The role of finance in the energy transition

E4S White Paper

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January 2023

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Many thanks to Carla Schmid, Oscar Vosshage, and Nicolas Wille for the research support, to Dominik Breitinger (E4S), Edoardo Chiarotti (E4S), Boris Thurm (E4S), and Jordane Widmer (E4S) for the precious feedback, and to Gino Baudry (EPFL-LEURE), Marc Briol (Pictet), Marie-Laure Schaufelberger (Pictet), Laure Castella (Retraites Populaires) and Jean-Christophe Van Tilborgh (Retraites Populaires) for the insightful discussions.

Enterprise for Society (E4S) is a joint venture of the University of Lausanne through its Faculty of Business and Economics (UNIL-HEC), the Institute for Management Development (IMD) and the Ecole Polytechnique Fédérale de Lausanne (EPFL), under the stewardship of its College of Management of Technology, with the mission of spearheading the transition towards a more resilient, sustainable and inclusive economy. E4S is committed to training the next generation of leaders, inspiring economic and social transformation, and promoting change by strengthening start-ups and boosting innovation.

This project was conducted under the aegis of a partnership with Retraites Populaires and Pictet Asset Services.

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EXECUTIVE SUMMARY

Transitioning away from carbon-intensive energy sources in the next decade is crucial. The fossil-fuel sector generates almost 80% of the energy consumed today and accounts for more than two-thirds of global greenhouse gas (GHG) emissions. To avoid the environmental and social impacts of increasing GHG emissions, it is necessary to keep the global atmospheric temperature change below +1.5°C compared to pre-industrial levels. At current emissions rates, this threshold will already be reached in nine years.

Finance can play a role in the decarbonization of the energy sector by divesting, engaging, and financing. This role is twofold: help foster the transition of emission-intensive sectors and invest in low-carbon alternatives. Finance has three levers that it can pull to do so, generally in tandem: 1) divesting, that is, excluding reprehensible actors from portfolios, 2) engaging with firms with the goal of altering their behaviours, and 3) financing the development of cleantech businesses and the transition of dirtier ones.

Firms' business activities, their ability to transition and their specific environment are key in the investor's choice between divesting, engaging, or financing. While some fossil-fuel companies are pure-players and focus on one type of operations, others, like oil and gas integrated firms, tend to cover a wide range of activities and are thus exposed to changes throughout the entire energy value chain. Energy firms have approached the transition in different ways from reducing operational emissions, to investing in low-carbon energy projects and, sometimes, more drastically, to divesting fossil-fuel business lines. But, for most, transitioning would mean completely rebuilding core business activities. Home-countries' transition agenda is a major influence on how firms, and state-owned companies in particular, approach the energy transition.

Divestment fails to incentivize fossil-fuel firms to transition, as alternative funding options are available, and transitioning, i.e., shifting its core business, is often more costly than the financial and reputational cost of being divested. The following three impact channels of divestment fall short of expectations:

1. Capital rationing. Divestment of bond and equity portfolios will rarely threaten the survival of the fossil-fuel sector as it can access alternative sources of financing, and sometimes at a lower cost.

2. Negative shock on stock prices. Sectoral divestment and its associated negative shock on stock price is not enough to incentivize change: best-in-class exclusion is more promising when the cost of reform is low, and management's remuneration is particularly affected by lower stock prices. But the cost of shifting business activities to reduce indirect (Scope 3) emissions – which account for the majority of fossil-fuel firms' – is very high and managerial compensation is only rarely tied to performance metrics effectively considering the energy transition.

3. Stigmatisation can challenge the industry's social license to operate and help reshape the public debate. Firms have however not reacted as expected and often used lobbying, greenwashing, and misinformation as a response to criticism and stigmatisation, rather than taking action to address their environmental impact.

Engagement aims at reducing emissions in the real economy by opening a dialogue with fossil-fuel firms. Considering the cost of transitioning and the frequent involvement of states in fossil-fuel firms, engaging requires both a firm-level and system-wide approach. Firm-level engagement focuses on the specific firm's environmental performance and in particular on disclosure of climate-related information, emission reduction targets, climate strategy plan implementation, and climate-governance practices. System-wide engagement considers the market performance as a whole and include interactions with other market stakeholders including collaborative engagement initiatives, banks financing fossil projects, and civil society actors.

Engagement with fossil-fuel firms about GHG emissions may not be as effective as with other sectors because of the high cost and uncertainty of the requested shift in core activities. While most engaged polluting fossil companies have started setting climate targets and establishing climate-governance practices, they are not yet walking the talk and most often fail to align capital allocation with global emission reduction objectives. Even if a company responds positively to shareholders' climate-related requests, it may take time and recurring efforts for engagement to result in actual emission reductions and Paris-Agreement-aligned capital allocation. This is particularly true for fossil-fuel pure-players and vertically-integrated firms that are required to significantly shift core business activities [53]. Involving other civil society actors, such as firms' capital providers or policymakers, is necessary to increase the pressure and create the adequate incentives for change.

Pro-climate investments have a more tangible impact on firms as it directly finances projects and operations. Financial institutions have a dual role as capital providers: increasing financing for clean energy projects while supporting transitions to low-emission activities. Investors who want to support the energy transition can do so through:

1. Early-stage financing. Early-stage tech firms are key to achieve the rapid energy transformation needed. They require smaller amount of capital and may seek funding through grants, crowdfunding, or other early-stage funding options. Policy and market uncertainty, perception of public support dependency, and firms' high failure rates can however create barriers to financing. State-investment banks and policy makers can help lower these barriers.

