

Green finance and decarbonization of petrochemicals:

Slim pickings in a crucial but hard-to-abate industry



United
Nations

Green finance and decarbonization of petrochemicals:

Slim pickings in a crucial but hard-to-abate industry



United Nations

Geneva, 2023

© 2023, United Nations

This work is available through open access, by complying with the Creative Commons licence created for intergovernmental organizations, at <http://creativecommons.org/licenses/by/3.0/igo/>.

The findings, interpretations and conclusions expressed herein are those of the authors and do not necessarily reflect the views of the United Nations or its officials or Member States.

The designations employed and the presentation of material on any map in this work do not imply the expression of any opinion whatsoever on the part of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Mention of any firm or licensed process does not imply the endorsement of the United Nations.

Photocopies and reproductions of excerpts are allowed with proper credits.

This publication has not been formally edited.

United Nations publication issued by the United Nations Conference on Trade and Development

UNCTAD/GDS/2023/2

eISBN: 978-92-1-002724-3

ACKNOWLEDGEMENTS

This paper is researched and written by Guy Finkill, Research Consultant at the Tyndall Centre University of Manchester, and Diana Barrowclough, Senior Economist, Globalization and Development Strategies, UNCTAD. The paper is part of a wider project titled Mobilising Resources for a Green New Deal in Asia, led by Diana Barrowclough. The findings of the authors are preliminary as this is a work-in-progress in a little studied area.

This paper has been presented at various inter-governmental meetings, and international and academic workshops and the authors appreciate the helpful feedback given by colleagues on our findings. The authors also acknowledge with gratitude the financial support of the United Nations Development Account; and feedback from colleagues at the Lund University project Pathways to Breaking the Fossil Fuel Lock-In, Petrochemicals and Climate: Mapping Power Structures. Any errors or omissions remain the authors' own.

The authors invite feedback or comments and can be contacted at guy.finkill@postgrad.manchester.ac.uk and Diana.Barrowclough@unctad.org

TABLE OF CONTENTS

Introduction.....	1
1. What is Green? Framework for adjudging green credentials of bond issuances	4
2. Methodology	5
2.1 Green Bonds Issued by Petrochemical Industry	6
2.2 Green Bonds Issued by State – Connected to Petrochemical Industry	7
3. Case Study Findings	9
3.1 Beijing-Tianjin-Hebei Low Carbon Energy Transition and Air Quality Improvement	9
3.2 Indorama PET Recycling	10
4. Summary of Research Findings and Recommendations	11
5. Takeaway Messages & Further Research Needs	12
References	13

INTRODUCTION

Achieving the greener, more equitable and sustainable future envisaged by the SDGs needs a massive investment push into new sectors, sources of energy, modes of transport and manufacturing and agricultural processes. It must support both decarbonisation and low-carbon economic growth. One line of thought argues that the finance for such a catalytic shift must come from public resources and a developmental State (Mazzucato 2011; UNCTAD, 2021). Another runs that the private sector is best equipped for this and must just be given space to do the job, albeit with some judicious de-risking by the government when needed. This paper aims to put some empirical evidence into the debate, looking at what is actually happening in terms of finance to the crucial but little studied petrochemical sector.

In a previous study, the authors examined thousands of financial transactions into the sector and separated them out according to their sources, including public and private, banks and bonds (Barrowclough and Finkill 2021). This was the first attempt to map the changing flows of finance, and we found that public sources of finance had fallen significantly since the Copenhagen and Paris climate agreements but had then increased sharply in the Covid-19 era of quantitative easing and corporate bond purchases. The majority of finance was still nonetheless private and in particular through market mechanisms such as bonds. This paper now focuses on one of the fastest growing categories of market-based mechanisms for so-called green finance, namely green bonds, issued both by sovereign states and by private corporations, in the crucial but little-studied sector of petrochemicals. Greening of the petrochemical industry could make a significant impact into de-carbonisation as it is highly fossil-fuel dependent and carbon-emitting. It is however difficult to abate, as the sector has over decades become extremely large and deeply embedded into numerous and far-reaching value chains that deliver useful final and intermediate products on which daily life depends – from fertiliser to pharmaceuticals. Transformation will impact both negatively and positively on the livelihoods of millions of people. In this challenging context, the paper asks the question whether market-based mechanisms such as bonds are likely to help to decarbonise the petrochemical sector.

The dangers of carbon lock-in are already well-documented (Seto et al, 2016; Bauer & Fontenit, 2021; Fisch-Romito et al, 2021), and major steps are already being taken to decarbonise the traditionally high-emitting energy and land transport sectors (IEA, 2021). There is a great deal of scholarly research in this broad field. However, petrochemicals have not received the same degree of attention – even though they are highly linked to fossil fuel use and to CO₂ emissions, as well as pollution. The majority of finance flowing through the petrochemicals industry is destined for producing plastics, for example, where there are ongoing efforts for regulation and pollution control at the end of the plastic lifecycle if not its beginning (Barrowclough & Deere Birkbeck, 2022). The petrochemical industry however remains in a comparably sluggish state in the race to decarbonise (Mah, 2021). This is unfortunate because a major investment push is required to accelerate the industry's transition to a greener low-carbon future, including the complementary financial support to address the shock to potentially 'sunk assets' and 'sunk employees' that have emerged over decades of high growth in this activity. The sector is so significantly embedded into multiple parts of the global economy that it is almost impossible to envisage change and yet change it must – unless pledges to a lower-carbon future are simply to be read as the pledge to push so-called compensatory activities such as tree-planting or other carbon sink activities that act to increase the carbon balance on one side of the equation without impacting the source.

How then can change be financed? Can market-mechanisms, in particular bonds, do the heavy lifting, as is hoped in some quarters. This traces the vertical line of "green finance" in the sector, to sketch out its scale and potential ability to support increased investment for transformation and transition. It gathers original information about the scale, source and purpose of green petrochemical bonds and finds they cannot be relied upon for the heavy lifting of structural transition or transformation, because the amounts raised are extremely small in dollar terms, especially when set against the scale and needs of the industry. Of the very large number of bonds issued in petrochemicals, only a small number are

designated “green”, and of these, there is seldom an explicitly pre-defined green target or ambition, nor is there sufficient evidence of their impact. This finding reinforces calls for more public finance and public financial institutions to play a catalytic role in financing structural transformation of high-carbon activities, in light of the expectations that this will prove too much for the private sector alone (UNCTAD 2019, 2021). The paper focuses in particular on the experience of Asia, where some of the challenges, but also the opportunities, of transitioning away from outdated and polluting processes are most acute. Detailed case-studies of two green bond issuances in the sector provide some interesting and potentially important lessons for future issuances; this may be crucial given the very wide-spread and ambitious pledges for low to zero-carbon made by industry players.

Current trends in petrochemical finance

Petrochemical production and demand are projected to increase sharply over the coming decades (IEA, 2018), in the absence of any new regulatory or other policies. This is due in part to a rise in global population and improved living standards, and the profitability of the sector. This projected increase stands to outstrip the beneficial impact of ongoing improvements in chemical recycling (Meys et al, 2020; Vollmer et al, 2020); increased levels of recycling after end-use processes (Vollmer et al, 2020); and other policymaking successes, such as the phasing out of products like single-use plastics in multiple countries (Masterson, 2020). These welcome reductions are only incremental compared to the sharp increases in demand and consumption for petrochemical products, especially in emerging economies. The petrochemical industry is renowned for being a hard-to-abate sector (Åhman, 2020), similar to the production of steel and cement, given its carbon-intensive lifecycle. Without the necessary support from financiers to transition away from a fossil fuel dependency, it will continue to guarantee a degree of carbon lock-in in the petrochemical industry, undermining attempts to make a real contribution to net-zero commitments.

