 tons of polypropylene (key plastics), as well as many other valuable petrochemical-derived products[81]. The equity of $1.4 billion for the project is split between four companies, Korea-based STX (5%), Germany-based Lotte Chemical Corporation (17.5%), Korea-based Korea Gas Corporation (17.5%), and the domestic Uzbekneftegaz (50%). The general announcement tendering external financing began in 2009, and the Asian Development Bank signed on in January 2012, with financing closing of the project occurring in late 2013[82]. Beyond equity, the financing for the project is 52% provided by PFIs, mostly based in the Asia Pacific region, with 34% of the debt financing underwritten by state-managed ECAs. Financial closing for the project was confirmed in May 2012. Surgil has a similar involvement of ECAs as we saw in the Sadara case, but the financing of this Uzbek project also includes a heavy direct involvement from multi-lateral and national development banks. Korean PFIs lead the way in both direct financing and loan guarantees, unsurprising given that 3 of the 4 owners of the Surgil gas and petrochemical complex are Korean companies: Korea Gas Corporation, Honam Petrochemical, and STX Energy[82–84].

3.4.3 Cabo Delgado natural gas and petrochemical cluster (Mozambique)

Cabo Delgado in Mozambique hosts Africa's single largest example of foreign direct investment to date, the Cabo Delgado natural gas and petrochemicals cluster[85]. Projections of natural gas discovery could potentially position Mozambique as the world's third largest LNG supplier with estimations that the project could contribute over $67 billion to the country's GDP. The Cabo Delgado project will house several large industrial projects that use gas as a primary feedstock, such as a $2 billion fertiliser production plant and a $5 billion gas-to-liquid plant. The downstream uses of the LNG production are earmarked for domestic use to serve as a crucial feedstock for plants producing petrochemicals and fertilisers[86]. However, the majority of the LNG produced will be destined for harbours beyond the shores of Africa[87].

The Cabo Delgado LNG project has received over $8 billion in direct state financing from the US EXIM ($4.7bn), Japan's Bank of International Cooperation ($3bn) and the African Development Bank ($400m). Loan guarantees to the tune of $6.14 billion were forthcoming from the ECAs and EXIMs of Japan, the UK, Italy, South Africa, Netherlands, Africa, and Thailand (AfDB, 2020). Private direct financing was much smaller and amounted to $485 million (AfDB, 2020), derived from a consortium of thirteen investment banks and the stakeholders at the time of writing were Total SA (26.5%), Mitsui (20%), ENH (15%), ONGC (10%), Bharat PetroResources (10%), PTTEP (8.5%), and Oil India (4%).

The project was greenlit in 2018 with LNG production scheduled for 2024. However, since the project got underway, there have been a number of hindrances that have hampered the complex's progress. Conflict involving Islamist militants across the region has already claimed over a thousand lives and displaced hundreds of thousands[88]. The growing conflict forced Total SA, as the principal sponsor of the project, to call a Force Majeure and cease construction of the cluster in April of 2021 due to an increasing number of security issues. As of September 2022, the pause on construction had not been lifted despite an improving security situation surrounding the onshore construction[89,90].

3.4.4 Lake Charles chemical complex (US/Louisiana)

The expansion to the Lake Charles chemical complex in the United States Louisiana was announced by the South African-based fossil fuel and petrochemical company Sasol in 2010. Sasol is one of the largest companies in South Africa and has strong historical ties to the South African state[91], as evident in that it has South African public financial bodies as their majority stakeholders. After progressively increasing cost estimates, the complex completed the last part of its expansion in November 2020 with a total price tag of $12.8 billion, and has been operational since[92,93].

The expansion tripled Sasol's chemical production capacity in the US. The project hosts an immense ethane cracker, capable of producing 1.54 million tonnes of etyhlene per annum. Equipped with ExxonMobil Corp's technology, the etyhlene cracker is part of the $2 billion 50/50% partnership with LyondellBasell Industries. LyondellBasell will possess half of the interest and the operatorship of the facility. Alongside the cracker are six chemical manufacturing plants that create high-margin speciality chemicals. In 2021, Sasol announced further growth plans on the site that incorporates modifications to a new emission reduction commitment. This includes carbon capture retrofits and the production of materials that are set to be used in renewable energy infrastructure[94].

3.5 International finance supports further lock-in in the industry

Our analysis shows how the international financial sector, including both private and public finance, is an important element of the lock-in of petrochemicals, and central in enabling its growth through continued investments. Recent and new projects, such as the ones highlighted in this chapter, will continue to produce (mostly cheap) petrochemicals for decades to come. These projects were realised with investment capital and support from a wide range of banks and other financial institutions. It is clear that finance for petrochemicals is truly global in reach, with much of the finance originating in industrialised countries but financing petrochemical plants in developing countries such as Mozambique and Uzbekistan. Furthermore, global bond markets and global institutions such as the MDBs are crucial for the financing of petrochemicals.

Public finance is an intrinsic part of the vast majority of financial flows going to petrochemicals. It may be much smaller than private finance, but it is deeply intertwined with private finance, and often leverages private finance. Without public finance, the overall level of finance would be much lower. Public finance is also tied to political contexts, such as the objective of making fossil fuel exporting countries less dependent on the demand for these fuels (e.g. Saudi Arabia and Uzbekistan) or the desire to promote domestic export industries (e.g. the ECAs funding petrochemical projects abroad).

Finally, there is little to no transparency regarding the financing of petrochemicals, both when it comes to public and private finance. This lack of transparency makes it more difficult to address this finance, e.g. in terms of commitments to reduce such finance or requirements that it only goes to plants that are, or can be converted into, low-carbon production of petrochemicals.

Addressing the financing of petrochemicals will have to deal with these factors and will be a difficult task, especially considering the urgency of the task. Yet, we argue there are important lessons to be learned from the (still nascent) efforts to address fossil fuel finance, especially public fossil fuel finance. Regarding public finance, these efforts have resulted in inter alia commitments to phase down inefficient fossil fuel subsidies and end public finance for unabated fossil fuel energy, both adopted in the context of UNFCCC COP26 in Glasgow, the latter by only 39 countries. One important lesson is that it is easier to get smaller groups of like-minded states or non-state actors to agree to phase out finance for particular kinds of investments and subsequently diffuse this norm to other actors.

4 Contesting the future of petrochemicals

This chapter highlights some of the ways that the climate impact and growth of the petrochemical industry are being contested as part of a larger discussion about industrial development and transformation towards a sustainable economy. This contestation has different forms and expressions depending on the context. First we highlight the ways the industry is acting to shape the conditions for its development by harnessing different avenues of influence. Second, we turn towards the ways that the industry's development and direction is shaped by contextual factors in different countries and regions. Finally we show how citizens, communities and social movements are mobilising forces to protest against the expansion of the industry.

4.1 Avenues of influence

Given how the petrochemical industry is a key contributor to both the climate, toxicity, and plastics crises[95], the industry might be thought to be under severe pressure to undergo a sustainability transformation. At the same time, the massive expansion of production capacity fuels competition and puts substantial pressure on producers to cut costs. Historically, the industry has prioritised such economic concerns over those related to climate change[96]. Where does this leave the industry given its intentions to massively grow production volumes? According to the head of petrochemical research at a major chemicals consultancy firm, as presented at a chemicals and polymers conference in 2021, the main question for industry actors is: "Can you negate or convert threats and position to capture opportunities?"[97]

In the context of strong transition pressures, this subsection seeks to answer how the petrochemical industry seeks to position to deflect threats and promote the sector. Corporate actors can generally invoke various tactics and strategies to influence the direction, form, and dimensions of change. Influencing policy and transformation processes involves employing different types of power including i) discursive, ii) institutional and iii) material or structural power[98]. In the following, we explore each of these in turn before we turn to how these forms of power work together to protect incumbent actors from potentially disruptive pressures by accommodating them in a way that leads to climate delay.

4.1.1 Petrochemical transition narratives

Narratives and discourses play an important role in climate policy. Influential discourses can delay crucial action[99] and reinforce carbon lock-in[100]. Problem framings can pre-empt solutions that favour fossil fuel interests[101]. Visions of the future constrain trajectories by rendering certain developments (im)plausible[102]. It is by now well-documented how fossil fuel companies have purposely misled the public in the face of climate change by mobilising discursive power[103–105], which is used to create support for incumbent interests[98]. And while the rhetoric has changed from denial to delay to lofty promises of sustainable futures, investments and business behaviour has not followed suit[106,107]. By now, a range of "discourses of climate delay" is prominent and invoked by an extended range of actors working to halt and postpone climate action[99].

Among large petrochemical producers, three transition narratives dominate corporate climate-related public relations activity. These are *realisers of sustainability*, *breakthrough technology pioneers*, and *already well underway*[97]. Taken together, these three narratives constitute a discursive strategy which positions the industry as indispensable to a sustainable future which will materialise thanks to the efforts of corporate actors. The three narratives and the overall vision they represent work to sideline and fend off criticisms raised against the industry

and corporate actors mobilise this discursive strategy in efforts to ensure lax and business-friendly regulation[96]. This section is based on the analysis in the paper on petrochemical transition narratives by Tilsted et al.[97].

4.1.1.1 Realisers of sustainability

The "realisers of sustainability" narrative frames the petrochemical industry as both facilitating and accomplishing sustainability by highlighting various uses of petrochemicals[97]. Prominently, industry actors emphasise that products derived from petrochemicals are used for solar panels and wind turbine blades[37]. Petrochemicals, for example, are in the words of industry organisations "key to" and even "advance" renewable energy[108,109]. Similarly, plastics are framed as sustainable by stressing that they are needed for electric vehicles, reduce food waste and/or are better than e.g. metal and glass[110]. According to ExxonMobil, "the environmental benefits of plastics are clear"[111] while Linde allegedly "enables" many more emission reductions than they emit[112]. In this narrative, corporate actors are the protagonists, not only aiding but being fundamental to a range of sustainability-related agendas. As such, critics of the sector do not understand the importance of petrochemicals and their role in various sectors and products that the critics themselves cherish as sustainable.

The narrative selectively points further down the petrochemical value chain, redirecting the attention away from GHG emissions stemming from production and end-of-life. This sort of cherry-picking and the use of "creative accounting" is an often-used strategy in the plastics industry[113] and resonates with the climate delay discourse *whataboutism*[99]. Redirecting attention from the issues at hand is a well-known strategy which is built around flagging ostensibly favourable statistics. However, while whataboutism often redirects the focus to others – as petrochemical industry actors have done in blaming consumers[113] – the realisers of sustainability narrative claim responsibility for sustainability achievements. The extent to which firms should be granted responsibility for what occurs elsewhere in the value chain is in this way a strategic question of whether it benefits the petrochemical industry.

The realisers of sustainability narrative promote relative rather than absolute sustainability. Relative sustainability assessments are made with reference to a given benchmark, such as the 1:1 substitution with plastics and other materials, but do not give insight into whether a product or industry performs well enough in reference to ecological limits and planetary boundaries[114]. Absolute sustainability assessments, on the other hand, show that the petrochemical industry is far from sustainable and needs to undergo transformative change while juggling difficult tradeoffs between different planetary boundaries[115].

4.1.1.2 Breakthrough technology pioneers

The narrative "breakthrough technology pioneers" reduces decarbonisation to a matter of developing and deploying key technologies with industry actors as the main protagonist[97]. Research and technological development and progress are framed as part of the industry's DNA, and as such decarbonisation represents a continuation of pioneering rather than a break from long-standing principles. Dow, for instance, delivers "breakthrough sustainable chemistry innovations that advance the well-being of humanity"[116] while BASF is "pioneering nearly carbon-free production processes"[117]. In this narrative, corporate actors are the main, if not solely, responsible for innovation which is presented as *the* way to reduce emissions[97], while alternative futures (such as diminishing resource-intensive forms of living) are most prominent in their absence. In framing key technologies capable of decarbonising the sector on a global scale as it continuously expands, substantive lifestyle changes are not needed.