2. Debt financing. More established energy firms are primarily funded through bonds and loans. Banks and other financial institutions can incentivize energy firms to support the transition by offering alternative, pro-transition forms of debt financing, i.e., green and sustainability-linked debt. Barriers to financing persist, however, and stem from the fear of greenwashing – in particular from the lack of credibility of the instruments, of official reporting standards and of ambition in sanctions and targets – as well as from sustainable-debt financial characteristics.

3. Equity financing. Although it is less often employed than debt financing, equity financing can take place through traditional private equity and public market offerings, yield companies and special purpose acquisition vehicles (SPAC). Equity financing could play an important role in financing capital-intensive renewable projects, which are too large for early-stage investors and too risky for traditional banks.

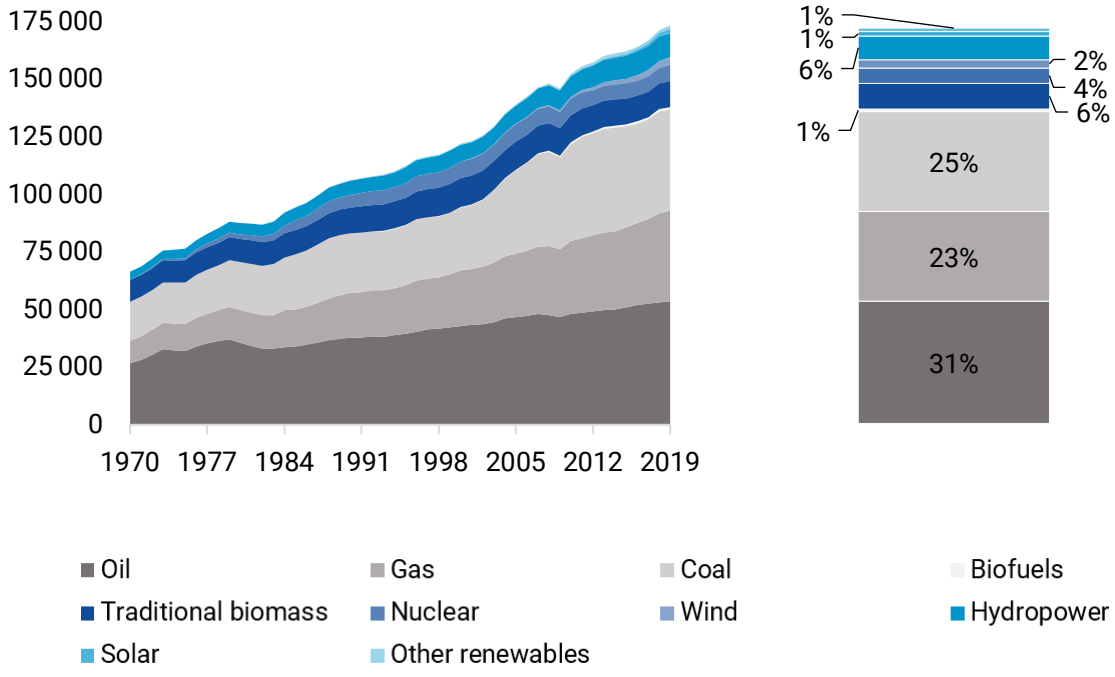
KEY TAKEAWAYS

1. Transitioning away from carbon-intensive energy sources in the next decade is crucial and finance can play a role in the decarbonization of the energy sector by 1) divesting from polluting firms, 2) engaging with them to change their behaviours, and 3) financing the development of cleantech businesses and the transition of dirtier ones
2. **Divestment** fails to incentivize fossil-fuel firms to transition, as alternative funding options are available, and transitioning, i.e., shifting its core business, is often more costly than the financial and reputational cost of being divested.
3. **Engagement** with fossil-fuel firms about GHG emissions may not be as effective as with other sectors because of the cost and uncertainty of the requested shift in core activities combined with the predominance of state-owned producers.
4. **Pro-climate investments** have a more tangible impact on firms as they directly finance clean energy and transition projects, through early-stage financing, debt, and equity.
5. Overall, the best way to achieve the transition is through a massive **decrease in the demand** for fossil fuels. Finance can judiciously accompany the movement but it cannot be a substitute for the essential role of governments and fossil fuel users.

1 INTRODUCTION

Transitioning away from carbon-intensive energy sources in the next decade is crucial. Almost 80% of the energy consumed today comes from fossil fuels (Figure 1) and the sector itself accounts for more than two-thirds of global greenhouse gas (GHG) emissions[1] (Figure 2) [1], [2]. Since 1990, the Intergovernmental Panel on Climate Change (IPCC) has been warning of the climatic consequences of these **anthropogenic GHG emissions**, released at fossil-fuel combustion (combustion emissions) and production (fugitive emissions) [3]. The rising levels of atmospheric concentration of GHG are changing global temperature and **precipitation patterns**. This in turn alters the entire climate system and can cause various economic and social damages, including decreased crop yield and agricultural productivity [4], biodiversity loss [5], decreased labour productivity and increasing work-related injuries [6]. To avoid these environmental and social impacts, it is necessary to keep the global atmospheric temperature change below +1.5°C compared to pre-industrial levels. Global temperature change has already risen to +1.1°C since 1850-1900 [7] and the **remaining carbon budget** to limit it to +1.5°C is estimated to be 380 $GtCO_2$[2]. At the 2022 emission rates of 40.5$GtCO_2$ per year, this carbon budget will be spent in nine years from now. To reach net-zero objectives by 2050, anthropogenic CO_2 emissions would need to decrease linearly by 1.4 $GtCO_2$ per year, which is equivalent to what has been observed in 2020 during the Covid-19