The major source of finance in the petrochemical industry is private, with public banks and government owners providing a steadily decreasing portion of finance to the entire industry (Barrowclough and Finkill 2021). In the years 2009-2021, there were financial transactions worth approximately \$320bn taking place in the petrochemical sector. Public financing accounting for less than a quarter of that total (ibid). Of currently active finance flows including loans and bond issuances at the time of research (mid-June 2021), \$212.7 billion was from private sources, including \$149 billion in commercial bonds and \$63 billion from commercial banks; while \$38 billion was sourced from public sources including \$2.4 billion from multilateral development banks, \$26 billion from central banks and 1.1 billion from Sovereign Wealth Funds (ibid, 2021: 14).

Launching from this research, the current paper examines the sub-category of green finance in petrochemicals, which is a small but specific category within the broader green finance market that took the financial sector by storm in the last decade. The total global value of green bonds issued is cited as over \$500bn in November 2021, according to the Climate Bond Initiative (CBI, 2021). At present they still account for only 5% of the total bond issuance in world financial markets, but prospects for their expansion are considered to be high because of the increasing number of investors looking for greener places to in direct their capital. The issuance of green bonds is not limited to the corporate sector where companies look for extra capital to fund a wide array of decarbonisation methods; as shown in Table 1 below, state issuances of green bonds are still significant, accounting for almost half the total green bonds issued from 2014-2020 (CB1, 2022). Development banks, government-backed entities, local government and sovereigns issued \$781 billion of bonds in the petrochemicals between 2014 and 2022. However, their share has been falling significantly over the decade from a high in 2015, when the State accounted for over 60% of bonds to the sector, to today when it accounts for 42%. The leading issuers of bonds in this sector are private sector corporates, both financial and non-financial, as shown below.

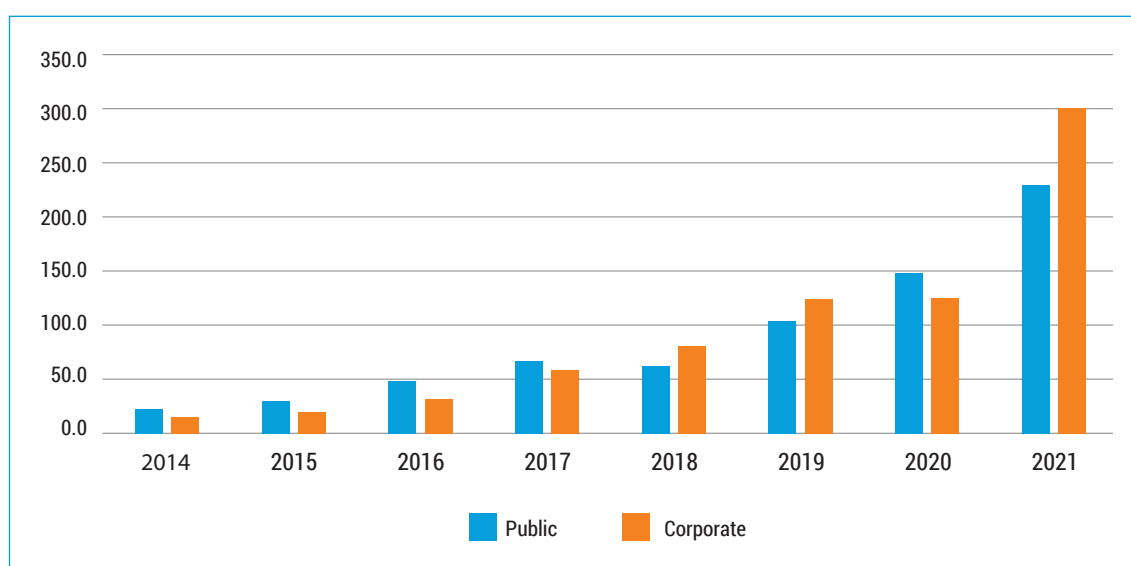
Green finance and decarbonization of petrochemicals:
Slim pickings in a crucial but hard-to-abate industry

Table 1: Green bonds by type of issuer 2014-2022.

Issuer Type	Total \$bn	% of total
Development Bank	202.4	11.9
Financial Corporate	434	25.6
Government-Backed Entity	281.8	16.6
Local Government	86.1	5.1
Non-Financial Corporate	420.2	24.8
Loan	61.2	3.6
Sovereign	211.5	12.5
TOTAL	1697.2	100.0

Source: Authors, derived from CBI database www.climatebonds.net/market/data/#use-of-proceeds-charts

Figure 1: Bond issuances in petrochemical sector, by sources, US \$Bn.



Source: as above.

Note data for 2022 is not shown as only the first quarter is available.

Their consistent popularity is epitomised by the frequency in which both corporate and state-issued green bonds are being over-subscribed (Shishlov, Morel, Cochran, 2016; García-Lamarca & Ullström, S., 2020) as the investment market has a seemingly insatiable appetite for bonds that can showcase their green credentials. Thus far, the majority of bonds have been directed towards the energy sector, although for the most part this is about electrification or switching to renewable energy feedstocks (Pollin, 2021). As they are a market mechanism it is not surprising that green bonds are primarily directed to climate change mitigation, where investors have a reasonable prospect of earning a return; they are not currently being used at all for climate change adaptation (UNCTAD, 2021) and so could not be likely called on for example to pay for carbon-offset tree-planting by petrochemical companies, unless they were linked to the returns from non-green activities by the firms.

The recent rise of the net-zero discourse has obviously not gone unnoticed in the petrochemical industry, with 60% of the ten largest petrochemical companies in the world pledging to achieve net-zero or carbon neutrality goals of some description by 2050 at the latest (Dow, 2020; Global Times, 2021; INEOS, 2021;

LyondellBasell, 2021; Nonnast, 2021; Rashad, 2021). The range of what these bold pledges include vary from company to company, Dow are the only petrochemical giant that have broadened their climate target (Dow, 2020) to also include Scope 3 emissions, which can often be elusive (Wang & Sueyoshi, 2018; Li, Wiedmann, Hadjikakou, 2020).

This paper looks beyond bold emissions targets and climate commitments and gets down into the nitty-gritty of how the industry is harnessing the tool of green bonds to overcome specific obstacles that currently hinder their sustainability goals.

1. What is Green? Framework for adjudging green credentials of bond issuances

Many commentators are sceptical about the credibility of claims of some 'green bonds' to be really green in impact and claims of "greenwashing" abound – namely the practice of channeling funds gained from green bonds into projects that have negligible or even negative environmental benefits. This is seen to be the case when green bonds hit implementation challenges (Al Mheiri, & Nobanee, 2020) or particularly when they are connected to refinancing purposes (Fatica & Panzica, 2021). More research is needed to examine the distinctions between different bonds from different issuers, especially given that green bonds do not need to be asset-backed (where the assets are defined a priori) compared to asset-linked (where the assets are defined after the event). It is loosely assumed that the former is more likely to be greener, if the finance is raised for a pre-defined greening activity. According to the latest data from the Climate Bonds Initiative, only \$29 billion out of almost \$600 billion bonds issued in 2021 were categorised as Asset-Backed Securities (ABS). For the years 2014-2022, ABS bonds totaled \$170 billion or about 10% of the total. The CBI data is not sufficiently granulated to know whether these were primarily public or privately backed issuances.