Promoting the "breakthrough technology pioneers" narrative resonates with the climate delay discourse *technological optimism*[99]. Technological optimism leads to climate delay by setting aside uncertainties and risks associated with new technologies, e.g. by presenting breakthroughs as certain. This phenomenon has been labelled "technological myths"[118], i.e. the continual promotion of technologies which repeatedly do not deliver as expected on what is promised within the initially declared timeframe.

Unlike the realisers of sustainability narrative, breakthrough technology pioneers are premised on the current mode of production being unsustainable in promoting alternative technologies which are

meant to remedy (some of) issues certain technologies. Industry actors forwarding this narrative thereby implicitly acknowledge criticisms related to GHGs and plastic waste. Nevertheless, industrial actors have sought to avoid responsibility by reframing these issues as a matter of littering and low recycling rates, ultimately blaming consumers[113]. Redirecting climate action towards the individual level in this way resonates with the climate delay discourse known as *individualism*[99], which obscures the importance of interventions on the systemic level and how consumption is influenced by actors and organisations in powerful positions.

4.1.1.3 Already well underway

The third prominent transition narrative in the petrochemical industry is that dominant actors are "already well underway"[97]. Industrial actors are also the protagonists in a storyline where companies are on a "journey" towards sustainability and/or carbon neutrality. The narrative typically presents corporate efforts as a natural continuation of past efforts and reaffirms that companies are on a path already set out towards further success. Various activities and initiatives are made part of an overall pathway from which divergence is unthinkable, implying that the industry is in control and will drive decarbonisation on its own. INEOS, for example, highlights that the company's plans for a blue hydrogen plant "builds on the significant CO2 reductions we've already made"[119] and SABIC's on-site consumption of solar power reinforces the firm's "support for and contribution to wider climate change initiatives".[120] In acknowledging that the industry has not yet arrived at the "end" of the journey, i.e. at real carbon neutrality, the narrative accepts that the sector is currently not (yet) sustainable. This premise is similar to the breakthrough technology pioneers narrative, wherefore already well underway and also relies on individualism to justify current production patterns.

The already underway narrative excels in framing corporations as the instigators and drivers of change. Climate action is here not a result of civil society, public, investor and/or political pressure but rather cast as driven by the industry's commitments to sustainability and its desire to "do good". Public pressure, legislation, economic factors and litigation are sidelined or neglected as factors of change, despite the widespread evidence and research documenting the opposite[26,96,113,121–125]. In this way, the narrative that the industry is already well underway suggests that it is in control and can easily be trusted to continue their "journey" also in the absence of external factors. But as the cumulative effects or the corporate initiatives currently underway are far from what is needed to align the industry with global temperature goals[5,126,127], overemphasising small wins instead of acknowledging the discrepancy between current outlooks and needed action risks leading to climate delay.

The tendency to emphasise achievements to a degree that downplays the need for further action and regulatory procedures encapsulated in the already well underway narrative resonates with *all talk, little action*[99]. This climate delay discourse often hinges upon setting targets that appear ambitious but which are voluntary and allow for loopholes as well as not contextualising key statements (for example, not relativising climate-oriented investments and abated emissions). Both when it comes to company-wide climate targets as well as targets that focus on increasing renewable energy consumption in different ways, large petrochemical producers are falling short. Many targets are not encompassing all scopes and/or use dubious accounting methods such as non-additional market-based instruments or "avoided emissions" from company products (see Section 4.1.1.1)[5,126].

4.1.1.4 Framing the industry as transition enablers

Taken together, the three transition narratives form a discursive strategy that defends the industry's actions across both the value chain and time. Figure 4 depicts an overview of the three narratives and the various discourses of climate delay they resonate with and build upon. By arguing that the industry is pivotal to sustainability now (realisers of sustainability), is continuously improving (already well underway) and is critical to future progress (breakthrough technology pioneers), the petrochemical sector is cast as indispensable to fight climate change across place and time. Rather than being an important part of the fossil energy regime that is at the root of the climate crisis and facilitator of carbon lock-in, this discursive strategy frames industry as transition enablers.

The discursive strategy of the petrochemical majors resonates with the rhetoric big oil although differing in certain important aspects. The overlap in rhetoric is evident from the list of climate delay discourses which are present in the communication of both industries including "technological optimism," "whataboutism," "no sticks just carrots," and "all talk, little action"[97]. When used strategically, these discourses deflect responsibility and promote climate delay.

When it comes to the future of the petrochemical industry, the scale of production and current expansion plans go unquestioned. Similar to both oil and gas as well as the tobacco industry before it[103,128], the industry takes consumer demand as given – unquestionable and outside the scope of influence[97,113]. This strategy helps cast the industry as innocent of the damages it causes by disproportionally presenting the continuously increasing production of petrochemicals as driven exclusively by the needs of the world's population.

Despite the similarities, petrochemical producers navigate their communication from a different position than that of oil and gas extractors, which is visible in their transition narratives. Whereas oil and gas have made sure to criticise and create uncertainty about renewables as a viable alternative to fossil fuels[101], petrochemical producers present it as if no alternative exists. Premised on the ubiquity and supposed inevitability of synthetic materials and products, industry organisations refer to petrochemicals as the "building blocks" of both modern and future ways of living[97]. Whereas fossil extractors have worked for fossil gas to become a "bridge fuel"[129], petrochemicals are framed as having no real viable alternative at scale – you cannot substitute the bricks with which you build far side of the bridge. This perspective thereby downplays the highly contested and open-ended nature of the prospects for a just transition to a low-carbon chemical industry.

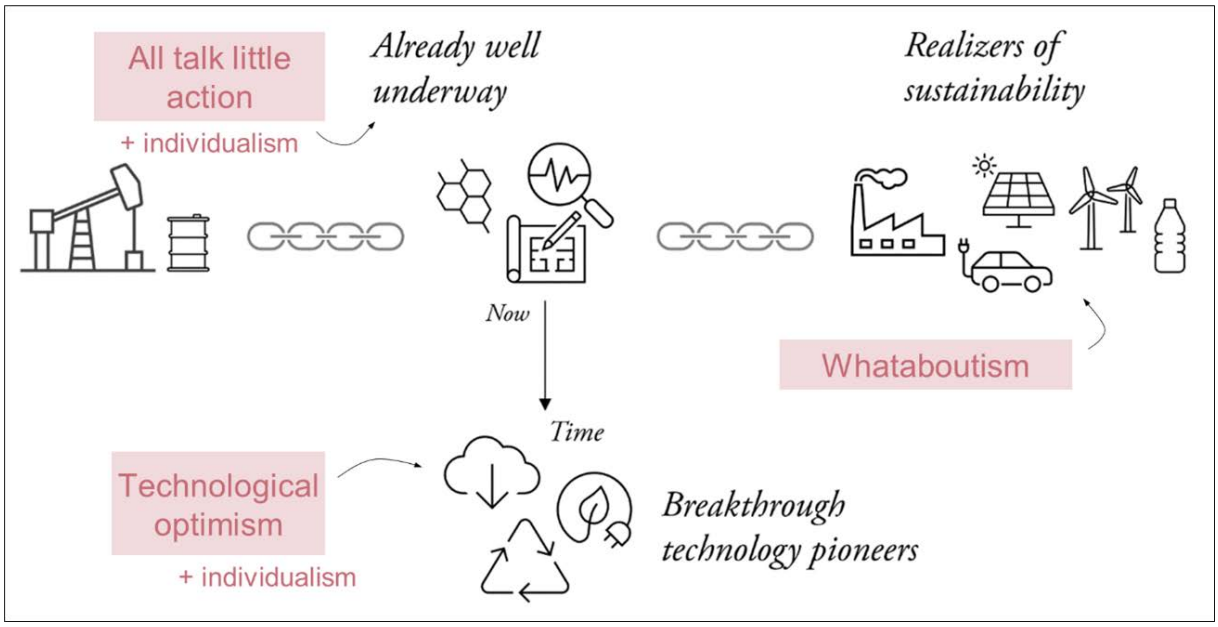


Figure 9. *Petrochemical transition narratives and the discourses of climate delay they resonate with. Source: Builds on Tilsted et al.*[97]

4.1.2 Institutional and lobbying efforts

Institutional power concerns the ways in which businesses and other actors seek to influence policymaking both formally and informally. This form of power is exercised through networks (see Chapter 2), official decision-making and lobbying. This section highlights the mobilisation of institutional power by actors in the petrochemical industry.

The petrochemical industry has for a long time and in various ways extensively engaged in lobbying activities to influence policy (see e.g. [26,96,122,130–132]). Producers of petrochemicals have helped spread doubt about the causes of anthropogenic climate change by taking part in funding the US climate denialism movement[133]. They have also generously supported the political campaigns of climate obstructive politicians and have – as part of the North American fossil energy regime (most obviously perhaps in the form of vertically integrated fossil fuel companies such as ExxonMobil) – been extremely successful in shaping public policy in the United States[26]. In terms of mobilising institutional power to influence other issue areas than climate, the industry also has a bleak history in relation to health and toxicity. The examples are so many that the general industry playbook concerning toxicity has been described as "deceit and denial"[113,134].

The employment of institutional power by petrochemical companies helps obstruct climate policy. In their 2022 ranking of the most influential companies blocking climate action globally, the independent think tank InfluenceMap ranked petrochemical-affiliated companies as number one (Chevron), two (ExxonMobil) and three (BASF), while other major chemical producers also made the list (including Dow and Phillips 66)[135]. The ranking is highly interesting because it shows how also a seemingly climate-positive chemicals company like BASF can in fact be very influential through institutional power, despite lofty rhetoric and low-carbon initiatives. BASF's ranking reflects their "intense" lobbying efforts in the EU and Germany related to expanding fossil infrastructure, opposing the Carbon Border Adjustment Mechanism and advocating for free emission allowances and indirect cost compensation[135].

The employment of industrial power can be coordinated and sector-wide for example through industry organisations. In relation to the global plastics treaty which is currently being negotiated, actors in the petrochemical sector are engaging collectively in shaping the contents of the treaty in an industry-friendly direction. Reuters reported that efforts led by the American Chemical Council and backed by large petrochemical producers including ExxonMobil, Shell and Dow focused on avoiding restrictions on plastic use and production[136], as has otherwise been called for by scholars researching plastics[137]. The coalition sought to invoke the realisers of sustainability narrative in framing plastics as environmentally friendly[136]. And recent Bloomberg investigation documents show how the American Chemical Council was pivotal in setting up a sector-wide response to criticisms related to plastic pollution[132].

The resources employed by industry actors are massive. In the data available through the official EU Transparency Register[138], the European Chemical Industry Council had the highest lobby costs in 2021 of all the 12,421 registered organisations, while the German Verband der Chemischen Industrie ranks 18th and PlasticsEurope 28th. Individual petrochemical producers like Bayer, Shell, and ExxonMobil are also all in the top 30. And based on data from the Senate Office of Public Records, the chemical industry spending on lobbying in 2021 in the US amounted to almost $60m[139].

4.1.3 The structural importance of petrochemicals

The mobilisation of discursive and institutional power by petrochemical industry actors, through, e.g., lobbying and public relations efforts, is underpinned by material or structural power[97]. This form of power stems from controlling production and finance, i.e. the petrochemical metabolism. Material power is structural in that it derives from the importance of certain actors in the economy and their contribution to core state aims related to economic growth (e.g. full employment)[98]. The petrochemical industry was key in facilitating growth in the 20th century[22] and chemicals remain structurally important in modern society[23,140]. Reliance on synthetic materials thus confers power to actors in the petrochemical industry and thereby conditions petroche-

mical transitions. The effectiveness of lobbying and the prospects for influencing policy is thus partly a function of this reliance and how it is perceived (which companies, therefore, have the incentive to overplay).