Figure 1: Global energy consumption in TWh (left) and global energy mix in 2019 (right)

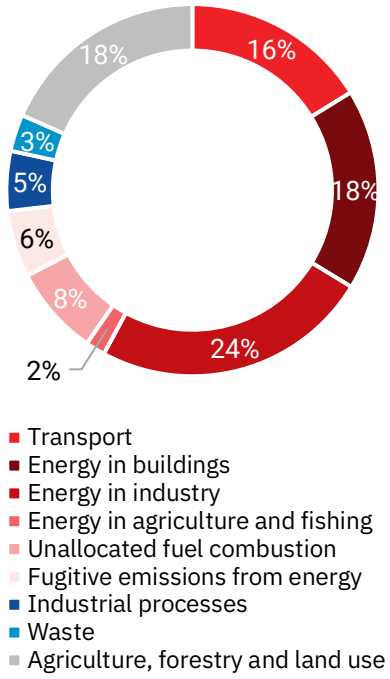


Source: Ritchie & Roser (2020)[1]

[1] Greenhouse gas include carbon dioxide, methane, nitrous oxide, and many others.

[2] This budget refers to the carbon budget for a 50% chance of limiting temperature rise to +1.5°C above pre-industrial level from beginning of 2023 and assuming 2022 emission levels [8].

Figure 2: Global greenhouse gas emissions by sector in 2016



Note: The energy sector is represented in red shades, by Transport, Energy in buildings, Energy in industry, Energy in agriculture and fishing, Unallocated fuel combustion and Fugitive emissions from energy (73.2% of total global GHG emissions). Source: Ritchie & Roser (2020) [2].

pandemic [8].[3] Hence, our society must 1) drastically reduce its reliance on fossil-fuel resources and 2) rapidly transition from a carbon-intensive energy system to carbon-free one [10].

Substituting fossil fuels is today's labour of Hercules. Fossil fuels have energy as well as non-energy purposes. Crude oil is substantially used to produce fuels for the transportation sector, e.g., diesel, kerosene, and gasoline, but also for lubricant and asphalt production. Coal and natural gas are primarily used to generate electricity but are also key element in industrial manufacturing processes.[4] Aside from transport, industrial and non-energy uses, oil, coal and gas are also often consumed for heating. Substituting fossil products for all these applications is not trivial and many policy, system-wide, infrastructure and technology barriers remain. This analysis will not focus on all fossil-fuel applications or these barriers but rather on how finance could create incentives to foster the transition to a low-carbon energy sector.

Finance has a role to play to drive the decarbonization of the energy sector. This role is two-fold: financial actors can help foster the transition of emission-intensive sectors and invest in low-carbon businesses. Finance has three levers that it can pull to do so, generally in tandem: divesting reprehensible actors (Section 3), engaging with firms with the goal of altering their behaviours (Section 4), and financing the development of cleantech businesses and the transition of dirtier ones (Section 5). The objective of this analysis is to evaluate the effectiveness and the limits of these three levers in the context of the **energy transition**.[5] But to assess the potential of finance in supporting this transition, it is necessary to get an understanding of the variety of actors associated to the energy sector supply chain and their particularities (Section 2).

[3] Consequently, the majority of Earth's known fossil fuel reserves – representing the equivalent 3,700 $GtCO_2$ emissions – must stay in the ground to keep global temperature rise below +1.5°C [9].
[4] The iron and steel production heavily depends on coal, for instance.
[5] Energy transition should not be confused with energy addition. The first one refers to transitioning away from already established energy sources and therefore declining their use in the energy system, whereas the second one indicates the development of infrastructure and the expansion of a new source of energy. Our societies have experienced energy transitions – when the existing energy sources were getting used up – as well as energy additions – which historically have led to an overall increase in the energy produced without the complete substitution of other energy types [11], [12]. In the climate change context, the ultimate goal of the energy transition is to decarbonize the energy system in order to prevent the rise of global atmospheric temperatures, while still having access to profitable fossil fuel reserves. Clean energy sources should therefore rather be used to replace fossil fuels, not to increase energy production and consumption [11], [13].