These challenges notwithstanding, in the absence of firmer agreed taxonomies, this paper makes an effort to examine the potential of green bonds in this sector, noting that green bonds are by no means uniform and come in many 'shades'. The differences between these shades can act as a shared common understanding (Ehlers & Packer, 2017; Immel et al, 2021; Dorfleitner, Utz, Zhang, 2021) of how the eligibility and exclusion criteria for the use of proceeds in green bond prospectuses shape up when put under scrutiny. Throughout the analysis section of this paper, we examine the use of proceeds in the green bonds, detailing aspects that could be rated under a green bond framework such as CIGERO (2022) or Sustainalytics (2022) amongst others. These frameworks utilise different rating systems that can be comparable to different shades of green that can then be applied to the use of proceeds of a particular bond or one of its tranches. Simply put, the division of shades are light green, medium green, dark green, and an undesirable brown. In our case study examples, we pull out discussion points that could be aligned with the following shades of green.

Light Green applies to projects that are environmentally friendly in isolation and indicate an improvement compared to what came prior – incremental improvements in emissions intensity of practices for a petrochemical plant for example. An improvement that leads to a decrease in cumulative emissions but does not have a long-term vision of removing fossil fuels as a core source of energy. Such as adding emission scrubbers to the chimneys of fossil fuel or waste-to-energy power plants.

Medium Green would be allocated to projects that are stepping-stones towards a decarbonised vision but do not achieve that goal currently. For example, a higher proportion of non-virgin plastic usage in new product manufacturing.

Dark Green is reserved for projects and solutions that can contribute to a net-zero emissions scenario that is both robust and resilient. For example, a procurement or construction of renewable energy infrastructure that has the highest environmental and social governance safeguards in place. Brown would be applied to

bonds that claim to be green but do not meet any of the above listed credentials and can be actively linked to operations that will have a negative impact on the climate of failing on other ESG principles.

The central idea behind a green bond is that it is specifically designated to be used for some kind of greening activity, and this attracts investors who also wish to support greening and may even be willing to accept a lower return because of it. This is what makes them special, because otherwise companies and governments could simply issue regular bonds and use them to fund green activities without having made any particular pledge for that particular round of raising funds. Studies in the green bond market in general have however found that there are often no explicit mechanisms included in the bond prospectus that guarantees the funds raised will be used as promised; nor are there any seniority clauses that would put green bond holders ahead of conventional bond holders in the case of a default. A recent analysis of 150 randomly selected sovereign, quasi-sovereign and supra national bond issues found “little or nothing that would be legally enforceable” regarding the use of the funds. (Bolton et al, 2022 pp.68). There are still ways that oversight can be put in place, and for example the Government of Fiji established an oversight committee with its green investments, reviewed by the World Bank (CBI, 2021). Building on these findings, we therefore also attempted to discover whether the green bonds issued in the petrochemical sector had a pre-defined use of purpose or indeed any other contingent measures by which investors could ensure that their funds had been used in a “greening” way.

2. Methodology

This investigation built on and expanded the first original research into financial flows in the petrochemical sector (Barrowclough & Finkill, 2021), by focusing on the narrower category of that whole that comprised only “green” bonds. As shown in Barrowclough & Finkill (2021) it is possible to see that financial flows into the petrochemical sector include a wide range of actors and modalities; our focus in this paper concerns the role of green bonds, stemming from both public and private financial entities.

In the 2021 study, we had found evidence of 2,417 petrochemical bonds at issue, with a total value of \$218bn. From these bonds, 20 bonds only were defined as green, valued at \$5.42bn (Table 2). The 20 bonds were issued by 13 companies, as shown in Table 4.

Table 2 - Petrochemical bonds currently issued.

Total Petrochemical bond issued	2,417	\$218 billion
Green Petrochemical bond issued	20 bonds (13 companies)	\$5.42 billion

Source: Barrowclough and Finkill (2021)

Our empirical results for this study were, like the 2021 study, derived from two principal data sources. Firstly, for private bond market engagement, we examined Bloomberg data from August 2021 detailing all corporate green bonds issued by the petrochemical industry. Secondly, from the Bloomberg database we also collected data on publicly issued green bonds stemming from 36 countries that had issued 463 governmental green bonds as listed by Bloomberg in August 2021. The countries are listed in the Appendix. In total the countries issued 463 green bonds, to a value of \$280.06bn. A figure dwarfed by corporate issued green bonds, valuing over \$960bn at the time of writing. None of the green bonds issued by nation states were linked explicitly to the petrochemicals industry.

The second question focused on the role of multilateral and development banks, which had been identified in the 2021 study as a small but potentially significant source of public finance into the petrochemical sector, accounting for \$2.3bn of flows (ibid). We investigated data from annual reports, websites and publications from 29 of the world’s largest public multilateral and bilateral development banks. The 29 largest public banks assessed were chosen as a comprehensive, yet not completely exhaustive, list to

Green finance and decarbonization of petrochemicals: Slim pickings in a crucial but hard-to-abate industry

give an accurate picture of development finance across a breadth of regions. The banks are listed in the Annex. Of the 29 banks, we found that 19 had issued green (or sustainability-linked) bonds. Of these prospectuses of the green bonds issued by these 19 public banks, we found two that were concretely related to the petrochemical industry. Both were based in Asia – one being a \$500m bond issue by the Asian Infrastructure Investment Bank AIIB and the other being a \$150-\$300m project financed by the International Finance Corporation for Thailand. Both are therefore very small compared to the bond market in general.

Finally, where green bonds in petrochemicals were identified, we assessed each one to map the projected use of proceeds and to gain an understanding of what types of bond frameworks the issuances were adhering to. Table 3 shows a snapshot of the green bond market for June 2021.

Table 3 - Green bonds currently issued by number and value

Total Green Bond Issuances	\$960 bn	16,697
Public Green Bond Issuances	\$280.06 bn	463
Multilateral Development Banks Green Bond Issuances	\$21.72bn	106

Source: Authors, based on data derived from Bloomberg.

Our analysis focuses on green bonds that are connected to the petrochemical industry. This firstly includes green bonds issued by petrochemical companies as recognised by the Bloomberg MSCI Green Bond Index in July 2021 (Bloomberg MSCI, 2021). Secondly, we have collated all 36 of the country issued green bond from the same index and combined it with our own searches of bond issuances from 29 major bilateral and multilateral development banks, all of which are listed in the appendix.

2.1 Green Bonds Issued by Petrochemical Industry

From the 2021 study we found that across the entire petrochemical industry, there were just 20 corporate issued green bonds across 13 companies, investable during mid-2021. These 20 bonds had an approximate combined value of \$5.42bn (Bloomberg, 2021), see Table 3. This value was based on currency exchange values at the time. To put this in perspective for other sources of finance for the industry, the ‘non-green’ or conventional bonds in the market from this industry totalled \$213bn – indicating that for petrochemicals at least, green bonds are still the minutest fraction of finance. This is not to say that bigger things are not possible – taken from another perspective, for industry as a whole in August 2021, there were just over 3,600 investable corporate green bonds available in the bond market, plus another 460 green bonds issued by state-run banks or municipalities (Bloomberg, 2021), with a total value of these over \$1.2tn. Of this, more than \$250bn being issued in each of the last three years (Barrowclough & Finkill, 2021).

Table 4 - Green bonds currently in the petrochemical industry (data from August 2022)

Company	Bond(s) Value USD millions	Country of Headquarters
Air Liquide Finance SA	565.3	France
Arkema SA	352.9	France
Asahi Kasei Corp	90.5	Japan
BASF SE	1,176.4	Germany
China Jushi	77.2	China
Hanwha Solutions Corp	154.5	Korea
Kaneka Corp	45.3	Japan
LG Chem	2,065.3	Korea
Ningbo Zhongpu Petrochemical Investment Group Co Ltd	61.8	China
Rongsheng Petro Chemical Co Ltd	144	China
Shaanxi Coal and Chemical Industry Group Co Ltd	435.7	China
Sinopec	168.2	China
SK Global Chemical Co Ltd	80.8	Korea

Source: Authors, derived from Bloomberg database.