Material power has often been leveraged to weaken climate policy through threats of capital flight, carbon leakage, job losses etc.[98], and the petrochemical industry is no different in that regard[96]. Worries over international competitiveness, an often-cited and historically influential concern in the European context, have watered down climate policy[141] and continue to do so[135,142]. For example, energy-intensive industries including the petrochemical sector have invoked fears of carbon leakage to powerfully lobby to secure massive amounts of free allowances in the European Emission Trading Scheme,[143,144] despite substantial evidence suggesting that such fears are overstated[145].

The employment of discursive power also hinges upon the structural power of the petrochemical industry. As highlighted above, petrochemical producers position themselves as indispensable to a sustainable future (see Section 4.1.1.4). This framing is possible due to the reliance on products derived from petrochemicals across production processes and the ubiquity of plastics. What makes petrochemicals, in the words of industry, "building blocks" is also what makes the petrochemical sector structurally important – it's many forward-linkages to a variety of sectors. Because of this role in the economy, companies can strategically (over)emphasise the dependence on the petrochemical sector for renewable energy transitions and highlight the "greenest" applications of petrochemicals. The reliance on petrochemicals thus enables whataboutism and the realizers of sustainability narrative, i.e., stressing certain petrochemical-related applications in the face of broader criticisms although few if any question the need for petrochemicals for upscaling renewables. Taken together, industry actors thus organise lobby-related activities around invoking the sector's structural importance and mobilizing certain narratives that can lead to climate delay.

4.2 Context matters - Prerequisites for transition of the petrochemical industry

Radically reducing greenhouse emissions from the petrochemical industry within a timeframe of less than three decades will require parallel efforts to avoid investments in new fossil-based capacity and to retire existing fossil production capacity while scaling up alternative processes. Ten countries are home to more than 70 percent of the operational petrochemical capacity today: China, US, India, South Korea, Saudi Arabia, Japan, Russia, Iran, Germany, and Taiwan (cf. Figure 1 above). These countries are, hence, central for the outlook of such a transition of the petrochemical sector at a global level. The importance of context, in terms of the structure in which something is embedded and that affects its development, has been underlined both for technological trajectories[146,147] and industry transition[96]. To understand the potential for transitions one must pay attention to economic, environmental, and social aspects simultaneously, as well as to the multiscale dynamics of how the development of these aspects unfold on various levels.

In the following, the prerequisites for transition in the petrochemical industry is presented by a combination of global and regional trends in the petrochemical sector. This involves the following three parallel perspectives: a) The availability of natural resources (involving both fossil resources that could motivate continued operation and renewable resources that could motivate and enable a transition are relevant), b) The petrochemicals' role in the economy and c) The socio-political landscape (focusing on climate policy, civil liberties and labour rights).

Regarding the availability of natural resources the countries rich in fossil resources (US, Saudi Arabia, Russia, and Iran in particular, but also China) can be expected to be less inclined to shift away from fossil fuels than countries with scarce fossil resources (in particular Germany, Japan, South Korea, and Japan, but to some extent also India). Lock-in of industry structure and reproduction of institutional patterns risk being the outcome of a desire to prolong the

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use of resources, diversify the economy and stabilise political regimes. On the other hand, several of these countries have access to significant renewable resources which might offer a way out of this fossil lock-in[7,19]. This is especially the case for China, the US, Saudi Arabia, Russia, India, and Iran, although one must also take into consideration the competition for renewable resources from other sectors and the difference between renewable potential and actual realised renewable production.

The level of economic development is an indicator of the resources available for incentivising a transition in the respective countries. This suggests the potential for change is higher in high-income countries like the US, Germany, Japan and South Korea than in low-income counties like India, Iran and Russia where economic resources to support a transition away from fossil fuels in the petrochemical industry can be expected to be more constrained[148]. It is reasonable to believe that this is true also for the respective group of countries' ability to provide financial support to workers and communities that may be impacted of a transition. The value of chemical sales in relation to total GDP is here used to give an indication of the relative importance of the petrochemical industry in the economy as a whole in the selection of countries. The petrochemical industry plays an important role in all the studied countries, but the relative importance of the industry varies significantly across countries. In China the value of chemical sales corresponds to more than 12 percent of GDP. In the US the corresponding figure is just over 2 percent. An interpretation is that the structural implications of a shift away from current production process, and therefore hesitancy to change, can be expected to be larger in countries like China, South Korea and Taiwan than in the countries where the petrochemical industries share of the total economy is less pronounced.

Regarding the socio-political landscape only two of the countries, India and Germany, have climate policies in place that are somewhat near being aligned with targets set out in the Paris agreement. Another indicator of the socio-political landscape is to what extent civil liberties and labour rights are respected and the level of social protection in each of the studied countries. Except for high-income countries like the US, Japan and Germany the potential for civil society actors to advocate for change and the societal preparedness to handle socio-economic stresses involved in structural change looks bleak.

It is clear that the material, economic and social contexts vary significantly between countries that currently dominate the global petrochemical industry. More detailed knowledge about these differences can contribute to a better understanding of the possibility and direction of change in the petrochemical industry both globally and on a country level[149]. The challenges involved in devising adequate policy responses, building legitimacy for change and potentially building a bottom-up pressure for a timely climate transition will for example look very different in oil and gas dependant economies like Saudi Arabia, Russia and Iran, in countries like China and India where there is a large potential/risk for growth in demand for petrochemical products compared to countries like Germany and Japan which have limited access to oil and gas, reasonably ambitious climate policies and reasonably well developed social safety nets.

4.3 Transition tensions

In the face of current trends, curbing and radically reducing the climate impact of the petrochemical sector will be a monumental challenge. Mah et al.[150] describes how escaping the existing petrochemical lock-in poses a multiscalar problem related to: the continued reliance on (both essential and seemingly superfluous) chemically derived products, not the least in the Global South; rising demand for plastics in green technologies; the limited availability of low carbon energy and alternative feedstock; local dependencies where cities and communities around the world have developed around economies that are dependent petrochemical production.

Handling this multiscalar challenge will require multiscalar responses including efforts on global and national levels to halt new and scale back existing fossil production capacity, scale up alternative production, limit overall demand and improve circularity. However, to build legitimacy, prevent the overriding of local democracy and handle the conflicts of interests that are an inevitable part of large-scale societal change, top-down driven

climate transition needs to be complemented with processes that capture and provide agency for communities and groups on the frontlines of the transition[151,152].

The conditions for creating legitimacy for change and building bottom-up pressures differ between and within the countries that are central to the global petrochemical plastics production chain[149] . Actors with different positions and interests tend to present disparate and sometimes antagonistic interpretations of what it means for a transition to be 'just'. Still, in its core interpretation, the concept of a 'just transition' centres on the justice and equity concerns of workers, front-line communities, and other marginalized groups affected by transition processes[153] . As for these groups, recent research points to a global trend of 'noxious deindustrialisation' in the petrochemical industry[154], where fenceline communities no longer significantly benefit from the industry in terms of jobs and public services while continuing to be on the receiving end of negative health and environmental impacts. The extent to which a transition addresses noxious deindustrialisation and supports fenceline communities is thus arguably a critical aspect of a just petrochemical transition.

4.3.1 Protesting petrochemicals: Struggles for environmental justice

The petrochemical industry has throughout its history been – and continues to be – linked to environmental injustices related to toxicity and pollution (see e.g. [123,154–160]). A just transition to a low-carbon industry therefore requires a broader perspective that takes a range of issues including plastics pollution, biodiversity, health and toxicity all closely link to the industry into account.

The noxious consequences of petrochemical production are associated with local opposition. Figure 6 shows an overview of social conflicts across the globe related to chemicals mapped in the Global Atlas of Environmental Justice[161]. The database does not claim to cover all relevant conflicts but helps illustrate the range of struggles around petrochemicals and production capacity expansion both geographically and temporally. So while the petrochemical industry has been under the radar when it comes to climate impact and greenhouse gas emissions, the sector has constantly been fighting scrutiny as well as a significant number of protests on a range of other issues. For example, the environmental movement in Taiwan – historically an important petrochemical hotspot – has been based on opposition to expansion of petrochemical production (see BOX 2: Examples of protests against petrochemical production across the globe). The social conflicts that take place around specific sites are somewhat fragmented and isolated incidences, but climate-oriented actors will do well to in linking to movements related to local pollution and toxicity.

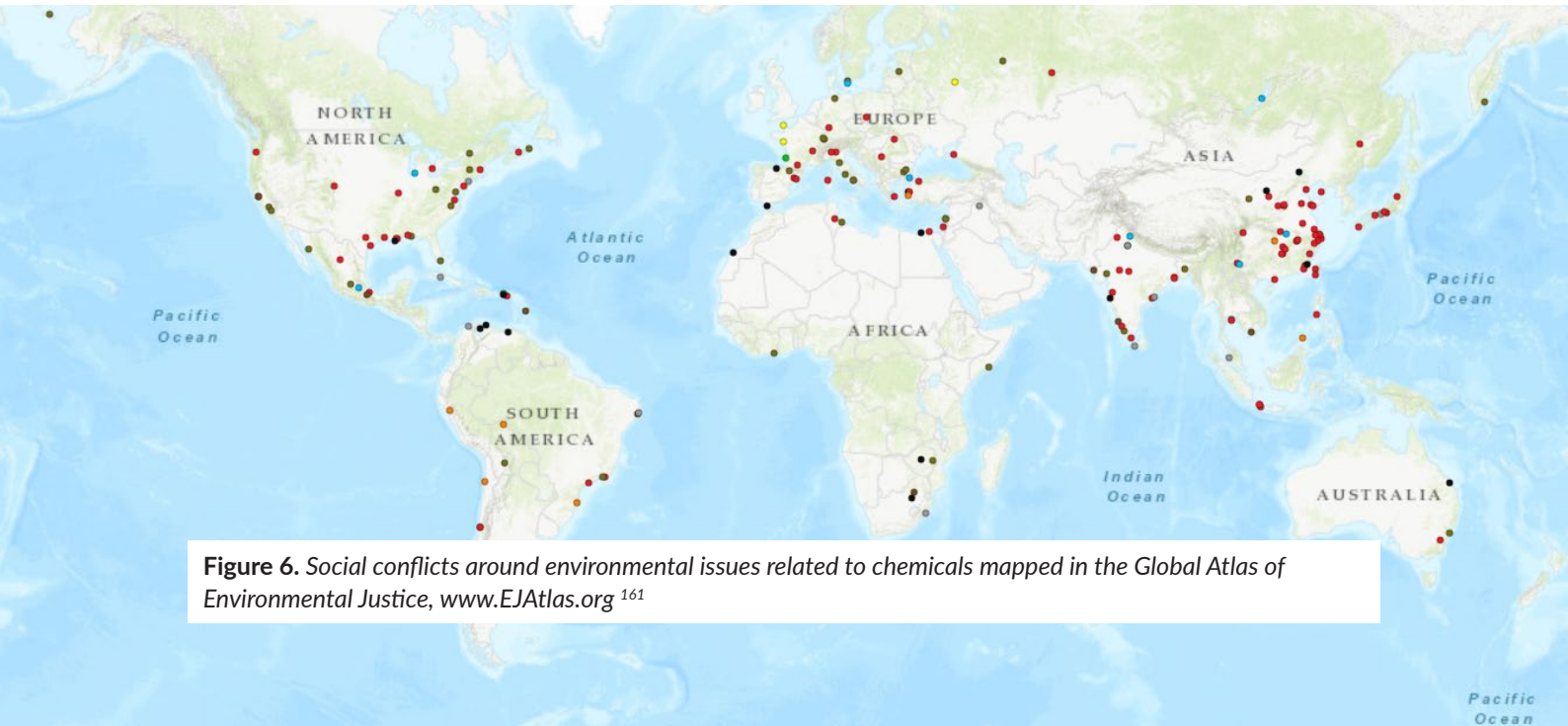


Figure 6. *Social conflicts around environmental issues related to chemicals mapped in the Global Atlas of Environmental Justice, www.EJAtlas.org* [161]

Box 2: Examples of protests against petrochemical production across the globe

Ending petrochemical expansions in Taiwan

Petrochemicals have played a key role in economic growth and economic self-reliance in Taiwan, propping officials to refer to it as the Petrochemical Kingdom[162]. It also has a decades-long history of protests related to petrochemical production sites – the so-called anti-naphtha cracker movements[155,162]. To combat the movement and neutralise local opposition, the petrochemical sector in Taiwan has targeted poor greenfield sites[162] as well as using financial compensation as a strategy against protests with local community leaders playing a critical role[163].