2 ACTORS OF THE TRANSITION

2.1 THE ENERGY SUPPLY CHAIN

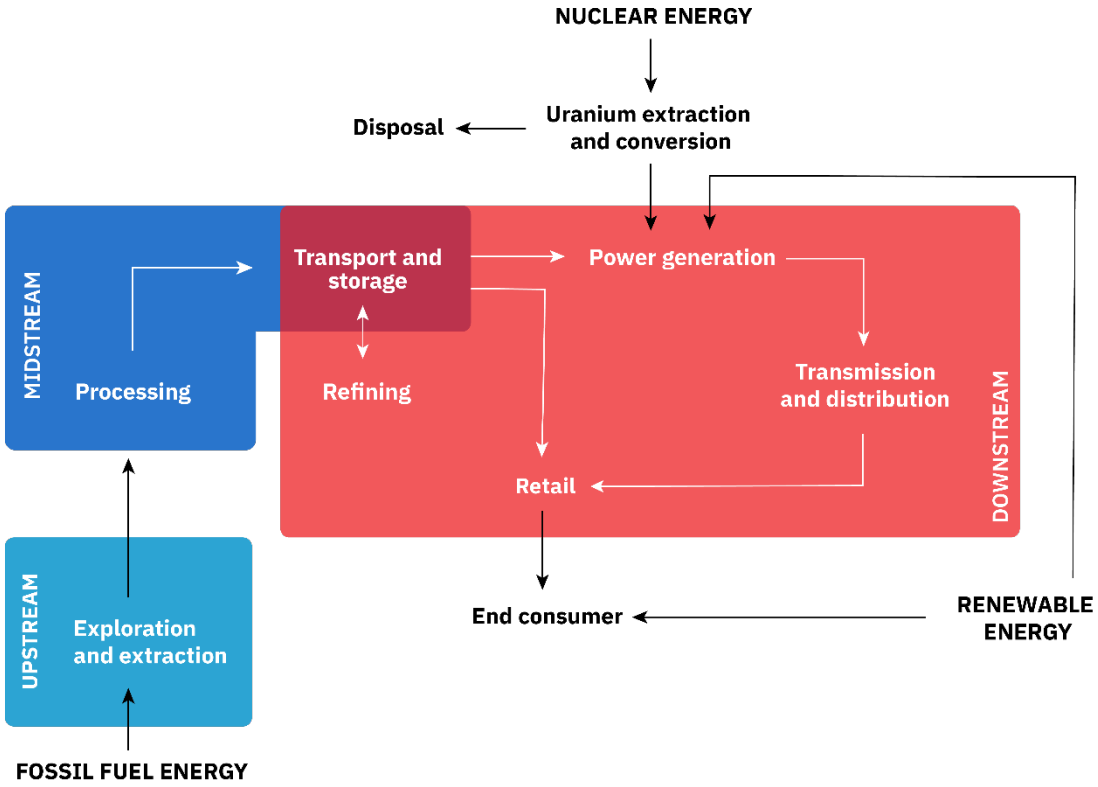
The energy sector is a central component in any country's economy, as it ensures its population well-being and fosters economic development. The energy supplied can be categorized based on how it is produced and generally fall between three categories: fossil fuel, nuclear and renewable. Renewables as well as nuclear energy, which are both low-carbon energy sources, are purely used for electricity and heat generation, while fossil fuels are also used for combustion-engine transport and non-energy usage.

Understanding the range of business activities in the energy sector is essential for investors willing to support the transition. Getting the energy extracted or produced to the market involves a variety of firms and, while some are specialized in one type of energy source, others can engage in both renewable and non-renewable energy (Figure 3)[14].[6] The firm's business activities and ability to transition will be key in the investor's choice of divesting, engaging or financing.

Fossil fuel firms are typically classified into upstream, midstream, and downstream operation categories. Oil and gas leaders or majors, such as Shell or ExxonMobil, typically engage in upstream, midstream and downstream activities (Box 1).

Upstream refers to fuel exploration and extraction and includes oil and gas well

Figure 3: Simplified energy supply chain



[6] Sector classification is generally based on firms' business lines contributions to total revenues or earnings. When a firm's activities are substantially diversified, it can be considered as an industrial conglomerate or multi-sector holding firm [14].

drilling contractors, equipment manufacturers, as well as miners and producers of coal and other related products.

Midstream activities link the upstream and downstream parts of the value chain and refer to processing activities – e.g., during which oil and gas are separated – as well as storage and transport. Midstream actors namely include oil and related product pipelines, coal slurry pipelines and oil and gas shipping companies.

Downstream refers the final processes of converting fossil fuels to finished products and distributing them. Downstream firms can be refining and marketing firms, electricity and heating producers, distributors, and traders, and fuel retailers.

Nuclear energy value chain essentially consists of uranium extraction and conversion, reactor operation, disposal of nuclear waste, and power generation, transmission, and distribution.

Renewable energy firms engage in the electricity generation and distribution using, among others, biomass, geothermal, solar, hydro, and wind power. Other actors revolve around the industry by manufacturing capital equipment such as solar power systems and photovoltaic cells.

Box 1: Oil and gas majors

Oil and gas majors are a central component of the energy transition and exposed to changes across their value chain. While some fossil-fuel companies are pure-players and focus on one type of operations, oil and gas majors tend to cover most of the value chain and as such, are referred to as integrated oil and gas companies [14].[7] They are importantly exposed to market-environment changes both on upstream and downstream business lines, in particular to 1) pressures from governments and society about the climate impact of their products and activities, 2) geopolitical instability, 3) competition from mature renewable substitutes as well as 4) safety, environmental and financial implications of operating and extracting resources in difficult locations [15].

Integrated oil and gas companies attempt to transform into integrated energy companies to lower these exposures. Several fossil-fuel majors have recently announced their willingness to contribute to the energy transition, sometimes together with renewable capacity targets and climate strategy plans. Fossil-fuel firms seeking to diversify their energy operations frame their strategic decisions and investments based on low-carbon sectors' attractiveness relative to their competitive position and capabilities. In particular, fossil-fuel firms appear well-suited to develop in areas such as geothermal, solar photovoltaics, and offshore wind energy as well as carbon capture, utilization and storage (CCUS) technologies and hydrogen [16]–[18].[8] Despite climate strategy announcements, companies' investments in renewable energy are, however, falling short compared to those in fossil fuels and related financial disclosures are unclear.[9]

[7] Vertical integration can remove operational and financial inefficiencies, reduce price volatility risk, and provide a direct contact with the industry end-market, which in turn allow firms to better respond to changing market demands.
[8] Oil and gas firms' drilling expertise and innovation can help scale deep geothermal energy in a cost-effective way [18], [19], while their technical capacities in offshore facilities and floating systems can be translated to offshore wind energy [17], [18].
[9] Between 2015 and 2019, less than 1% of the capital expenditures of large oil and gas companies were spent on low-carbon activities [17]. Also, low-carbon investments not only include renewable investments but also CCUS technologies [17], [20].