2.2 Green Bonds Issued by State – Connected to Petrochemical Industry

As stated in the methodology section above, we looked at 29 bilateral and multilateral development banks to see if they had active issuances of green bonds. 19 of the studied 29 banks had issued green bonds, predominantly related to the ramping up of renewable energy infrastructure (wind, solar, hydro, geothermal, biomass), implementing improved wastewater management systems, conservation projects, and improving energy efficiency in buildings. Following a similar line to the use of proceeds found in corporate green bonds (Flammer, 2021).

In the prospectuses of all 463 green bonds issued by individual countries and their municipalities, we were unable to find any explicit links to concrete petrochemical projects, where data was publicly available. Across the assessed green bond prospectuses from the 19 development banks there were 2 explicit examples of projects receiving green bond financing that had an innate connection to the petrochemical industry. The two projects are summarised in Table 5 below.

Table 5 - Case-Study petrochemical related projects receiving public or state-issued green bond financing.

Asian Infrastructure Investment Bank (AIIB) - Beijing-Tianjin-Hebei Low Carbon Energy Transition and Air Quality Improvement Project via Sustainable Development Bond. Project ID: 000323.
--

Green bond financing for project: \$500m
--

International Finance Corporation (IFC) - IVL Thailand via IFC's first ever 'blue' loan. Project ID: 43300
--

Green bond financing for project: \$150-300m
--

Source: Authors

Green finance and decarbonization of petrochemicals:

Slim pickings in a crucial but hard-to-abate industry

The financiers of these projects both MDBs; the AIIB and one of the World Bank's subsidiaries, the IFC. AIIB is awarded a low-risk ESG¹ rating from Sustainalytics (2021) and their sustainable development bond framework has received credible ratings from 3rd party verifiers ISS ESG, Sustainalytics and Vigeo Eiris² (AIIB, 2021). CICERO, one of the world leading 2nd opinion providers for green bonds, rate the IFC's green bond framework CICERO Medium Green (IFC, 2021a), the 2nd highest rating available from CICERO. The IFC follows best practices and the ICMA Green Bond Principles (ICMA, 2021), a voluntary set of guidelines for transparency and disclosure.

Re purpose, we find some examples of financing being used for sustainable purposes such as diversifying production to include more bio-based feedstocks and biodegradable products (BASF, 2018; LG Chem, 2021) and consequently moving away from petrochemicals and fossil fuels. Procurement of renewable energy for operations is also a good step in the right direction and will bring quick reductions in an emissions portfolio. However, it could also be considered as the low-hanging fruit of a decarbonisation strategy.

Across these corporate issued bonds, there is a focus on chemical recycling, improving waste management practices, conservation, and the introduction of CCUS³ technologies. There is an array of incremental improvements that will bring down emission intensity, but most projects listed for use of proceeds do little to address the elephant in the room of carbon lock-in (Brown et al, 2008; Bauer & Fontenit, 2021).

It was seemingly not possible to obtain the use of proceeds for some of the corporate bonds issued in China. However, they had been ranked by the Climate Bonds Initiative as non-green and therefore would either receive no ranking green bond frameworks or would be labelled as brown; especially if they are linked to the financing for coal-to-chemical plants. Transparency varied across the set of assessed bonds in relation to the monitoring use of proceeds after issuance. Contingencies of funding being explicitly linked to delivering on green targets were found only in the management of proceeds section of LG Chem's Green Financing Framework (LG Chem, 2021), where funding could be removed if proceeds were found not to be aligned with expected progress. Possibilities for refinancing eligibility were based on 'look-back' periods for BASF and SK Global Chemical (BASF, 2018; SK Innovation, 2019). These 'look-back' periods were used to ascertain whether of the use of proceeds had gone towards meeting the sustainability criteria as per the original issuance, the results of which will be published in annual green bond impact reports. SK Global Chemical has an annual working group to review the Eligible Green Project List to ensure their alignment with their Green Bond Framework (SK Innovation, 2019), but it is unclear if unalignment would result in green bond financing being revoked.

When bondholder information is available for these corporate issued bonds, it is dominated by the high yielding Exchange Traded Funds from the investment firm giants Blackrock and Vanguard, being consistently prevalent. Large PFIs have also found to be involved with the European Central Bank being listed as having holdings in the Arkema SA and BASF bonds at the time of analysis.

¹ Environmental and Social Governance

² Eiris is now part of the Moody's Group

³ Carbon Capture Utilisation and Storage

3. Case Study Findings

3.1 Beijing-Tianjin-Hebei Low Carbon Energy Transition and Air Quality Improvement

The Beijing-Tianjin-Hebei Low Carbon Energy Transition and Air Quality Improvement Project, referred to from now as BTH, is a vast project that incorporates various forms of infrastructure. The project received a \$500m commitment from the AIIB, as listed in their 2020 Sustainable Development Impacts Report, covering 26% of the overall project cost.

The objective of the project is to increase the availability of natural gas to help reduce coal consumption and related emissions in the region of Beijing, Tianjin, and Hebei (the BTH region), in line with China's greater plan to transition away from coal dependency (AIIB, 2019a). The BTH region had air quality that used to be the worst in the country mainly due to concentrated energy-intensive heavy industries and massive coal consumption. The project reduces coal combustion related emissions such as CO₂⁴, SO₂⁵, NO_x⁶, and particulate matter through an embracement of LNG⁷ infrastructure. The project includes construction of a LNG terminal in Binhai District, Tianjin Municipality, which includes two principal components: i) construction of LNG receiving, storage and regasification facilities with an annual handling capacity of 5 million tons of LNG; and ii) construction of an unloading wharf.

Tianjin is home to a massive world-class petrochemical industry in the Nangang Industrial Zone, where the LNG terminal is under construction (AIIB, 2019b). Energy demand is on the rise in the area, and LNG is considered to be a low-carbon alternative to heavy coal consumption (ibid). In Section 3 of the project's Social Impact Assessment and Environmental and Social Management Plan, the AIIB assesses "With and Without Project Alternatives" (ibid, pp.55). In their assessment, they conclude that the existing LNG supply capacity cannot guarantee the demand of Beijing, Tianjin and Hebei province and the project is expected to largely enhance natural gas reserve and peak capacity in the BTH region.

The project has already gathered the interest of many petrochemical majors such as Sinopec, PetroChina, CNOOC, Shell, BP, Akzo Nobel and other leading domestic and foreign enterprises with over 40 individual petrochemical projects connected to the infrastructural expansion, including ethylene-propylene plants, polyurethane and lubricant plants (AIIB, 2019b; Bork & Rais, 2020). Key products produced in this complex include ethylene, polyethylene, polypropylene, and ethylene glycol. All of these products are inextricably connected to the development of plastics and other synthetic products that are derived from petrochemical feedstocks (Offshore Technology, 2021).

As part of AIIB's twice-yearly 'Project Implementation Monitoring Report', there is an opportunity for investors to track progress made in the projects eligible for financing from the AIIB's Sustainable Development Bonds. In March 2022, the BTH monitoring declared that "The Project has been implemented well. But it is still too early to measure the designed results indicators." Thus, it has not yet been possible to measure progress against the targeted annual reduction goal of 7.5Mt of CO₂ compared to previous coal-fired practices.