In 2011, the Kuokuang Petrochemical Technology Company's (CPC) plans to build a plant in Tacheng, Changhua County, came to an end due to massive protests, despite it being a USD 20 billion investment which the Ministry of Economic Affairs promised would bring hundreds of thousands of new jobs, additional investments and large annual revenues[164]. Several environmental issues mobilised the protest including high water consumption, high CO_2 emissions, and the loss of habitat for the Chinese white-tip dolphin. Protests included local farmers and residents and environmental NGOs. Unlike several other protests, this movement was successful without the leadership of a political party[162]. Beyond terminating the plans for the Tacheng site, the protest also signalled the end of new large-scale naphtha cracker facilities in Taiwan, as industry actors deem it impossible to expand further due to "strong environmental protection influences"[164]. The opposition has, however, not necessarily decreased production on a global scale, as investments have been reoriented elsewhere[164].

Anti-PX protests in China

As highlighted above China has seen the most rapid expansion of the petrochemical industry in recent decades. It has also seen a wave of so-called anti-PX protests in several cities across China dating back to at least 2007[165.] The protests have primarily focused on local environmental pollutants from paraxylene (PX) production facilities and negative effects for neighbouring communities, which tend to be impoverished and minority communities[156]. In April 2015 large groups took to the streets in protest against the expansion of a PX plant in Maoming, in the province of Guangdong. The PX plant is run by the local government and state-owned Sinopec Corp[166], one of China's biggest petrochemical producers and refiners. The local government organised a series of pre-emptive PR campaigns stating the benefits of expansion and downplaying environmental problems[167]. This did not have the decided effect. Instead the protest resulted in the first violent (and bloody) confrontation with anti-PX protesters, which led to several injured protesters, police chasing demonstrators with batons, and burning cars[168]. In the case of Maoming, protests were more disorganised, and locals felt more powerless than in other anti-PX protests, such as Xiamen, which host a more affluent middle class. The outcome of the protest was that the local government promised that the PX project would not get started until "a consensus among citizens is reached"[167,168].

'Deadly air' protests in South Africa

In early 2021, campaigners sued the South African government in a bid to ensure tougher action being administered in response to Sasol's heavy levels of pollution around their facilities and the associated power generation[169]. The South African state remains a major shareholder in the company that specialises in coal-liquefication, petroleum refining and distribution. Sasol has previously come under scrutiny for monopolising the polymer and ammonia production and distribution in the country. The effects of Sasol's prior and continued state support have removed alternative options for customers and competitors alike and skewed power in Sasol's favour even when met with critique and resistance[91]. The recent campaign is reminiscent of and influenced by earlier protests against dangerous levels of air pollution linked to heavy industrial development in the South Durban basin. A major concern in the Basin area is the effects of air pollution on human health that are caused by the emissions of hazardous amounts of toxins, chemical waste and a large content of sulphur dioxide, characteristic of Sasol's processes and activities[170]. The close proximity of densely populated communities to the industrial area has been linked to a racist apartheid era of industrial planning which forced black workers and communities to reside in close proximity to mines[171]. Activist groups, including Groundwork, say there are "dangerous levels of air pollution" in the area, where coal is mined and burned to generate electricity. In response to the lawsuit, the environment ministry stated that although the air quality in the area is substandard, the industrial plans for the area are still prior to completion and aspirations for a healthy environment is a long-term goal that must be balanced with economic needs.

4.3.2 A just petrochemical transition?

Shifting away from petrochemical plastics involves, like for transitions in other sectors, concerns related to equity and justice. The concern is therefore not only how to undo the current carbon lock-in, but also to formulate transition strategies and policies that adhere to the principles of a just transition, responding to the concerns and needs of the affected. Otherwise, measures to escape the current carbon lock-in might reproduce the patterns of exploitation and dispossession that characterise the current global political economy[172]. Any attempt to restructure the global fossil fuel economy (and with it petrochemicals and plastics), however, faces immense political resistance and institutional challenges on the global, national as well as regional and local level[23]. And working with incumbents, which arguably hold the power needed to break the fossil lock to accelerate the process of reaching near zero industrial sectors, risks exacerbating injustices[97,173]. Zooming in on the justice claim of workers effectively illustrate some of the challenges at hand. Indeed, a restructuring of the petrochemical industry will impact the everyday life of millions of people globally.

One of the more recent estimates of the number of employees in the global petrochemical industry comes from Oxford Economics, which in a report for the International Council of Chemical Associations found that 15 million people were employed in the global chemical industry in 2017[174.] This figure covers a range of sub-sectors, including basic chemicals, fertilisers, plastics and synthetic rubber in their primary forms, synthetic fibers, paints, pesticides and more. Although the share of workers employed in the petrochemical industry represent a relatively small share of the total workforce in, for instance, China (8.7 million) and the rest of the Asia Pacific region (2.5 million), North America (0.6 million), or Europe (1.6 million), a transition for the industry must meet legitimate concerns and needs among workers. As petrochemical industries in many cases are clustered in major production units which are geographically concentrated the role of the petrochemical industry tend to be even more pronounced in local and regional economies as a source of employment, tax revenues and not seldom a source of both conflict and pride. To illustrate how such regional dependencies can be manifested we here use the states of Texas and Louisiana (US) and the German Bundesland Nordrhein-Westfalen (NRW) as examples in the below (Box 3: Petrochemicals and the job versus environment dilemma).

The examples are not to suggest that the job versus environment dilemma[175] is unsurmountable but intended to illustrate why policies and strategies to handle legitimate concerns and needs among workers and frontline communities must be at the centre of plans to transform the petrochemical industry. This includes giving agency and voice to workers, worker unions and citizens organizations who have a unique understanding of how the required shift in production will affect the livelihood in the affected communities or regions[176]. To have a realistic chance to achieve a timely climate transition of the global petrochemical industry mechanisms have to be in place to handle the socio-economic stresses involved in structural change also in countries with less resources available including through international climate financing and technological transfers.

Box 3: Petrochemicals and the job versus environment dilemma[149]

Texas and Louisiana

Texas and Louisiana account for more than 70 per cent of all primary petrochemical production in the US and the petrochemical industry is an important source of employment and tax revenues in both states. In Texas, the petrochemical industry employs close to 70 000 workers (0.4 per cent of the total workforce) and in Louisiana, approximately 25 000 (1.2 per cent of the total workforce). In Texas, in 2021, the value of chemical sales corresponded to close to 5 per cent of the state's GDP, in Louisiana the same figure was 17 per cent. Thus while the industry often exploits the benefits of job creation and tax revenue as an excuse to overlook or justify various (unethical) actions it is worth bearing in mind that the transition of the petrochemical industry will have real considerable ramifications for the local communities. In the US context, however, the contestations still tend to revolve around further expansion of fossil-based petrochemical production rather than some sort of green transition. Texas and Louisiana have both recently been a battleground between petrochemical multinationals, who want to expand production, and local residents, who worry about the health and environmental impacts of new massive petrochemical plants[177–179]. While the contours of a shift away from current practices remain to be seen local and state governments can play an important role when it comes to policy support, industry engagement, and the coordination of stakeholders (including labour groups and civil society)[180,181].

Nordrhein-Westfalen (NRW)

NRW is the most important hub of the petrochemical industry in Germany. The petrochemical industry employs just over 100 000 workers in NRW (1 per cent of the total workforce) and chemical sales account for 6 per cent of the regional GDP. Thus, scaling down or transitioning the petrochemical industry in NRW to more sustainable practices would have significant employment impacts and impacts on the local economy. The petrochemical industry in NRW is also closely linked to other industries and a low-carbon industry transition would also impact these secondary labour markets. NRW which is located in the Northern part of the Ruhr area, the former so-called 'coal pot' of Europe is also home to several other emission-intensive industries and has already experienced significant structural change[182,183]. Recognising the peculiar position, the regional government has made early attempts to address the key challenges involved in a low-carbon industry transition[184]. The region of North Rhine-Westphalia has also received funding (€680 million) from the EU Just Transition fund to help alleviate the socioeconomic impact of the climate transition[185]. These funds will, however, be dedicated to handling the phase-out of the remainder of the coal industry.

5 The global governance of petrochemicals

In this chapter, we review a range of international organisations, regimes and processes relevant to petrochemical governance in the context of the climate crisis. In the global governance arena, a general anchor for international cooperation on the transformation of the petrochemicals sector is the UN Sustainable Development Goals (the SDGs), which commit countries to pursue sustainable consumption and production patterns. However, to date, the SDGs have not spurred a focus on the petrochemicals sector specifically.

This chapter explores where petrochemicals are being addressed in evolving global governance regimes addressing climate, chemicals and plastics. It also explores the relevance of arrangements for global economic governance, highlighting how international trade, development, investment and finance regimes influence the expansion of the petrochemicals sector as well as efforts to harness the same regimes to tackle plastic pollution. While we do not aim to cover all possible governance regimes and processes that are potentially relevant, we provide a snapshot of key areas of governance as well as gaps. The overarching purpose of the chapter is to identify where strategic opportunities might exist within different parts of the evolving governance system to improve governance and policy action on the climate, the climate and sustainability impact of the petrochemicals sector.

5.1 Petrochemicals in Global Climate Governance

In the context of efforts to fight the climate crisis and fulfil the goals of the Paris Agreement, the petrochemicals sector is highly relevant to ongoing efforts to reduce the carbon footprint of energy and carbon-intensive industries.

At the international level, climate diplomacy has yet to focus specifically on the petrochemicals sector(as compared, for instance, to steel, cement, aluminium and agriculture). At the domestic level, however, as countries seek to implement their Nationally Determined Contributions under the Paris Agreement, greater scrutiny of the carbon footprint of the chemicals sector, including petrochemical plastics and fertilisers, is emerging, with some countries explicitly working toward Net Zero commitments focused on the decarbonisation of the chemicals sector.

Further, in 2022, for the first time at a UN Climate Summit, COP 27 featured a high-level panel as part of the official UN side event agenda linking the climate and plastics crises, entitled "how combatting plastic pollution and illegal traffic in plastic waste can help reduce emissions" where a number of panellists underlined the links between the expanding production of primary petrochemical plastics and the climate crisis. Beyond this effort to put plastics – and the petrochemical sector – more centrally on the climate agenda in the context of the UN Framework Convention on Climate Change (UNFCCC), a range of climate-related governance initiatives are relevant to petrochemicals. Most central to these are initiatives relevant to the commitment made in COP27's Glasgow Pact, calling on all Parties "to accelerate the development, deployment and dissemination of technologies, and the adoption of policies, to transition towards low-emission energy systems, including by rapidly scaling up the deployment of clean power generation and energy efficiency measures, including accelerating efforts towards the phasedown of unabated coal power and phase-out of inefficient fossil fuel subsidies, while providing targeted support to the poorest and most vulnerable in line with national circumstances and recognising the need for support towards a just transition"[186]. This call for phasing-out inefficient fossil fuel subsidies is directly relevant for the petrochemical industry because its expansion has relied upon cheap, subsidised fossil fuel feedstocks. Following is a synposis of several

other climate governance initiatives relevant to the petrochemicals sector.