2.2 Energy firms: The Good, The Bad and The Ugly

Energy firms approach the energy transition in different ways and an investor's decision to divest, engage or finance will depend on where a company sits on the "green-spectrum". As a result of market, government, and social pressures as well as dwindling reserves, some fossil fuel firms have started to shift their business strategies in this direction.[10] Others however keep the transition at the bottom of their agenda. Below are some examples of how companies conducted or are conducting their low-carbon transition.

Renewable energy power companies sit on the greenest corner in terms of carbon emissions. Some of them originally came from the fossil fuel industry and recently transitioned to renewable activities. In 2009, when about 85% of its generation mix was coming from fossil sources, the Danish multinational Ørsted undertook a major strategic shift: heavily invest in offshore wind, phase out of coal, and reach an 85% renewable and 15% conventional fuel split by 2040.[11] The firm, now positioned among top green power generators, is expecting to completely exit coal in 2023 and have carbon-neutral power generation in 2025 [21], [22].

Some oil and gas majors invest in renewables across their value chain from generation to storage and supply. This is generally done through company acquisition or joint venture. TotalEnergies, which is considered one of the front-runners in adjusting its core business from oil and gas to a full energy company [23], has been diversifying along the value chain by initiating several of such partnerships - more recently in Brazil, the US and India, in onshore-wind infrastructure and storage facilities, and green hydrogen.[12]

Other players simply consider renewables as a way to diversify their investment portfolio and hedge against transition risk and do not intend to fundamentally change their core strategy. In 2021, Brazilian state-controlled company Petrobras for instance announced its intention of only investing in renewable research rather than operational assets [27]. Shortly after, it decided to exit wind and hydroelectric activities and focus on investing in biofuels and CCUS technologies, with the objectives of decarbonizing operations and aligning portfolio strategy with shareholder value creation [28], [29].

At the very bottom of the green spectrum sit companies with weak governance practices and which are regularly subject to environmental controversies. Often these companies are located in developing countries with risk of economic collapse, conflicts and corruption [30]. Venezuelan state oil company PDVSA for instance self-reported more than 46,000 oil spills between 2010 and 2016. This number – that keeps growing daily in certain regions of the country – is the result of poor infrastructure, lack of capital and technical expertise and weak governance practices.

[10] Actions range from reducing operational emissions e.g., with investments in CCUS technologies, to investing in low-carbon energy projects and sometimes more drastically to divesting fossil-fuel business lines.

[11] Management's decision came after a failed attempt to develop a new coal-fired power plant project in Northeast Germany, following strong local opposition, and the global renewable-energy agenda of Copenhagen Accords supported by Denmark and the firm's board of directors [21].

[12] In 2022, French energy provider took a 34% stake into a joint venture created with Brazilian leading onshore-wind developer Casa dos Ventos [24], acquired a majority stake of US renewable player Clearway Energy Group owning solar and wind assets and storage facilities [25], and entered a partnership with Indian fully integrated green-hydrogen player Adani, acquiring a 25% minority interest to "pioneer the production of green hydrogen"[26].

Although oil remains a central component of the Venezuelan economy, it has tremendous negative impacts on other sectors of the local economy such as tourism and fishery [31]. Companies in this category are expected to extract resources and generate revenues until their assets become entirely stranded and do not have transition plans at the top of their priority list [30].

The location of a company can influence how it approaches the energy transition. As firms deciding to invest in renewable energy often start in their home-country [32], countries' transition agenda plays a central role in the strategic approach adopted by fossil firms and even more by state-owned companies (Box 2). European fossil majors tend to expand their activities beyond oil and gas production and to invest in renewable technologies, as a result of recent social, legal and government pressures. In contrast, their American counterparts are keeping a more business-as-usual approach and continue betting on non-renewable energy in the long-term, while investing in CCUS and energy efficiency technologies to reduce their operational emissions [20]. Firms active in countries with depleting reserves or with ambitious GHG reduction targets also face pressure to diversify, while traditional fossil firms in rentier states have no incentives to transition as long as reserves are filled and margins high [30].

Supporting a just energy transition as an investor is not straightforward. Due to the diverse range of operations and markets that an energy company may engage in, the distinction between a good and bad energy firm can sometimes be unclear. Also, investors may have limited influence, in particular with state-owned companies. Nevertheless, investors have three main tools they can use to support the energy transition: divestment, engagement, and financing. These tools are usually employed in tandem to tackle the energy transition. The following sections evaluate the effectiveness and limitations of each of these tools in the context of the energy transition.