Since AIIB's inception in 2013, there was a premise that they would invest in clean energy and other infrastructure alongside other development banks. Yet, the AIIB have focused financing on gas generation, and infrastructure with a dependency on coal; alongside limited implementation of renewable energy projects (Inclusive Development International, 2021). However, the AIIB have a target of aligning 50% of their investment portfolio to specific climate financing by 2025. This target is outlined in their 2020

⁴ Carbon-dioxide

⁵ Sulphur-dioxide

⁶ Nitric oxide

⁷ Liquefied Natural Gas

Corporate Strategy Report, “Financing Infrastructure for Tomorrow” (AIB, 2020a). In late 2020, AIB president Jin Liquin doubled down on this commitment by ensuring that the PFI would not finance any project that held any functional relation to coal (AIB, 2020b).

3.2 Indorama PET Recycling

The PET8 recycling scheme in collaboration with the 30th largest petrochemical company Indorama (Tullo, 2021), referred to herein as ‘IVL recycling’, marks IFC’s first blue loan which has been funded primarily by IFC’s issuances of green bonds as detailed in their FY2021 Green Bond Impact Report (IFC, 2021b). The project is receiving \$500m from the IFC green bond to primarily address marine plastic pollution, predominately in the Asia region where Indorama’s operations are prevalent (IFC, 2021a).

The IML recycling project falls under the umbrella of IFC’s ‘Green Reboot for Emerging Markets’ (IFC, 2021c), that looks to support the recovery of carbon-intensive industries, such as petrochemicals, and to ensure their uptake of greener pathways to implement “best industry practices, new business models, and technology advancements to significantly reduce emissions and bolster industry sustainability” (ibid, pp.21). The IVL recycling project is also buttressed from two other PFIs, the Asian Development Bank (ADB) contributed \$50m of financing via the Leading Asia’s Private Infrastructure Fund (LEAP) and the public finance consortium received a further \$50m from Germany based Deutsche Investitions- und Entwicklungsgesellschaft mbH (DEH), a subsidiary of the KfW group (ADB, 2020). The project will boost the capacity of Indorama’s plastic recycling plants in India, Indonesia, Thailand, the Philippines. It will also increase their PET recycling capacity in Brazil, the only aspect of the project falling outside the borders of Asia. The plants to be built under the project are expected to be fully operational by 2022 and will ensure that nearly 5 billion additional bottles are diverted from waste annually (ibid). 80% of global plastic waste comes from Asia (IFC, 2021b). By using post-consumer PET bottles as a feedstock for new bottles; Indorama is aiming for a minimum of 750,000 metric tons of recycled PET use globally by 2025 (ibid). A key feature of the investment is to create value out of waste, processing post-consumer PET bottles that would have ended up in landfill or been processed into lower-value products. This promoting of higher-value bottle-to-bottle recycling can bring significant value generating potential (ibid).

The project adheres to the IFC Green Bond Framework, which has a medium-green rating from CICERO (IFC, 2021a). The project’s success results in a relative reduction of virgin plastic use, which of course reduces the dependency on petrochemical feedstocks and draws down emissions on a relative intensity level. However, PET bottles and their increased usage, recycled or otherwise, is ultimately based on feedstocks that are derived from high-emitting infrastructure and will therefore contribute to carbon lock-in (Gills & Morgan, 2020; Alexander & Stanley, 2021; Jenkins et al, 2021). This is unless suitable bio-based alternatives are introduced. For the IFC and its affiliates, there is an opportunity to boost the sustainability credentials of their green bonds and their use of proceeds; but it will require bold measures to address multi-faceted issues such as marine plastic pollution that go beyond adaptive circular economy thinking to include stringent measures of mitigation which will have knock-on effects upon multiple ecosystems (Michaelowa, Allen, Sha, 2018).

As part of the ‘Core principles and recommendations’ in the IFC’s ‘Green Bonds Working Towards a Harmonized Framework for Impact Reporting’ (IFC, 2015) “As part of its due diligence in monitoring projects included in its green bond program, an issuer may elect to remove a project from its green bond program [...] Possible reasons for removing a project from a green bond program include, but are not limited to [...] restructuring that results in the project no longer meeting the eligibility criteria.” (ibid, pp.2). Thus, if the applicable indicators are not being met, as per the green bond framework (ibid), project funding can be withdrawn accordingly. So, if Indorama’s usage of the IFC’s bond proceeds is not consistently on track to achieving the promised deliverables on upping their PET recycling capacity, they will be deemed ineligible for the green bond’s continued support.

⁸ Polyethylene Terephthalate

4. Summary of Research Findings and Recommendations

On the basis of examination of the two clear examples found, it seems there is still a long way to go before the petrochemical industry is likely to be able to significantly change its practices and products. As noted above, this is a potential tension with their high-profile and ambitious pledges. The financial support coming from market-based mechanisms such as bonds is far too small; at the same time, finance from public development banks is not sufficient to enable the heavy lifting needed for transition let alone transformation.

The preliminary findings from the petrochemical sector are of course limited by the fact that only a very small number of green bonds exist in this large and hard-to-abate industry. Compared to the conventional or non-green bonds, their share is indeed miniscule. It is also miniscule compared to the needs of the industry, if it is to transform in any kind of meaningful way. The following must therefore be taken lightly. Nonetheless, the results do lend some albeit small support to the hope that public banks, including central banks and multilateral development banks, could, despite their steadily declining role in the industry's financing, still play a significant part in financing real transformation towards decarbonisation (Barrowclough and Finkill, 2021). Similarly, some corporate-issued bonds appear to be making incremental progress towards decarbonisation goals, but it will not be clear to see if absolute and transformative decarbonisation goals are met until after the respective dates of bond maturity. There are measures of both climate adaptation and mitigation found across the breadth of named projects receiving finance from the green bonds.

The case-study examples in this paper suggest that Indorama's IVL recycling project, backed by the World Bank green bond, could be a potentially effective use of publicly sourced financing for climate adaptation. The IVL recycling shows an example where green bond proceeds in the petrochemical industry can make a direct impact on pervasive issues of pollution such as marine-litter build-up and the externalities of virgin plastic use. Although the move towards increased circularity is certainly a step in the right direction, the superfluity inherent to the plastic bottle industry (Hawkins, 2009; Elmore, 2013; Lau, 2022) is a considerable stumbling block for a wider industry which is keen to reach decarbonising goals but has a profit dependency on a high turnover of throughput (Bauer et al, 2018; Barrowclough & Birkbeck, 2022).

AIB's extensive BTH project is a necessary move away from coal as a primary energy feedstock. However, the scale of the industry expansion in the region is furthering carbon lock-in despite a drawdown of emissions intensity with the switch from coal to gas. Thus, whether the BTH project can be considered as a low-carbon proponent of a Green Transition remains debatable.

Central recommendations from this study are that both corporate and public issuers of green bonds must adhere to the following;

- 1) Green bonds must be verified by an independent third party, with a framework that aligns with a verified dark-green rating.
- 2) Green bonds must uphold stringent eligibility criteria to be awarded financing from the bonds' use of proceeds.
- 3) Beyond eligibility criteria, there should be robust and transparent monitoring, reporting, and verification (MRV) on each project receiving green bond financing under the stated 'use of proceeds'. Verified impact reports should be completed annually and projects not realising stated deliverables within indicated timeframe should be excluded from future rounds of financing.

Further recommendations based upon this study are as follows;

- 1) Green bond indices, i.e., Bloomberg's MSCI Green Bond Index, should be independently verified by a green bond 2nd opinion provider. Indices that include >5% of bonds that are not delivering on the three central recommendations outlined, on an annual impact report basis, will be scored accordingly under a 'shades of green' rating system.

- 2) Clear outlining of projected impacts for measures of climate adaptation and climate mitigation. Green bond 2nd opinion providers should ensure a full MRV process of each green bond financed project is undertaken to ensure that absolute goals towards decarbonisation are being delivered.