Statement on International Public Support of the Clean Energy Transition

At COP26, 39 countries and organisations committed to a statement on *International Public Support for the Clean Energy Transition* to align international public support towards the clean energy transition and phase down or out support for unabated fossil fuels. The signatories committed to prioritising support towards the clean energy transition and strived not to do significant harm to the goals of the Paris Agreement, local communities and local environments. Furthermore, the signatories committed to ending new direct public support for the international unabated fossil fuel energy sector within one year of signing the statement (by 2022). The signatories also agreed to further encourage governments and their official export credit agencies and public finance institutions to implement similar commitments into COP27 to align with the Paris Agreement goals[187]. This commitment represented the first international political commitment addressing international public finance for oil and gas, as previous international commitments were solely committed to limit public finance to coal[188].

The Beyond Oil and Gas Alliance (BOGA)

The Beyond Oil and Gas Alliance (BOGA) is an international alliance of governments and stakeholders collaborating to facilitate gas production phase-out. The alliance seeks to elevate the issue of oil and gas production phase-out in international climate dialogue, mobilise commitments and create an international community of practice on this issue[191]. In practical terms, BOGA's core members are committing to end new concessions, licensing or leasing rounds and to set a Paris-aligned date for ending oil and gas production. BOGAs core members are the co-chairs Denmark and Costa Rica as well as France, Sweden, Portugal, Wales, Ireland and also the governments of Quebec, Washington State and Greenland. BOGA's associate members, such as New Zealand, are required to, at least, have taken some concrete step to limit oil and gas production, such as reforming domestic fossil fuel subsidies or ending international and national public finance supporting oil and gas exploration, production as well as investigation and development activities. In

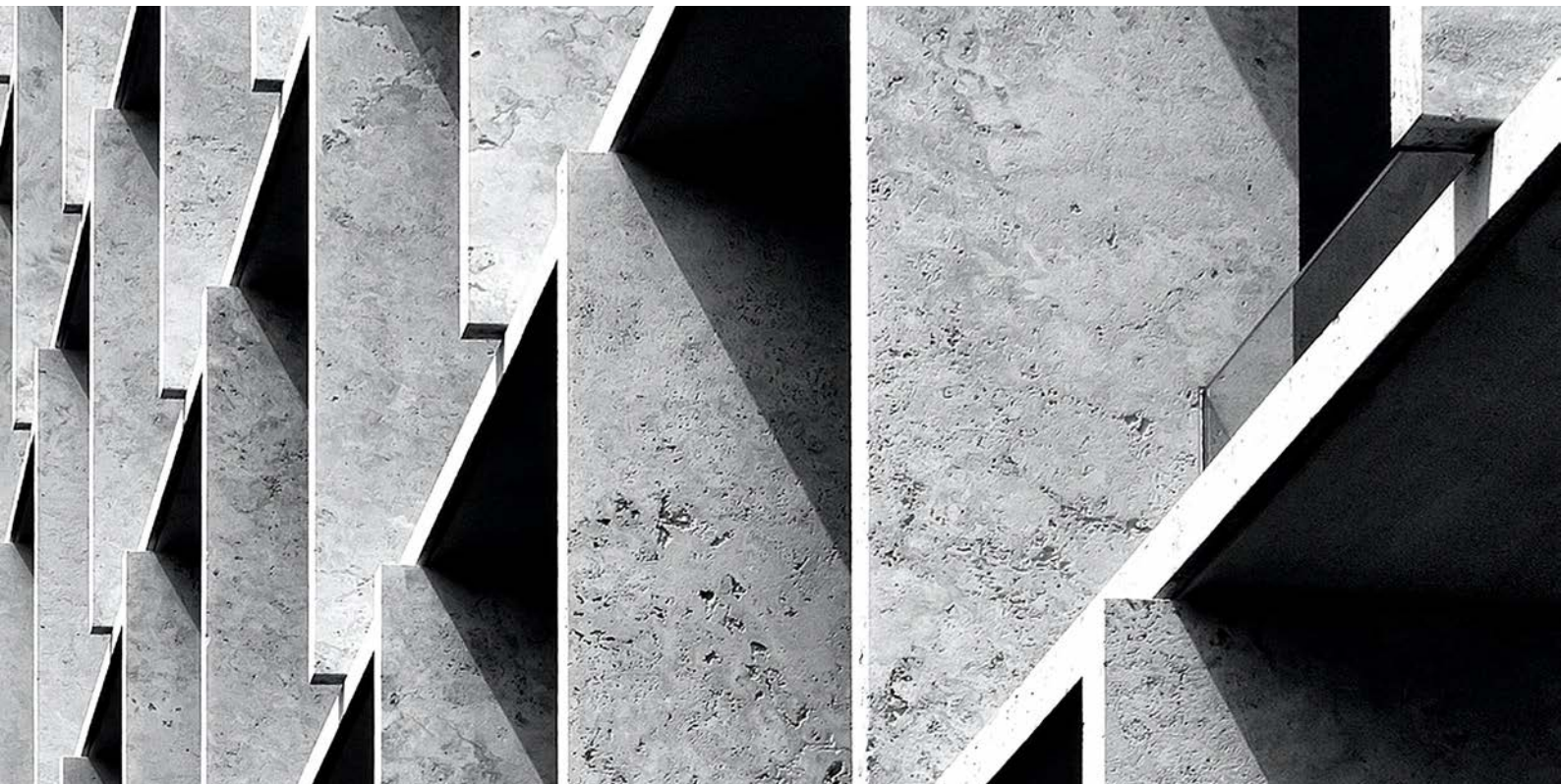
addition, national and sub-national governments, as well as other actors, (indigenous peoples, international organisations, financial institutions, companies and civil society organisations, among others), have the possibility of becoming Friends of Boga by signing BOGA's declaration and committing to work to facilitate the development of efficient measures in line with the Paris Agreement and national climate neutrality targets[191].

Fossil fuel non-proliferation treaty

The Fossil Fuel Non-proliferation Treaty initiative seeks to directly address the essential contribution of oil, gas and coal to the climate crisis. The initiative aims to work towards an international regime addressing the challenges brought by fossil fuel extraction, production and use to meet the 1.5°C Paris Agreement by addressing the supply side of fossil fuels.. Accordingly, the initiative centres on three pillars: non-proliferation of fossil fuels, a global phase-out of existing production, and support for a just transition[189]. The initiative has received the support of the Governments of Vanuatu, Tuvalu, the European Parliament and the World Health Organization World Health Organization, as well as. a large range of subnational entities worldwide, such as the cities of Los Angeles, London, Lima and Sydney, scientists and international organisations[190]. The Fossil Fuel Non-Proliferation Treaty seeks to develop an international regime to complement the Paris Agreement by addressing the supply side of fossil fuels. The initiative will emulate the efforts and strategies from previous successful global campaigns for international agreements such as the Treaty on the Prohibition of Nuclear Weapons, the Anti-personnel Landmine Convention and the Montreal Protocol. Importantly, the initiative's organisers do not necessarily aim to develop a universal treaty but also a treaty formed by a smaller set of "champion" countries. The iinitiative's strategy focuses on building public support for the treaty, increasing the government's accountability concerning fossil fuels and fomenting eagerness for a set of countries to launch negotiations on the treaty. In addition, the initiative is also exploring the appropriate legal pathway to form the treaty drawing inspiration from previous efforts in the fields of humanitarian and environmental international law[189].

Industrial Deep Decarbonisation: An Initiative of the Clean Energy Ministerial

The Industrial Deep Decarbonisation Initiative (IDDI) is an initiative of the Clean Energy Ministerial. It gathers a coalition of public and private organisations aiming at increasing demand for low- carbon industrial materials. The IDDI is coordinated by UNIDO, co-led by the United Kingdom and India, and brings together other related initiatives and organisations such as the Mission Possible Platform, the Leadership Group for the Industry Transition,



the International Renewable Energy Agency (IRENA) and the World Bank. The IDDI aims at limiting carbon emissions originating from carbon intensive construction materials such as steel, cement and concrete and to facilitate this process by addressing missing policy gaps and stimulating market demand for decarbonised industrial materials[192]. A key area of IDDI's work is establishing consistent minimum standards for low-carbon steel, cement and concrete products to encourage best production and manufacturing practices, along with a standard environmental reporting mechanism for construction materials. A further area is to support and empower governments and public contracts to source and purchase decarbonised building materials[193]. While this initiative focuses primarily on construction-related industrial materials, it highlights the potential for focused and collaborative sectoral initiatives, such as potentially in the petrochemicals sector.

5.2 Petrochemicals and Global Plastics Governance

A broad number of international and regional efforts exist to tackle plastic pollution, including by transforming the petrochemical plastics sector. In terms of international environmental governance, efforts to address plastic pollution date back several decades, starting with efforts to reduce plastic marine debris. More recently, attention has focused on addressing gaps in global governance frameworks for plastic pollution, resulting in the launch of negotiations through the United Nations for a new legally binding international instrument to end plastic pollution[194–199].

5.2.1 Plastics Treaty Negotiations

In May 2022, governments agreed to launch negotiations for a new global plastics treaty. Notably, in the resolution that launched the negotiations, governments explicitly agreed on the importance of addressing the full life cycle of plastics, including upstream dimensions. The focus of the resolution on negotiating a treaty that will include attention to sustainable production and consumption of plastics and the full life cycle is being seized by some governments as an opportunity to tackle the expanding production and supply of primary plastics. Recent submissions by governments outlining their views on options for elements of the treaty have, for instance, included reference to eliminating certain problematic and harmful polymers and additives, including through bans and restrictions, and also to controlling the overall volume of primary plastics production.

Taking leadership on this topic is the High Ambition Coalition (HAC) to End Plastic Pollution, which brings together a diverse group of over 50 countries and is co-chaired by Rwanda and Norway. The coalition is guided by three global strategic goals: restraining plastic consumption and production to sustainable levels, enabling a circular economy for plastics that protects the environment and human health; and achieving environmentally sound management and recycling of plastic waste[200]. Related priorities noted by governments in their submissions for the treaty negotiation process include the development of criteria and standards for plastics, focusing through-out the life cycle of plastics, including requirements for ensuring transparency of the material and chemical composition of plastics, improved monitoring and reporting at each stage of the life cycle, as well as scientific assessments of impacts.

5.2.2 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal

In May 2019, 187 countries adopted a number of amendments to the Basel Convention (the so-called 'plastic waste amendments') to better regulate the transboundary movements of hazardous and other plastic wastes. They agreed to amend the Basel Convention to help regulate and improve the transparency of plastic waste exports, focusing specifically on contaminated, mixed, and non-recyclable plastic waste. Following their entry into force in 2021, the amendments require exporters to obtain the prior consent of receiving countries before shipping most contaminated, mixed, or non-recyclable plastic waste and ensure that these are destined for environmentally sound recycling or disposal[201]. While these new amendments don't directly address

the upstream part of the plastics value chains, they do strengthen the governance of the plastics sector by bolstering the ability of countries to refuse unwanted or unmanageable plastic waste and generating incentives 'upstream' for the production of plastics that are not hazardous and are recyclable. If this results in stronger markets for recyclates, this principle could reduce demand for primary plastics as inputs into plastic products[201-202].

5.3 Petrochemicals in Global Chemicals Governance

The global governance of chemicals is fragmented among multiple international efforts at the UN. This is especially the case regarding efforts to improve regulation of the chemicals and chemical production processes relevant to the plastics sector, including efforts to phase out the use of certain polymers, additives and colourants deemed toxic to human health and the environment, including persistent organic pollutants[203]. In addition to the work of the Basel Convention noted above, the work of two sister Conventions – the Stockholm Convention and Rotterdam Convention are relevant, as are international efforts such as the Strategic Approach to International Chemicals Management (SAICM), created in 2006 at the first International Conference on Chemicals Management (ICCM) and the creation of a new Science Policy Panel by the UN Environment Assembly. Notably, none of the processes listed has, at least to date, focused significant attention on the climate impacts of chemicals as a rationale for closer regulation.