Box 2: States and their role in the transition

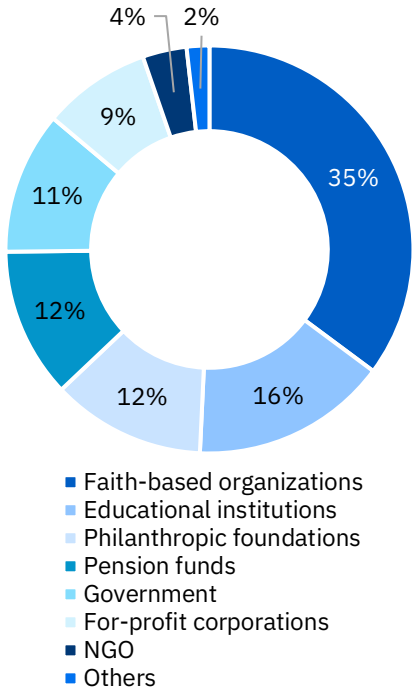
States have a predominant place in the energy industry, with regards to both their emission legacy and role in the energy transition. State-owned companies (SOC) represent about 85% of current global oil production [23] and own about 56% of existing coal plants and 52% of planned ones [33]. Also, 59% of the CO_2 emissions generated since 1988 have been attributed to SOC, while 32% and 9% were produced by publicly traded and private firms [34].[13] Nonetheless, states can push for a pro-climate agenda and incentivize change. Indeed, state ownership seems to have a positive impact on renewable electricity investments in OECD countries and G20 [33]. When supported by governments pushing for low-carbon strategies, SOC with technical expertise and access to capital could be central actors in the deployment of renewable energy infrastructure [30], [33].

[13] In 2015, the top 8 most emitting companies were state-owned companies, including Saudi Aramco, Russia's Gazprom and Rosneft, National Iranian Oil, Coal India and China's Shenhua Group, CNPC and ADNOC [34].

3 DIVEST

Divestment, also called exclusion, is a socially motivated investment strategy, in which asset owners or managers decide not to invest in companies that engage in activities that do not align with their values. In the context of the energy transition, divestment movements have been putting pressure on both firms and governments with three main objectives: 1) stop fossil fuel extraction to meet carbon budgets, 2) transform polluting business activities to low-carbon ones, 3) pass legislations introducing drilling bans, carbon tax and other climate policies [35]. Investors excluding fossil fuel might also do so to completely dissociate from a polluting firm, e.g., after unsuccessful engagement efforts. In November 2022, assets under management (AuM) committed to fossil-fuel divestment were of USD 40.5 trillion, up from USD 52 billion in 2014, and these commitments were primarily driven by religious, academic, and philanthropic organizations (Figure 4) [36], [37].

Figure 4: Proportion of fossil fuel divestment commitments by type of institution



Note: The total number of institutions and AuM committed to fossil fuel divestment are of 1552 and USD 40.5 tn respectively in November 2022. Source: Fossil Fuel Free (2022).

Exclusion can possibly affect the target's operating conditions and its ESG strategy through three different channels: 1) a direct capital rationing effect, 2) a negative shock on stock prices, and 3) the strengthening of stigmatisation. The instinctive view is that exclusion, just like consumer boycotts, leads to weaning the targeted companies from capital, which will force them to change their strategies. Reality is disappointing on this score. First, because a direct weaning impact can only occur in the primary markets whereas most financial transactions occur on the secondary markets. Second, because whether on the primary or the secondary markets the intended outcomes are plausible only under very specific conditions [38]. The analysis below discusses how that applies to the energy sector, in particular to fossil-fuel firms, based on the study of Danthine & Hugard (2021).

3.1 CAPITAL RATIONING

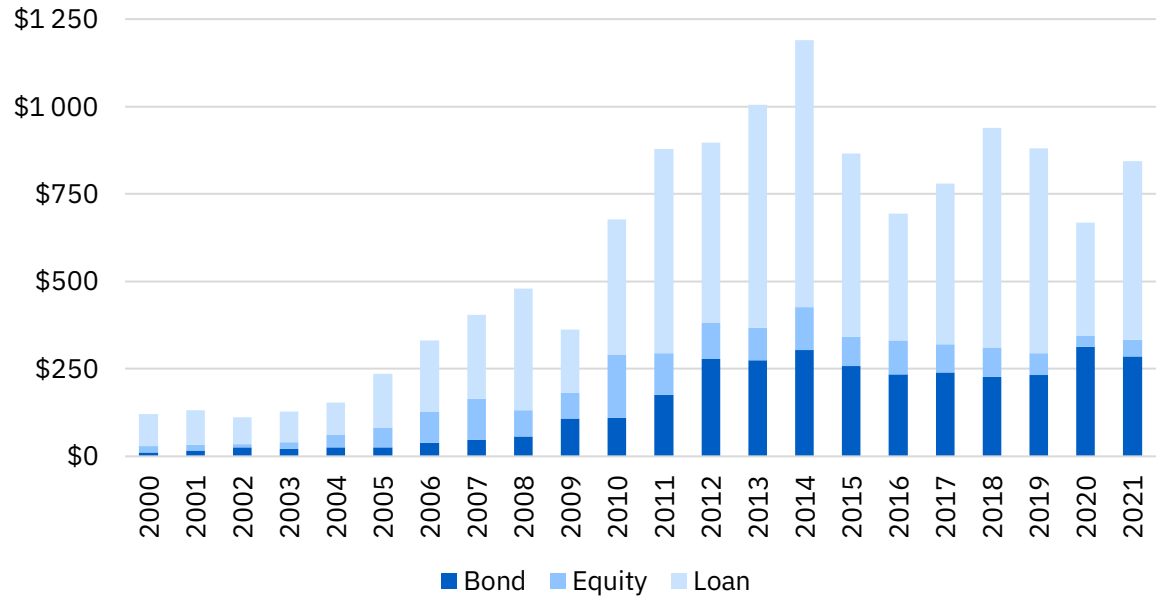
Divestment of bond and equity portfolios will not instantly threaten the survival of the fossil fuel sector as it can access alternative sources of financing. Bank loans have been by far the main source of capital for the fossil fuel sector, representing 63% of firms' funding on average between 2000 and 2020. Over the same period, bond and stock issuance have been financing 23% and 15% of the sector's activities on

average. Interestingly, since the beginning of the fossil fuel divestment movement in 2010, equity financing has been more and more disregarded by fossil-fuel firms, representing on average 10% of the sector's total financing down from 20% the previous decade and benefitting to bond financing (Figure 5).