More generally, even these preliminary findings suggest that it is not a good idea to rely on the bond market to finance the kinds of transformative investments needed in this sector. Out of the many billions of dollars in the bond market, only a fraction of them are designated “green” and an even smaller fraction of these are destined for the problematic petrochemical sector.

5. Takeaway Messages & Further Research Needs

Further research is still required in the mapping of how green bonds across public and corporate issuers are being used ‘on the ground’. The focus in this research paper has been the use of green bonds within the petrochemical industry. Through the use of green bonds, the petrochemical industry is seeking, to a lesser or greater degree, ways to finance activities that will help reduce their emissions, or even to become carbon-neutral, although what this means in an intrinsically carbon-defined industry has not been discussed on a global stage.

Wide-scoping PFIs such as public pension funds, development banks, and central banks are currently exposed to the high-carbon activities of the petrochemical industry, and their associated risk, through their bondholding. One issue concerns their exposure to shocks in the sector that could undermine the value of their holdings and hence their ability to deliver on obligations to their stakeholders, such as pensioners. This risk has been well discussed in the literature, starting from the “climate Minsky moment” identified by Bank of England governor general Mark Carney in 2015 and picked up by many others since then, including UNCTAD (Carney 2015; TDR 2019, Chapter IV; Matikainen, Campiglio, Zenghelis 2017; Dikau and Volz, 2021). A related issue, and one that is more directed towards financing transformation for the future, concerns the impact on the industry of their investment choices. One could argue that these PFIs have a responsibility to only invest in green bonds that maintain the highest level of MRV protocols in relation to their respective ‘use of proceeds’ within the decarbonisation efforts of the petrochemical industry. Anything less than that can perpetuate scenarios of carbon lock-in that will increase the risk profile that these PFIs are exposed to, not to mention contributing to the impacts of climate change.

In some cases, pension funds and public banks have been actively removing financial support; in others they are raising the risk profile and cost of capital to the sector or reducing their exposure in other ways. Such moves and the subsequent risk of a Climate Minsky Moment have long been forecast in public and central banking circles. Green bonds usage in the petrochemical industry are an opportunity to not only decarbonise an inherently high-emitting sector but also bring about revitalising employment opportunities that can aid the just transition ambition as global economies shift away from fossil fuel reliance. Appropriate funding, via the use of green bonds, from MDBs and Central Banks stand as an opportunity for PFIs to set the benchmark on how public money can accelerate climate ambition in an industry where it is desperately needed.

REFERENCES

- ADB - Asian Development Bank. 2018. Completion Report - People's Republic of China: Beijing–Tianjin–Hebei Air Quality Improvement–Hebei Policy Reforms Program. [online] Available at: <<https://www.adb.org/sites/default/files/project-documents/49232/49232-001-pcr-en.pdf>> [Accessed 8 January 2022].
- ADB - Asian Development Bank. 2020. Indorama Ventures Sign \$100 Million Blue Loan to Boost Recycling, Reduce Ocean Plastic Waste. [online] Available at: <<https://www.adb.org/news/adb-indorama-ventures-sign-100-million-blue-loan-boost-recycling-reduce-ocean-plastic-waste>> [Accessed 8 January 2022].
- AIIB - Asian Infrastructure Investment Bank. 2019a. Beijing-Tianjin-Hebei Low Carbon Energy Transition and Air Quality Improvement Project. [online] Available at: <https://www.aiib.org/en/projects/approved/2019/_download/china/PSI-P000323-China-Beijing-Project-PSI_final-12.12.pdf> [Accessed 8 January 2022].
- AIIB - Asian Infrastructure Investment Bank. 2019b. Asian Infrastructure Investment Bank (AIIB) People's Republic of China Beijing-Tianjin-Hebei Low Carbon Energy Transition and Air Quality Improvement Project Environmental and Social Impact Assessment and Environmental and Social Management Plan. [online] Available at: <https://www.aiib.org/en/projects/approved/2019/_download/china/BTH-Low-Carbon-Project-ESIAESMP.pdf> [Accessed 8 January 2022].
- AIIB - Asian Infrastructure Investment Bank. 2020a. Corporate Strategy Financing Infrastructure for Tomorrow. [online] Available at: <https://www.aiib.org/en/policies-strategies/strategies/.content/index/_download/AIIB-Corporate-Strategy.pdf> [Accessed 30 May 2022].
- AIIB - Asian Infrastructure Investment Bank. 2020b. AIIB and Amundi Launch Climate Change Investment Framework to Drive Asia's Green Recovery and Transition - News - AIIB. [online] Available at: <<https://www.aiib.org/en/news-events/news/2020/AIIB-and-Amundi-Launch-Climate-Change-Investment-Framework-to-Drive-Asia-Green-Recovery-and-Transition.html>> [Accessed 30 May 2022].
- AIIB - Asian Infrastructure Investment Bank. 2021. AIIB Launches Inaugural Sustainable Development Bonds Impact Report - News - AIIB. [online] Available at: <<https://www.aiib.org/en/news-events/news/2021/AIIB-Launches-Inaugural-Sustainable-Development-Bonds-Impact-Report.html>> [Accessed 7 January 2022].
- Al Mheiri, W. and Nobanee, H., 2020. Green Bonds: A Mini-Review. Available at SSRN 3538790.
- Alexander, C. and Stanley, A., 2021. The colonialism of carbon capture and storage in Alberta's Tar Sands. *Environment and Planning E: Nature and Space*, p.25148486211052875.
- Barrowclough, D. and Birkbeck, C.D., 2022. Transforming the Global Plastics Economy: The Role of Economic Policies in the Global Governance of Plastic Pollution. *Social Sciences*, 11(1), p.26.
- Barrowclough, D. and Finkill, G., 2021. Banks, Bonds and the Petrochemicals/Plastics Industry: Greening the Path from Copenhagen Agreement, Covid and Beyond. UNCTAD Research Paper No. 69.
- Bauer, F. and Fontenit, G., 2021. Plastic dinosaurs–Digging deep into the accelerating carbon lock-in of plastics. *Energy Policy*, 156, p.112418.
- BASF Green Finance Framework. 2018. [online] Available at: <https://www.basf.com/global/documents/en/investor-relations/creditor-relations/bonds/green-finance/BASF_Green-Finance-Framework.pdf> [Accessed 29 May 2022].

Green finance and decarbonization of petrochemicals:

Slim pickings in a crucial but hard-to-abate industry

- Bauer, F., Ericsson, K., Hasselbalch, J., Nielsen, T. and Nilsson, L.J., 2018. Climate innovations in the plastic industry: Prospects for decarbonisation.
- Bauer, F. and Fontenit, G., 2021. Plastic dinosaurs—Digging deep into the accelerating carbon lock-in of plastics. *Energy Policy*, 156, p.112418.
- Bloomberg MSCI. 2021. Bloomberg MSCI Green Bond Indices. [online] Available at: <<https://www.msci.com/documents/1296102/26180598/BBG+MSCI+Green+Bond+Indices+Primer.pdf>> [Accessed 26 May 2022].
- Bolton, P., Buchheit, L., Gulati, M., Panizza, U., Weder di Mauro, B. and Zettelmeyer, J., 2022. Climate and Debt. [online] CEPR. Available at: <<https://cepr.org/voxeu/columns/climate-and-debt>> [Accessed 9 October 2022].
- Bork, H. and Rais, A., 2020. Tianjin to Become the Leading Center for Petrochemicals in Northern China. [online] *Process-worldwide.com*. Available at: <<https://www.process-worldwide.com/tianjin-to-become-the-leading-center-for-petrochemicals-in-northern-china-a-969896/>> [Accessed 8 January 2022].
- Brown, M.A., Chandler, J., Lapsa, M.V. and Sovacool, B.K., 2008. Carbon lock-in: barriers to deploying climate change mitigation technologies (No. ORNL/TM-2007/124). Oak Ridge National Lab.(ORNL), Oak Ridge, TN (United States); Georgia Institute of Technology, Atlanta, GA (United States).
- CBI - Climate Bonds Initiative. 2021. Climate Bonds Initiative. [online] Available at: <<https://www.climatebonds.net/>> [Accessed 25 November 2021].
- CICERO - Center for International Climate Research. 2022. Second opinions on green bonds - Cicero. [online] Available at: <<https://www.cicero.oslo.no/en/posts/single/CICERO-second-opinions>> [Accessed 12 January 2022].
- Dikau, S. and Volz, U., 2021. Central bank mandates, sustainability objectives and the promotion of green finance. *Ecological Economics*, 184, p.107022.
- Dorflleitner, G., Utz, S. and Zhang, R., 2021. The pricing of green bonds: external reviews and the shades of green. *Review of Managerial Science*, pp.1-38.
- Dow. *Corporate.dow.com*. 2020. Sustainability Targets. [online] Available at: <<https://corporate.dow.com/en-us/science-and-sustainability/commits-to-reduce-emissions-and-waste.html>> [Accessed 16 January 2022].
- Ehlers, T. and Packer, F., 2017. Green bond finance and certification. *BIS Quarterly Review* September.
- Elmore, B.J., 2013. Citizen Coke: an environmental and political history of the Coca-Cola Company. *Enterprise & Society*, 14(4), p. 717-731.
- Fatica, S. and Panzica, R., 2021. Green bonds as a tool against climate change?. *Business Strategy and the Environment*, 30(5), pp.2688-2701.
- Fisch-Romito, V., Guivarch, C., Creutzig, F., Minx, J.C. and Callaghan, M.W., 2021. Systematic map of the literature on carbon lock-in induced by long-lived capital. *Environmental Research Letters*, 16(5), p.053004.
- Flammer, C., 2021. Corporate green bonds. *Journal of Financial Economics*.
- Friedrich, J. and Damassa, T., 2014. The History of Carbon Dioxide Emissions. [online] World Resources Institute. Available at: <<https://www.wri.org/insights/history-carbon-dioxide-emissions>> [Accessed 25 November 2021].

Green finance and decarbonization of petrochemicals:

Slim pickings in a crucial but hard-to-abate industry

- García-Lamarca, M. and Ullström, S., 2020. "Everyone wants this market to grow": The affective post-politics of municipal green bonds. *Environment and Planning E: Nature and Space*, p.2514848620973708.
- Gills, B. and Morgan, J., 2020. Global climate emergency: After COP24, climate science, urgency, and the threat to humanity. *Globalizations*, 17(6), pp.885-902.
- Global Times. 2021. Sinopec to achieve carbon neutrality in 2050, 10 years ahead of national goal - Global Times. [online] Available at: <<https://www.globaltimes.cn/page/202103/1219712.shtml>> [Accessed 16 January 2022].
- Hawkins G (2009) The politics of bottled water: assembling bottled water as brand, waste and oil. *Journal of Cultural Economy* 2(1–2): 183–195.
- ICMA. 2021. Green Bond Principles » ICMA - International Capital Market Association. [online] Available at: <<https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/>> [Accessed 8 January 2022].
- IEA, 2018. International Energy Agency. The Future of Petrochemicals Towards more sustainable plastics and fertilisers. [online] Available at: <https://iea.blob.core.windows.net/assets/bee4ef3a-8876-4566-98cf-7a130c013805/The_Future_of_Petrochemicals.pdf> [Accessed 25 November 2021].
- IEA, 2021. - International Energy Agency. Net Zero by 2050 A Roadmap for the Global Energy Sector. [online] Available at: <https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroBy2050-ARoadmapfortheGlobalEnergySector_CORR.pdf> [Accessed 25 November 2021].
- IFC - World Bank International Finance Corporation. 2015. Green Bonds Working Towards a Harmonized Framework for Impact Reporting. [online] Available at: <<https://www.ifc.org/wps/wcm/connect/35c1cd76-b75f-474c-815a-dfb876543a22/Updated+logo+FINALPROPOSALIRH+CLEAN.pdf?MOD=AJPERES&CVID=mHrR8w4>> [Accessed 26 May 2022].
- IFC - World Bank International Finance Corporation. 2021a. CICERO Shades of Green - International Finance Corporation Green Bond Second Opinion. [online] Available at: <<https://www.ifc.org/wps/wcm/connect/d16622e0-38b0-4947-b69b-a73e6971f420/Cicero+SPO+IFC+Green+Bond+Program.pdf?MOD=AJPERES&CVID=nMh.euC>> [Accessed 7 January 2022].
- IFC - World Bank International Finance Corporation. 2021b. GREEN BOND IMPACT REPORT Financial Year 2021. [online] Available at: <https://www.ifc.org/wps/wcm/connect/0db566bb-d24e-4e46-a4d4-a7c5b508d1de/FY21+Green+Bond+Impact+Report_Final.pdf?MOD=AJPERES&CVID=nN.g3ZH> [Accessed 8 January 2022].
- IFC - World Bank International Finance Corporation. 2021c. A GREEN REBOOT FOR EMERGING MARKETS - KEY SECTORS FOR POST-COVID SUSTAINABLE GROWTH. [online] Available at: <https://www.ifc.org/wps/wcm/connect/79ef3830-ff20-4430-ad10-c0cf01e93a42/IFC_GreenReport_FINAL_web_1-14-21.pdf?MOD=AJPERES&CVID=nx64Q7F> [Accessed 8 January 2022].
- Immel, M., Hachenberg, B., Kiesel, F. and Schiereck, D., 2021. Green bonds: shades of green and brown. *Journal of Asset Management*, 22(2), pp.96-109.
- Inclusive Development International. 2021. China Global Newsletter - The Asian Infrastructure Investment Bank (AIIB). [online] Available at: <https://www.inclusivedevelopment.net/china-global-program/china-global-newsletter-edition-5/?__cf_chl_f_tk=nMZgdaA7LrGbJPeA9i937vErf6SGuoWGz1FYIuAjlLc-1642357969-0-gaNycGzNCKU> [Accessed 16 January 2022].
- INEOS. 2021. Our Journey to Net Zero | INCH Magazine Issue 22. [online] Available at: <<https://www.ineos.com/inch-magazine/articles/issue-22/our-journey-to-net-zero/>> [Accessed 16 January 2022].