Stockholm Convention on Persistent Organic Pollutants

The Stockholm Convention aims to eliminate or restrict the production and use of Persistent Organic Pollutants (POPs). As of 2018, the Convention controls 28 POPs, including those which have been used as additives, flame retardants or plasticisers in plastics such as brominated diphenyl ethers, Hexabromocyclododecane, Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride and short-chain chlorinated paraffins[204]. Under the Stockholm Convention, for instance, parties must eliminate use of polychlorinated biphenyls (PCBs) in existing equipment by 2025 and ensure environmentally sound waste management of PCBs by 2028[205]. There are ongoing proposals and negotiations to update the range of chemicals that should be eliminated or restricted under the Stockholm Convention, including a number that are relevant to the plastics industry, such as perfluorohexane sulfonic acid (PFHxS) and its salts (used as a water and stain repellent in textiles), UV-328 (used in transparent plastics) and Dechlorane plus used as a flame retardant.

Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade

The Rotterdam Convention aims to promote shared responsibility and cooperative efforts among parties in the international trade of certain hazardous chemicals (covering pesticides and industrial chemicals) in order to protect human health and the environment from potential harm. It also aims to contribute to the environmentally sound use of those hazardous chemicals by facilitating information exchange about their characteristics, providing for a national decision-making process on their import and export, and disseminating these decisions to Parties. The Convention creates legally binding obligations for the implementation of a Prior Informed Consent (PIC) procedure. Various measures aimed at promoting the exchange of information among parties also include labelling requirements for exports of chemicals included in the PIC procedure and for other chemicals that are banned or severely restricted in the exporting country[206].

Strategic Approach to International Chemicals Management (SAICM)

SAICM is an international policy framework designed to foster the sound management of chemicals throughout their life cycle so that chemicals, including those used for petrochemicals, are produced and used in ways that minimise significant adverse impacts on the environment and human health. Developed by a multi-stakeholder and multi-sectoral Preparatory Committee, SAICM was created to support the achievement of the goal agreed upon the 2002 Johannesburg World Summit on Sustainable Development of ensuring that, by

2020, chemicals would be produced and used in ways that minimise significant adverse impacts on the environment and human health[207]. While the 2020 deadline has now passed, SAICM and its stakeholders are in the process of developing a post-2020 framework and strategy[208–210]. The Intersessional Process for Considering the Strategic Approach to International Chemicals Management and the Sound Management of Chemicals and Waste Beyond 2020 is advancing the work on the outline of a future framework on chemicals and waste for the post-2020 years. The latest conference resulted in the consolidated document to serve as the basis of future discussions[211]. The document covers the visions, scope, strategic objectives, targets, institutional arrangements, implementing measures, financial considerations, and procedures for designating "issues of concern" for special attention and concerned action[210].

Science-Policy Panel

A new Science-Policy Panel on chemicals, waste, and pollution was adopted at the UN Environmental Assembly in 2022 with the goal of ensuring that policymaking regarding chemicals, waste and pollution is backed by science. Proposals regarding the establishment of the panel will be discussed by an Open-ended Working group that is expected to finalise its work by the end of 2024[212]. According to the UNEA resolution, the functions of the panel should include, among others, the identification of issues of relevance to policymakers and, where possible, proposing evidence-based options to address them; conducting assessments of current and identifying potential evidence-based options; providing the up-to-date and relevant information, identify key gaps in scientific research and encourage and support communication between scientists and policymakers and facilitate information-sharing with countries seeking relevant scientific information[213].

5.4 Petrochemicals in Global Economic Governance

5.4.1 Trade governance

In terms of global trade governance, there are a number of developments that are relevant to petrochemicals and climate governance.

At the WTO, a group of 76 WTO members is engaged in an ongoing Dialogue on Plastics Pollution, which aims to identify how improved trade cooperation within the WTO framework could support domestic, regional, and global efforts to tackle plastic pollution. The Dialogue's work is organised around three workstreams, focused on cross-cutting issues for international cooperation,s, the promotion of trade to tackle plastic pollution and reduction and circularity. The workstream on

promoting trade focuses on exploring the potential to promote trade in environmentally sustainable waste management technologies; environmentally sustainable and effective substitutes and alternatives; reused and recycled plastics, including by incentivising increased reuse and recycling of plastics (considering evidence of their long-term impacts); and technologies for environmentally sustainable and effective substitutes and alternatives of interest to developing members and least developed members. The workstream on circularity and reduction explores how trade-related cooperation could help to support efforts to reduce unnecessary or harmful plastics and plastic products, including single-use plastics and plastic packaging associated with international trade and sharing experiences of effective approaches to move towards more circular, resource-efficient, and environmentally sustainable plastics trade[214]. Members of the Dialogue on Plastic Pollution are currently considering concrete outcomes for the next WTO Ministerial Conference (scheduled for February 2024), where one pathway under consideration is for Members to make voluntary pledges, including, for instance, to reduce trade in certain harmful primary plastic polymers or unnecessary or harmful plastics, to reduce or place a moratorium on subsidies to petrochemicals and related fossil fuel inputs.

A further relevant development in the trade governance arena is the Fossil Fuel Subsidies Reform initiative at the World Trade Organization. The 47 WTO Members that are cosponsors of the initiative have agreed to a Ministerial Statement in which they commit to rationalising and phasing out inefficient fossil fuel subsidies that encourage wasteful consumption along a clear timeline while encouraging other WTO members to join the initiative. The work of the initiative currently focuses on working sessions designed to allow participant members to share information and experiences to advance discussions to develop ambitious disciplines on inefficient fossil fuel subsidies[215]. In the new high-level work plan following the Twelfth WTO Ministerial Conference, the FFSR initiative sessions have been dedicated to a stocktake of'current activities developed by WTO members and international bodies; current evidence concerning fossil fuel subsidies and environmental harms as well as existing knowledge gaps; and on members' experiences regarding development and social issues interlinkages with fossil fuel subsidies reform. Related international mechanisms for fossil fuel subsidy reform include the APEC voluntary stand-still mechanism implementation[216] and the Agreement on Climate Change, Trade and Sustainability (ACCTS) currently being negotiated by New Zealand, Norway, Fiji, Switzerland, Costa Rica and Iceland p Costa Rica and Iceland, where there are plans to include first-of-their-kind rules on fossil fuel subsidies. Broader policy options include unilateral subsidy reform or soft law options (e.g. voluntary reductions or moratoriums for subsidies for expansion of productive capacity) which could be discussed outside the WTO, in fora like the G20 or the G7.

In the multilateral trade arena, the work of the UN Conference on Trade and Development is also highly relevant for plastics. UNCTAD's work on Financing a Global Green New Deal, which focuses on challenges and strategies for developing countries in regard to green economic transformation, is directly relevant to discussions of reform of the plastics sector as well[217.] UNCTAD's work on Sustainable Manufacturing and Environmental Pollution is also taking a lead role in exploring the opportunities in developing countries for expanding the production and trade of environmentally sound non-plastic substitutes and alternatives[218].

More broadly, there is growing interest in ensuring trade policy is aligned with climate ambition and environmental sustainability. To date, there has been little focus on the chemicals sector, but this is rapidly evolving in ways that are relevant to petrochemicals. On the one hand, in their bilateral and regional trade agreements, many governments are working hard to expand economic opportunities and market access for their petrochemicals sectors, as well as for plastics and fertilisers, and importers that rely on such products and inputs for their own production have been keen to secure reliable, affordable supplies. On the other hand, many governments face pressures to green their trade deals and their trade policies to align with climate priorities and support their domestic climate policies.

For instance, the European Union's new Carbon-Border Adjustment Mechanism (CBAM) targets the imports of goods that are highly carbon intensive with high risk of carbon leakage with a border adjustment tax[219]. As the CBAM proposal has been

deliberated upon by European policymakers, its scope has been expanded from cement, iron and steel, aluminium, electricity and fertilisers, to also cover a number of organic chemicals and polymers.

A further trade policy-related development is the effort to reform international investment law and policies to discourage investment in fossil fuel sectors and promote investment that supports transformation to sustainability. In the past year, campaigners have successfully argued that the Energy Charter Treaty, which plays a key role in governing investment in the sector, is not fit for the climate crisis, spurring a number of countries to withdraw from the treaty. For the petrochemicals sector, a key priority will be to ensure that new investment law and policy equally recognises the petrochemical sector as one reliant on fossil fuels and of central relevance to the climate crisis.

5.4.2 Development banks and exports credit agencies

A key set of players in global economic governance relevant to the transformation of the petrochemicals sector are development banks and export credit agencies which can be multilateral, regional or bilateral. Together, these agencies play a key role in financing the expansion of the petrochemicals sector, especially in developing countries, and also have the potential to play a critical role in supporting the decarbonisation of petrochemicals. Together, these actors have a range of policy tools at their disposal – from loans to grants, trade finance and risk insurance. The World Bank Group has been the biggest provider of finance for fossil fuel projects in developing countries through its policy-based support and private-sector lending[220]. While the World Bank argues that its key bodies for providing loans and grants have not engaged in new fossil fuel financing in 2021 and stopped investing in upstream oil and gas in 2019[221], the organisation has remained invested in providing investment guarantees and support through financial intermediaries such as bank or financial institutions, private equity funds and commercial banks which can de-risk fossil fuel projects and has also supported a range of new petrochemical projects (see Chapter 3)[222]. As public development banks and export credit agencies are publicly financed, there is scope for increase pressure on them to adopt and abide by strong transparency and accountability requirements as well as sustainability requirements and guidelines for investment.

An example of governance efforts to improve the accountability and direction of the export finance sector is the Export Finance for Future (E3F) coalition, formed by seven European countries (together accounting for around 40% of OECD export finance), which has formally committed to end official trade and export finance to unabated coal power, thermal coal mines and coal supply chain infrastructure. The Coalition has also promised to review official and export finance support and assess how to phase out support for other fossil fuel support[223]. Alongside, the Berne Union, which brings together a diverse group of public and private organisations involved in trade finance, launched a Climate Working Group in 2022 to advance thought leadership and practices within export credit, trade finance and political risk insurance and contribute to global problem-solving around climate challenges and sustainable development. As this group works to "encourage the development of innovative products, incentives, and financing opportunities; to promote alignment around low-carbon methodologies; and to foster greater collaboration across the financial sector", there may be opportunities to ensure that the petrochemical sector is properly acknowledged as centrally relevant to the climate crisis[224].

5.4.3 International standard-setting bodies

International standard-setting bodies will also have a role to play in the transformation of the petrochemical sector. The International Organization for Standardization (ISO) is recognised as the leading international body for standard-setting. It published over 24 000 standards, including a range of standards relevant to petrochemical production processes and to plastics and fertilisers specifically. For instance, the ISO has a technical committee that works specifically on plastics and develops standards related to "nomenclature, methods of test, and specifications applicable to materials and products in the field of plastics including processing (of products) by the assembly in particular, but not

limited to, polymeric adhesives, sealing, joining, welding." Among its subcommittees is on that deals specifically with all standardisation activities, in the field of plastics, relating to environmental and sustainability aspects." The focus of this committee includes, for instance, bio-based plastics, biodegradability, environmental footprint including carbon footprint, resource efficiency including circular economy, characterisation of plastics leaked into the environment including microplastics, and waste management including organic, mechanical and chemical recycling.[225]

5.4.4 Plurilateral fora: OECD, G20 and G7

A number of plurilateral fora either are relevant to – or could be harnessed to – the low carbon transition of the petrochemicals sector. The Organisation for Economic Co-operation and Development (OECD) is an intergovernmental organisation of 35 industrialised countries in North and South America, Europe and the Asia and Pacific region, as well as the European Commission. Members meet at the OECD to co-ordinate and harmonise policies, discuss issues of mutual concern and respond to international problems. Most of the OECD's work is carried out by more than 200 specialised committees and working groups composed of member country delegates[226].