Costs are playing in favour of loan financing. The preference for **syndicated loans** is often linked to their transaction speed and lower information requirements compared to other financial instruments. In the case of fossil fuel firms' debt financing, costs might play an equally important role: recently issued syndicated loans tend to present lower yields than corporate bonds. Firms with high climate policy exposure, such as fossil fuel firms, seem to be exposed to lower credit spreads on the loan markets compared to the bond markets and tend to substitute corporate bond issuance with syndicated loan underwriting as this exposure become stronger [39]. This suggests that: 1) commercial banks take less into account climate regulatory risks, although or because they benefit from private information collected during their interactions with borrowers; 2) through this substitution mechanism, capital rationing imposed by pro-climate market participants is less effective.

A country's stance towards fossil fuels affects how the sector is getting financed. The oil and gas sector indeed raises less capital in countries where the fossil fuel divestment movement is strong. This negative impact on financing is more significant in countries with strict environmental policies but is reduced in countries that heavily subsidize fossil fuels [41]. As long as states will keep supporting the sector, the impact potential of divestment is limited on primary markets.

Figure 5: Fossil fuel sector funding by type between 2000 and 2021 (in 2015 USD bn)



Note: These results align with Cojoianu et al. (2019) and Cojoinu et al. (2021)[40], [41]. The proceeds of these bond, equity and loan deals can finance both traditional and more sustainable projects. Source: Thomson Reuters.

3.2 Shock on stock prices

A central argument in favour of divestment is the associated negative shock on stock prices and lower stock demand – as they would incentivize the targeted company's management to transition. Two conditions must first be met to create this negative shock on stock prices to begin with. First, investors must publicly declare their intention to divest and, second, the amount divested must be sufficiently large compared to the firm's market capitalization. Both conditions are necessary to create sufficient pressure on prices and to, in turn, raise stakeholder awareness and possibly incentivize management to improve business practices. While the first condition is the least burdensome to achieve, the second is more challenging as the divestible capital, i.e., the market capitalization available to investors, may be limited. For instance, if an investor decides to divest a traditional state-owned energy company (Box 2), its impact potential is negligible compared to the government's majority stake.

To create the necessary incentives for changes at corporate levels, certain requirements need to be fulfilled on top of these two conditions. They are linked to 1) the type of exclusion undertaken by the investor, 2) the cost of the investor's requests and 3) managerial compensation scheme. The discussion below concludes that sectoral divestment and its associated shock on stock price is not enough to incentivize for change: best-in-class exclusion is more promising when the cost of reform is low, and management's remuneration is particularly affected by lower stock prices, whether from a reputational or financial point of view (Figure 6) [42].

3.2.1 Type of exclusion

Best-in-class exclusion is thought to be more effective than sectoral exclusion. Investors who use best-in-class exclusion only remain invested in fossil-fuel companies that are making the most effort to transition according to specific criteria. In theory, this provides incentives for change, compared to sectoral exclusion, in which all fossil-fuel firms are divested from the investor's portfolio. Indeed, a fossil-fuel firm threatened by divestment could be willing to develop renewable energy business lines to reduce its negative impact on the environment. Applying a sectoral exclusion could disincentivize the firm to take a corrective action, as the investor would not reinvest even if the firm started developing a renewable segment and performed better on environmental matters, simply because it belongs to the fossil-fuel sector. On the contrary, best-in-class exclusion would motivate the firm to perform better than its peers on these matters.

Figure 6: Conditions for divestment to have an impact on targeted firms

Note: Based on the analysis of Danthine & Hugard (2020)

Opting for best-in-class exclusion instead of sectoral exclusion would be particularly effective in cases for which 1) a corrective action could reduce the externality created by the firm and comes at a little cost, and 2) management is particularly concerned by stock price levels [42].

3.2.2 Cost of reform

The costs of decarbonizing activities depend on the type of emissions at stake. In the case of a fossil-fuel company, Scope 1 and Scope 2 emissions, which are directly or indirectly released during production, would be relatively easier to reduce compared to Scope 3 emissions – which occur in the company's value chain for instance when the fossil fuel is burnt by end-users. Emissions occurring during production – which represent 15% of global energy-related GHG emissions – can be greatly reduced by preventing methane leaks. This can even be profitable, as the gas can worth more than the cost of decarbonizing [17], [43]. A fossil firm willing to decrease its Scope 3 emissions will have to shift its business strategy, as it per se rely on products made to be burnt, or compensate with massive CCUS technology investments. Both come at a substantially higher price and add up to the costs and the complexity of assessing these emissions in the first place. While some integrated fossil fuel companies, like TotalEnergies or Shell, might have the capacity to conduct such changes, pure-players specialized in coal mining or oil drilling will have more difficulties.