Green finance and decarbonization of petrochemicals:

Slim pickings in a crucial but hard-to-abate industry

- Jenkins, S., Mitchell-Larson, E., Ives, M.C., Haszeldine, S. and Allen, M., 2021. Upstream decarbonization through a carbon takeback obligation: An affordable backstop climate policy. *Joule*, 5(11), pp.2777-2796.
- Lau, J.C.H., 2022. Towards a care perspective on waste: A new direction in discard studies. *Environment and Planning C: Politics and Space*, p.23996544211063383.
- LG Chem. 2021. LG Chem, Ltd. GREEN FINANCING FRAMEWORK. [online] Available at: <http://www.lgchem.com/upload/file/sustainability/LG_Chem_Green_Financing_Framework.pdf> [Accessed 29 May 2022].
- Li, M., Wiedmann, T. & Hadjikakou, M. 2020, "Enabling Full Supply Chain Corporate Responsibility: Scope 3 Emissions Targets for Ambitious Climate Change Mitigation", *Environmental science & technology*, vol. 54, no. 1, pp. 400-411.
- LyondellBasell. 2021. LyondellBasell Announces Goal of Achieving Net Zero Emissions by 2050. [online] Available at: <<https://www.lyondellbasell.com/en/news-events/corporate--financial-news/lyondellbasell-announces-goal-of-achieving-net-zero-emissions-by-2050/>> [Accessed 16 January 2022].
- Mah, A., 2021. Ecological crisis, decarbonisation, and degrowth: The dilemmas of just petrochemical transformations. *Stato e mercato*, 41(1), pp.51-78.
- Masterson, V., 2020. World Economic Forum. As Canada bans bags and more, this is what's happening with single-use plastics today. [online] World Economic Forum. Available at: <<https://www.weforum.org/agenda/2020/10/canada-bans-single-use-plastics/>> [Accessed 25 November 2021].
- Matikainen, S., Campiglio, E. and Zenghelis, D., 2017. The climate impact of quantitative easing. Policy Paper, Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, 36.
- Mazzucato, M., 2011. The entrepreneurial state. *Soundings*, 49(49), pp.131-142.
- Meys, R., Frick, F., Westhues, S., Sternberg, A., Klankermayer, J. and Bardow, A., 2020. Towards a circular economy for plastic packaging wastes—the environmental potential of chemical recycling. *Resources, Conservation and Recycling*, 162, p.105010.
- Michaelowa, A., Allen, M. and Sha, F., 2018. Policy instruments for limiting global temperature rise to 1.5° C—can humanity rise to the challenge?. *Climate Policy*, 18(3), pp.275-286.
- Offshore Technology. 2021. Sinopec SABIC Tianjin Petrochemical Tianjin Complex, China. [online] Offshore Technology. Available at: <<https://www.offshore-technology.com/marketdata/sinopec-sabic-tianjin-petrochemical-tianjin-complex-china/>> [Accessed 8 January 2022].
- Partington, R., 2018. Mark Carney warns of climate change threat to financial system. [online] the Guardian. Available at: <<https://www.theguardian.com/business/2018/apr/06/mark-carney-warns-climate-change-threat-financial-system>> [Accessed 4 October 2022].
- Pollin, R., 2021. The industrial policy requirements for a global climate stabilization project. *International Review of Applied Economics*, 35(3-4), pp.389-406.
- Rashad, M., 2021. [online] Available at: <<https://www.reuters.com/business/cop/saudi-sabic-targets-carbon-neutrality-by-2050-statement-2021-10-23/>> [Accessed 16 January 2022].
- Seto, K.C., Davis, S.J., Mitchell, R.B., Stokes, E.C., Unruh, G. and Ürge-Vorsatz, D., 2016. Carbon lock-in: types, causes, and policy implications. *Annual Review of Environment and Resources*, 41, pp.425-452.

Green finance and decarbonization of petrochemicals:

Slim pickings in a crucial but hard-to-abate industry

- Shishlov, I., Morel, R. and Cochran, I., 2016. Beyond transparency: unlocking the full potential of green bonds. Institute for Climate Economics, pp.1-28.t
- SK Innovation - GREEN FINANCING FRAMEWORK. 2019. Green Financing. [online] Available at: <<http://eng.skinnovation.com/ir/greenloan.asp>> [Accessed 29 May 2022].
- Sustainalytics. 2021. AIB Company ESG Risk Rating – Sustainalytics. [online] Available at: <<https://www.sustainalytics.com/esg-rating/the-asian-infrastructure-investment-bank/2004822920>> [Accessed 7 January 2022].
- Sustainalytics. 2022. Green and Sustainability Bonds. [online] Available at: <<https://www.sustainalytics.com/corporate-solutions/sustainable-lending-and-finance/second-party-opinions/second-party-opinions-for-green-bonds>> [Accessed 16 January 2022].
- Tullo, A., 2021. C&EN's Global Top 50 chemical firms for 2021. [online] C&EN. Available at: <<https://cen.acs.org/business/finance/CENs-Global-Top-50-2021/99/i27>> [Accessed 8 January 2022].
- UNCTAD 2019 Financing a Global Green New Deal. Trade and Development Report 2019. United nations: Geneva and New York.
- UNCTAD 2021. Trade and Development Report 2021 - From recovery to resilience: the development dimension. [online] Available at: <https://unctad.org/system/files/official-document/tdr2021_en.pdf> [Accessed 29 May 2022].
- Vollmer, I., Jenks, M.J., Roelands, M.C., White, R.J., van Harmelen, T., de Wild, P., van Der Laan, G.P., Meirer, F., Keurentjes, J.T. and Weckhuysen, B.M., 2020. Beyond mechanical recycling: Giving new life to plastic waste. *Angewandte Chemie International Edition*, 59(36), pp.15402-15423.
- Wang, D.D. & Sueyoshi, T. 2018, "Climate change mitigation targets set by global firms: Overview and implications for renewable energy", *Renewable & sustainable energy reviews*, vol. 94, pp. 386-398.

APPENDIX

Countries that had green bonds issued as recognised by the Bloomberg MSCI Green Bond Index, July 2021

Table 6 - 36 Countries with 463 Investable Green Bonds. Bloomberg MSCI Green Bond Index, July 2021

Argentina (3)	Australia (6)	Belgium (1)	Brazil (2)	Canada (27)	Chile (4)
China (12)	Denmark (5)	Egypt (2)	Fiji (2)	Finland (6)	France (44)
Germany (5)	Hong Kong (8)	Hungary (4)	Latvia (1)	Lithuania (1)	Iceland (1)
India (7)	Ireland (1)	Italy (1)	Indonesia (9)	Japan (39)	Korea (32)
Mexico (2)	Netherlands (22)	New Zealand (3)	Nigeria (2)	Norway (13)	Pakistan (1)
Poland (4)	South Africa (1)	Spain (8)	Sweden (109)	Switzerland (8)	USA (67)

Green finance and decarbonization of petrochemicals:
Slim pickings in a crucial but hard-to-abate industry

Public (Bilateral and Multilateral) Development Banks Assessed for Green Bond Issuances

Table 7 - Development Banks Assessed for Green Bond Issuances

Development Bank	Green/Sustainability Bond(s) Issued
African Development Bank (AfDB)	Yes
Arab Bank for Economic Development in Africa (BADEA)	No
Arab Petroleum Investments Corporation (APICORP)	Yes
Asian Development Bank (ADB)	Yes
Asian Infrastructure Investment Bank (AIIB)	Yes
Black Sea Trade and Development Bank (BSTDB)	No
Caribbean Development Bank (CDB)	No
CEB Council of Europe Development Bank	No
Central American Bank for Economic Integration (CABEI)	Yes
Climate Investment Funds (CIF)	Yes
Development Bank of Latin America (CAF)	Yes
East African Development Bank (EADB)	No
Eastern and Southern African Trade and Development Bank (TDB)	No
Economic Cooperation Organization Trade and Development Bank (ETDB)	No
Eurasian Development Bank (EDB)	Yes
European Bank for Reconstruction and Development (EBRD)	Yes
European Commission	Yes
European Investment Bank (EIB)	Yes
Inter-American Development Bank (IADB)	Yes
International Fund for Agricultural Development (IFAD)	No
International Investment Bank (IIB)	No
Islamic Development Bank (IDB)	Yes
New Development Bank (NDB)	Yes
Nordic Investment Bank (NIB)	Yes
North American Development Bank (Nadbank)	Yes
OPEC Fund for International Development (OFID)	No
West African Development Bank (BOAD)	Yes
World Bank International Bank for Reconstruction and Development (IBRD)	Yes
World Bank International Finance Corporation (IFC)	Yes