The OECD conducts a range of activities relevant to the petrochemicals sector, including work on plastics pollution; environmental policy, standards and circular economy as they apply to plastics; fossil fuel subsidies as well as on trade and environment. The OECD has work, for instance, on extended producer responsibility, resource efficiency, sustainable material management, transboundary movements of waste, and waste prevention and minimisation. The OECD's Global Forum on the Environment addressed the sustainable design of plastics, with a focus on the criteria that define sustainable plastics, the tools available to designers, and the policies that can help to incentivise their design. In 2022, the OECD prepared a Plastics Outlook Report, which identified trends in plastics production and demand, and policy options for tackling plastic pollution, including proposals for introducing a fee on primary plastics production[11].

The OECD Joint Working Party on Trade and Environment (JWPTE), which meets twice a year, provides a forum for Members to take up questions related to trade, plastics and the circular economy. The issue of plastics subsidies could, for instance, be tabled by interested governments in the context of meetings of the JWPTE meetings, accompanied by a call for research. The OECD could, for instance, be asked to supplement its existing work on an Inventory of Support Measures for Fossil Fuels to incorporate data relevant to subsidies to the petrochemicals sector. The OECD also created in 2023 an Inclusive Forum on Carbon Mitigation Approaches, which can be harnessd space to ensure a specific focus on the petrochemicals sector.

At the political level, the G7 and G20 are also forums that could be harnessed to forge political commitments on the petrochemicals sector, either in the context of action on plastic pollution or climate action (following the example of the 2015 G7 Action Plant to Combat Marine Litter[227] and the G20 agreed to an Implementation Framework for Actions on Marine Plastic Litter[228]. The prospects of action at the G7 and G20 vary depending on the host in a given year, and record of implementation of both G7 and G20 commitments is not impressive. Both processes do, however, provide a political opportunity to raise the profile of issues and draw attention to them at the highest levels within governments.

5.4.5 IMO and the shipping of plastic pellets

The IMO has adopted an action plan to address marine plastic litter from ships, aiming to strengthen the international framework and compliance with current IMO instruments and to achieve zero plastic waste discharges to sea from ships by 2025.
A disaster off the shores of Sri Lanka in 2021, where a capsized ship spilt billions of plastic pellets with devastating impacts on Sri Lanka's coastal environment, has renewed attention to the volume of plastic pellets lost in the course of shipping, and has spurred efforts at the IMO to consider the "options for reducing the environmental risk associated with the maritime transport of plastic pellets"[214].

The IMO has, for instance, been called upon to

classify pellets as marine pollutants in recognition of their persistent, polluting nature and the harm to marine life and ecosystems[229,230].

5.5 Private industry governance and strategies

The private sector, together with some NGOs, is advancing a range of different initiatives to encourage companies and the financial sector to divest from investments and activities driving the climate the crisis, and also the plastic pollution crisis. Many of these private governance efforts have the potential to shape global markets in ways that warrant their consideration as part of the wider global governance dynamics relevant to petrochemicals. While the array of initiatives at hand is broad – ranging from initiatives to promote the disclosure of corporate carbon footprints to principles for responsible investment – a general conclusion is that there is very little focus on the petrochemical sector per se, as compared to oil, gas and coal. However, the 2023 World Economic Forum (WEF) in Davos saw the launch of a Finance Leadership Group on Plastics. Convened the by the United Nations Environment Programme Finance Initiative (UNEP FI), the group gathers leading financial institutions supporting the development of the plastics treaty and its subsequent implementation across the global financial sector. The vision is that the Finance Leadership Group on Plastics will provide contributions and recommendations which represent the desired outcomes of banks, insurers and investors to the Intergovernmental Negotiation Committee (INC). Additionally, the initiative will work on raising the financial sector's eagerness to tackle plastic pollution by engaging in awareness-raising and capacity-building activities as well as target-setting support. The vision is for a core group of banks and insurers to showcase their support for the Principles for Responsible Investment and to support outreach to a broader community of financial institutions to promote the role of investors in tackling plastic pollution[231]. A number of stakeholders are also working on corporate transparency initiatives to promote the corporate disclosure of plastics footprints across global supply chains, with the goal that this information may also help inform investor decisions with regard to sustainability impacts and reputational risk.

5.6 Stronger integration of global governance is needed

Having reviewed the relevant intergovernmental treaties and processes in the global governance, this chapter has underscored how little the petrochemical industry is directly addressed in global governance arrangements and related policy discussion relevant to a low carbon transition. The chapter highlights, for instance, that there is no single regime for petrochemicals governance and that, as a sector, the petrochemical industry is rarely specifically addressed through existing international regimes. The absence of a sectoral approach is not unusual within global governance (although examples of sector specific initiatives and approaches exist, such as on agriculture (the UN Food and Agriculture Organization (FAO)), on fisheries (e.g. regional fisheries management organisations), and on timber). Notably, while there is growing attention to the global governance of plastics, there has been less focus in global governance on two other key substreams of the petrochemicals sector, namely fertilisers and pesticides.

In terms of the climate regime, the chapters notes the limited attention within the UNFCCC process to the petrochemicals sector. Amidst a growing range of sectoral initiatives launched by groups of governments and sometimes stakeholders, there are none that focus specifically on links between the climate crisis and the petrochemical sector. There are however climate initiatives of particular relevance, notably those focused on phasing out fossil fuels, such as the Beyond Oil and Gas Alliance and proposals for a fossil fuel non-proliferation treaty.

Beyond the climate regime, this chapter has highlighted that there are efforts and opportunities to address the carbon footprint of petrochemicals plastics and the 'upstream' production of primary plastics in the ongoing negotiations for a global plastics treaty. Alongside, there is the potential to improve governance of petrochemicals, including their climate footprint, through efforts at the UN

to bolster more effective global governance of chemicals, including in the Basel, Rotterdam and Stockholm Conventions as well as through efforts to strengthen the post-2020 framework for chemicals management and UN Environment Assembly's initiative to create a Science Policy Panel.

This chapter has also highlighted the relevance of global economic governance regimes to addressing the climate impact of the petrochemical sector, with the potential for greater focus on the sustainability and decarbonisation of the petrochemicals sector through international processes related to trade, development assistance, investment and financial policy. For instance, this chapter has noted the opportunity to harness discussions underway in the WTO Dialogue on Plastic Pollution to build support and practical action on options for reducing the volume of plastics production and trade to sustainable levels, which would help reduce the climate impact of plastics. It has also noted the importance of addressing the practices of financial institutions and export credit agencies that provide financial support to the expansion of the petrochemicals sector. While recognising important challenges with accountability, it also observes the range of 'informal' governance processes and initiatives, including financial investment forums, private-public partnerships, industry collaborations and networks, seeking to shape and redirect global markets toward global sustainability, which could also be spurred to focus on the petrochemicals sector as a target sector.

6 Synthesis and recommendations: Breaking the lock-ins of the petrochemical industry

Today, the petrochemical industry operates outside the planetary boundaries that define a safe operating space for humanity[232,233]. The sector's environmental impacts are massive and concern climate change[5] as well as several other dimensions of sustainability, including the planetary boundaries for novel entities, biosphere integrity, and ocean accidification[21,234,235]. Alongside, the production of petrochemicals and its toxic impacts have detrimental consequences for human health, disproportionally affecting marginalised communities[95,156,157,236], while commercial benefits accrue mostly to owners and consumers elsewhere[154]. In short, from the perspective of both the global environment and public health, a pressing need to transform the petrochemical industry.

The transition to a petrochemical industry that lowers emissions in line with the temperature goals of the Paris Agreement, is aligned with the Sustainable Development Goals, and operates within planetary boundaries is a monumental undertaking. It requires achieving net zero greenhouse gas emissions throughout the value chain, stopping plastic pollution of terrestrial and marine environments, eliminating toxic chemicals, and ending water and air pollution. Such visions of sustainability are difficult to achieve because emissions from the petrochemical industry are challenging to abate in terms of the range of technologies required[19] and the ongoing search for effective technological solutions[126]. Moreover, transitioning to a petrochemicalt industry without detrimental ecological impacts is difficult due to the strong fossil fuel dependency and the lock-ins that underpin petrochemical expansions mapped out in this report. In addition to the presence of powerful vested interests and ownership structures, the financing of production capacity expansion based on expectations of uninterrupted growth, corporate lobbying power, and weak global governance all threaten to undermine progressive change in the industry.

The future of the petrochemical industry is further complicated by the ifact that achieving zero greenhouse gas emissions[19,115,237] will require limiting use (or consumption) as compared to business as usual projections. Reducing actions to techno-centric change would mean overreliance on technologies and resources whose feasibility is limited by constraints relating to scalability and availability[19]. For each of the often-proposed technological interventions, mportant trade-offs and large risks of burden-shifting to other environmental domains exist, and recycling is limited by thermodynamics and socio-economics[238,239]. Reduced use, by contrast, breaks with industry expectations over continuous increases in global demand and stands in stark contrast to the build-out of petrochemical infrastructure that is currently underway.

This predicament—fossil lock-in and expectations of continuous growth—threatens the integrity of the biosphere and climate and undermines the prospect of a just petrochemical transition. To break with fossil fuel dependence, interventions targeting each of the domains investigated in this report are needed. In this chapter, we outline the implications of the findings from the previous chapters and make recommendations to decision-makers iand stakeholders, and for a range of relevant decision-making processes.

Although the importance of addressing GHG

emissions from petrochemicals and other emissions-intensive industries is increasingly recognised, the development of measures and technologies that could deliver deep emissions cuts has been slow, and policy interventions have been unable to incentivise the necessary changes[240].

Despite the challenges, there are opportunities and make progress. There are a growing number of initiatives and partnerships across the energy-intensive processing industries aimed at accelerating the industrial transition and decarbonisation, which can be inspirations for change in the chemicals industry. This includes the development and deployment of direct reduced iron for the steel industry based on low- and zero-carbon hydrogen[241], the pursuit of a clusters approach to decarbonisation that cuts across technologies and industrial sectors[242], joint ventures that lower the risks involved in transformational investments, as well as buyer coalitions and clubs to build markets for fossil-free commodities[243].

On the policy side, there have been significant developments in some of the countries most responsible for the climate crisis on industrial decarbonisation that have the potential to include a stronger focus on the petrochemicals sector. Together, the EU's Fit for 55 policy, the EU Innovation Fund and the EU Net Zero Industry Act, as well as the US Inflation Reduction Act, will make billions of dollars available for innovation and investments in the EU and US markets to drive emissions reductions in emission-intensive industrial sectors, such as cement, chemicals, and iron and steel. While international perspectives on the EU's Carbon Border Adjustment Mechanism vary, it is notable that these new border tax measures will also be applied to parts of the chemicals sector.

6.1 Industrial organisation

Key findings: Deep ties exist between the fossil fuel and petrochemical industries – organisationally, institutionally, and materially – as well as within the chemical industry, which is connected on a global scale through ownership ties. At the same time, the petrochemical industry is backed by states, many of which with vast hydrocarbon reserves, with strong interests in creating a future for oil in chemicals as a means of diversification and growth. Such dynamics underpin and support the expansion and resilience of fossil-based chemical production.

Restrict expansion of fossil-based production capacity. The 2020s are critical in terms of investments in terms of investments in transition away from fossil-based infrastructure. The year 2050, i.e., the target year for most net zero goals, is only one investment cycle away. This decade, therefore, is a crucial time to act. The International Energy Agency emphasises how refurbishing and extending the lifetime of existing industrial assets to continue along conventional routes does not align with the Paris Agreement, and that all capacity additions should feature "near-zero" technologies by 2030[244]. Moreover, progressive scenarios for the industry also show the need for decommissioning existing plants[127]. Given the strong ties between fossil fuel interests and petrochemicals, there is a compelling case to restrictthe expansion of fossil-based production capacity. This proposition aligns with the calls made by scholars for limits to global plastic production and restriction of plastics[137], focusing on problematic and harmful types of plastic that use hazardous chemicals and/or are hard to recycle.

Require transition plans and pathways from incumbents. To ensure a sustainable future for the chemical industry, incumbent actors need to plan for a path away from fossil dependence. Companies and asset owners who do not operate with a time horizon of decades will, given the long investment cycles of the petrochemical industry, most likely not align with the Paris Agreement and properly plan for the investments and actions a transition demands. Therefore, to ensure credibility around the sustainability claims of major petrochemical producers, transition plans and roadmaps that put forward a convincing pathway towards net zero are required.

First-mover chemical firms could form a "Beyond fossil chemicals alliance" to show what is possible. Within the chemical industry, considerable heterogeneity exists across corporate actors in terms of both political and business climate strategies. The extensiveness of anti-climate lobbying and the progressiveness of transition plans differ, and such differences are likely to persist as firms operate under various conditions in diverse institutional contexts and

are subject to different forms of pressure. Given the entrenched fossil lock-in and vested interests materially anchored in global ownership networks, a voluntary transition across the petrochemical industry is highly doubtful. To put pressure on the rest of the industry and show what is possible, first-mover chemical firms could lead the way with a progressive alliance to move "beyond fossil chemicals."

States with ownership of chemical firms must push them towards transformation. States that own carbon-intensive capital, such as petrochemical asset generally have three different options for reducing emissions: divestment, redirection, or phase-out[245]. Of these, phasing out or retiring existing plants is arguably the most effective in terms of lowering emissions, while a combination of the three is more likely in practice. Given the widespread state involvement in the sector, many states are in a position to push for a transformation of the industry. However, since a transition is likely to involve foregoing expected returns with the close connection between state and industry, it is inadequate to solely rely on states to drive the transformation of the industry. To create opportunities for low-emission chemical production, a transition should be grounded in a comprehensive and progressive green industrial policy framework[246].

Support developing countries dependent on oil and gas revenues to find alternative diversification strategies. A transformation of the chemicals industry is likely to have big implications for the sector's geographical configuration on a global scale (as favourable conditions for sourcing the renewable energy needed are found in the Global South, see for example SYSTEMIQ[127]). Meanwhile, for a number of developing countries, fossil-based chemicals production constitutes a potential diversification strategy for fossil fuel incumbents as the market for transport fuels and the use of oil, gas, and coal for electricity production diminish[12,247]. For low and middle-income countries dependent on oil rents, petrochemicals can appear as an attractive option to foster value-adding activities domestically, improve the trade balance and seek export-oriented growth. The fossil-dependent and ecologically unsustainable nature of conventional chemicals production, however, means that petrochemicals as diversification is a climate dead end. To offer alternatives, international support is needed for developing countries that cannot source funds and resources

independently. A particularly important form of support is technology transfer, such as through patent pools and/or common access to key technologies for decarbonisation[242]. As a guiding principle, the benefits from such support should accrue to local populations as opposed to institutional investors in the Global North seeking to accumulate returns from financing derisked infrastructural developments[248] .

6.2 Finance

Key findings: Petrochemical projects attract financing from all regions of the world. While the majority of the capital comese from private investors, this capital is closely tied to support from public financial institutions, which are often used as leverage for investments. Finance for petrochemicals is truly global in reach, with much of the finance originating in industrialised countries but to finance petrochemical plants in developing countries. There is limited transparency in finance for petrochemicals, which makes it more difficult to, in terms of requirements that it only go to plants that are or are planned to be converted into low-carbon production.

Ban public financial involvement in fossil-based chemical projects. Public financial institutions must be directed to take a leading role in fulfilling the aim of the Paris agreement to make finance flows consistent with a pathway towards low greenhouse gas emissions. This requires that public financial institutions immediately stop financing investments in in the expansion of the petrochemical productoin capacity and fossil fuels. A multi-faceted strategy is needed that fthat stops the flow of public and private money to the expansion of the petrochemicals sector, including through improved transparency and accountability of lending, grantmaking, subsidies, and other financial support granted by multilateral and regional development banks as well as by export credit agencies and domestic financial institutions. Alongside these efforts, financial support for meaningful efforts to decarbonise and phase out existing capacity will require international cooperation, in particular to ensure just transitions, and thecontribution of development banks will be vital.

Asset managers aiming to support the transition must recognise the hidden emissions in chemical and plastics value chains. Chemicals and plastics are complex value chains and accounting of emissions from investments in firms in these industries is difficult. However, a value chain perspective is absolutely necessary to apply when considering the climate impact of these sectors as the fossil carbon embedded in the products is such a large share of the fossil dependency and harbours large potential emissions if incinerated after end-of-life.

Use best available guidance to evaluate and question propositions from firms issuing bonds or requesting loans. A number of sustainability initiatives within the financial sector or with financial sector actors as primary stakeholders are recognizing the importance of the petrochemical industry for global climate targets. Financial sector actors must look to the best available guidance for how to assess the progress and efforts that chemical firms are making to reach zero emissions. Examples of such guidance documents are the criteria determined by the Climate Bonds Initiative for basic chemicals and the sector-specific guidance for chemicals that is currently being developed by the Science-Based Targets initiative. While all approaches to setting sector criteria are far from perfect, they aim to draw a clear line between business as usual logic and the strategies necessary to reach climate targets.

Alongside, the Finance Leadership Group on Plastics and efforts to promote corporate disclosure of carbon and plastic footrpints across supply chains provide opportunities to ensure investors have access to information relevant to sustainability of their investments and reputational risks.

6.3 Public discourse and protests

Key findings: Incumbents in the petrochemical system seek to influence policy and institutional arrangements through different avenues including lobbying and affecting policy debates and public discourse. Actors strategically mobilise narratives that cast criticisms of their climate impacts as mere misunderstandings and mirror discourses of climate delay.

Devising adequate policy responses, building legitimacy for change, mobilising bottom-up pressure for a timely climate transition will likely look very different in the range countries that currently dominate the global petrochemical supply chains. To have a realistic chance of achieving a timely climate transition for the global petrochemical industry, mechanisms have to be in place to handle the socio-economic stresses involved in structural change, such as countries with fewer resources available, including through international climate financing and technological transfers.

As petrochemical plants are clustered in many cases in major production units that are geographically concentrated, it is important to pay attention to the regions and communities where the petrochemical industry, despite a continuous trend towards automation and outsourcing of work, continues to play an important role as a source of employment, tax revenues, and not seldom also both conflict and pride. Social movements and fenceline communities, which most directly suffer the negative consequences of petrochemical production, have historically influenced and can continue to influence the petrochemical industry.

Ensure high standards for net zero goals, follow best-practise principles for accurate corporate GHG inventories and move beyond climate delay rhetoric. Creative GHG accounting practices including the use of erroneous market-based methods and offsets, claiming emission reductions based on questionable benchmarks and declaring climate neutrality based on "product benefits" are widespread in the chemical industry. To escape greenwashing, petrochemical producers should rely on ambitious standards for GHG accounting and climate targets that are informed by research such as the Science-Based Target Initiative's Net-Zero Standard and the emerging guidelines from the recently established UN High-Level Expert Group on Net Zero[249]. To prevent the amplification of climate delay discourse *(i.e., whataboutism, technological optimism, individualism and all talk little action)*, petrochemical companies should revisit their climate communication strategies to improve transparency and advocate their progress with reference to their transition plan.

Recognise the harm the industry does to fenceline communities. Recent research points to a global trend of 'noxious deindustrialisation' in the petrochemical industry, where fenceline communities in many places no longer significantly benefit from the industry in terms of jobs and public services but are still exposed to harmful environmental and health impacts. The extent to which a transition addresses noxious deindustrialisation and supports fenceline communities is a critical aspect of a just petrochemical transition.

Include local stakeholders and social movements in shaping the transformation of the industry. Policies and strategies to handle legitimate concerns and needs among workers and frontline communities must be at the centre of plans to transform the petrochemical industry. To build legitimacy, prevent the overriding of local democracy and handle the conflicts of interest that arise in large-scale socio-technical change, top-down driven change needs to be complemented with processes that capture and provide agency for communities and groups on the frontlines of the transition.

6.4 Global governance

Key findings: In terms of climate action, the petrochemical sector suffers from weak and fragmented global governance. This report has underscored how little the petrochemical industry is directly addressed in global governance arrangements and related policy discussions relevant to a low carbon transition. The chapter highlights, for instance, that there is no single regime for petrochemicals governance and that, as a sector, the petrochemical industry is rarely specifically addressed through existing international regimes. In terms of the climate regime and the UNFCCC, there is minimal attention to the petrochemicals sector. Amidst a growing range of sectoral initiatives launched by groups of govern-

ments and sometimes stakeholders, there are none that focus specifically on links between the climate crisis and the petrochemical sector.

Integrate fragmented international governance landscape by bringing together the global plastics treaty with global climate efforts and boost global governance of chemicals. A key step needed to realise this vision will be for the global plastics treaty to include provisions requiring parties to control the total volume of production and trade of primary plastics (measures for consideration include caps on volume, taxes, standstills or moratoriums on the further expansion of production, and the removal of subsidies, including fossil fuel subsidies, that support the petrochemicals sector) and to eliminate the manufacture, export, and import of certain harmful, problematic, and unnecessary precursors, additives, primary plastics, and products. Alongside this emphasis on controlling the "upstream" production of primary plastics in the ongoing negotiations for a global plastics treaty, the global governance of chemicals, including their climate footprint, could be bolstered through efforts at the UN to ensure more effective global governance of chemicals, ensuring sustainable production and consumption, and phasing out certain chemicals, including through the Basel, Rotterdam, and Stockholm Conventions, as well as through efforts to strengthen the post-2020 framework for chemicals management and the UN Environment Assembly's initiative to create a Science-Policy Panel.

Petrochemicals should be one of the key sectors individually outlined in Nationally Determined Contributions delivered as part of the UNFCCC process. Regarding Nationally Determined Contributions (NDCs), incorporation of a sectoral focus on commitments and strategies for decarbonising the petrochemicals sector into a broad range of NDCs would help to build a basis for more focused attention nationally to this sector and for international cooperation across supply chains, investors and standard-setters, and to build support for just transitions. In addition, governments and stakeholders could seek to initiate a sector-specific initiative on climate and petrochemicals at COP28, which could in turn seek to establish linkages with the ongoing plastics treaty negotiations as a potential point of leverage.

Intensify international efforts to directly confront and reduce the scale of the fossil fuel industry as a key driver of petrochemical expansion. Here, parallel governance strategies could be pursued. The campaign for a new Fossil Fuel Non-Proliferation Treaty could be expanded to include the petrochemical industry as a key sector for attention given its increasingly important role in fossil fuel value chains. Alongside, collaboration with the Beyond Oil and Gas Alliance and its efforts to block future exploration and expansion of oil and gas would help restrain access to fossil feedstocks for petrochemicals. The fact that this alliance steps beyond energy in its mission to oil and gas extraction and processing means that it is well-framed in ways that would also tackle the petrochemical sector. Finally, governments and stakeholders could also support efforts at the WTO to build support for updated trade rules on subsidies so as to support the transparency and phase-out of fossil fuels. They can and should also work to align development, trade, and investment regimes with the goal of reducing the climate impact of the petrochemicals sector. In the trade arena, this could include stepping back from efforts to expand markets for primary plastics and conventional plastics products through trade and investment deals. Instead, they should advance work in the WTO Dialogue on Plastic Pollution to build support and practical action for volume of primary plastics production and trade and substituting environmentally sound products and services.

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