3.2.3 Management compensation scheme

Performance-based compensation accounts for the majority of the final executive salary and typically relies on production growth, financial, and ESG metrics [44].[14] Direct production growth metrics include among others reserves value, production levels or hydrocarbon project targets. Financial metrics can refer to total shareholder return, EBITDA, production costs, or free cash flows. To account for the low-carbon transition and social concerns, ESG metrics such as emission reduction and safety targets have started to make their way to executive compensation [44], [45].

The industry's current compensation structures work against the transition to a low-carbon economy. While some positive developments have been observed over the past years, performance-based compensation is typically tied to performance metrics failing to consider the energy transition. Direct growth production metrics are still present, despite fossil majors' transition strategies.[15] Transition metrics have progressed into compensation policies, but they sometimes relate to renewable fuels and natural gas targets and incentivize hydrocarbon production. Financial metrics, which often include relative total shareholder return, represent the largest portion of variable compensation [45]. In certain cases, they can also indirectly encourage increased fossil volume production, though metrics such as revenues or EBITDA [44].

[14] In 2021, annual and long-term performance-based compensation of US oil and gas exploration and production firms represented on average 78% of executives' total compensation. Also, part of the performance-based compensation was often discretionary [45].

[15] Among major European fossil firms, only Shell does not account for fossil production growth in executive compensation packages [44].

Given the current compensation schemes, divestment could defeat the purpose of transition. The one-off divestment-induced price shock could have a financial impact on executives' pay particularly if stock returns are part of the financial metrics in compensation plans. However, the sector's other commonly used managerial incentives and their implications seen above are even more critical and concerning. It is necessary to understand and adjust them accordingly to encourage the transition and, for shareholders, this is only possible through engagement and pressure (Section 4.1.4).

3.3 Stigmatisation

Stigmatisation can challenge the industry's social license to operate and help reshape the public debate. Fossil-fuel companies are heavily criticised by scientists and climate activists because of their important contribution to climate change. This can drive away suppliers, subcontractors, customers, and employees. A radical flank advocating for an immediate world without fossil fuel and divestment of the sector can allow more moderated stakeholders, such as responsible investors, to engage with firms on the topic of climate change [46], [47].[16]

Firms have however not reacted as expected and often used lobbying, greenwashing, and misinformation as a response to criticism and stigmatisation, rather than taking action to address their environmental impact or changing their business practices [49].

Lobbying. Fossil-fuel lobby groups are known to work against regulations promoting renewable energy, environmental policies and climate actions and often seat at environmental global forums and meetings with governmental institutions. Between 2015 and 2021, European fossil-fuel giants Shell, BP, TotalEnergies, Equinor, Eni and Galp and their lobby groups reportedly spent EUR 170 million on lobbying activities in the EU and had over 500 meetings with top executives of the European Commission [50].

Greenwashing. Fossil fuel firms have also been known to engage in greenwashing or presenting themselves as environmentally responsible through advertising and public relations efforts, while downplaying their negative environmental impacts [51]. Between 2008 and 2016, major US oil and gas companies significantly increased their advertising expenditure, with an average spend of USD 217 million compared to an average of USD 35 million between 1986 and 1996 [52].[17]

Misinformation is another possible tactic in response to stigmatization. This can include promoting the supposed benefits of fossil fuels for improving living standards; casting doubt on the most well-established scientific evidence about the impact of fossil fuels on the environment and public health; hiring scientific spokespeople to distort selected facts; or attempting to distract from the need for action to address global warming through misleading claims about climate science [53]. However, in recent years, some actors in the fossil-fuel industry have begun setting climate targets and publishing transition plans in

[16] "Radical flank effects are interactive processes involving radical and moderate factions of social movements and third parties outside those movements. They result in detrimental and/or beneficial impacts of radical group actions upon the reputations and effectiveness of more moderate collective actors – typically social movement organizations." [48].
[17] Media coverage and the attention given to climate change by Congress were key factors influencing these advertising expenditures [52].

response to increasing pressure from stakeholders (Section 2).

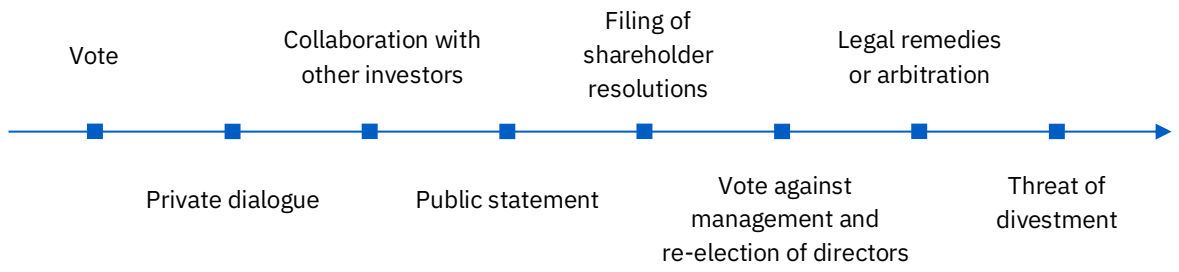
It is difficult to measure how much the fossil-fuel divestment movement has contributed to increasing stigmatisation and changing behaviours. Stigmatization is complex and multi-dimensional, and the potential for divestment movements to contribute to stigmatization may depend on various factors such as the specific issues being addressed and the way the movement is carried out. Changes in behaviour may be more driven by the threat of divestment of other investors and the stigmatisation of civil society.

4 ENGAGE

Engagement aims at reducing emissions in the real economy by opening a dialogue with fossil-fuel firms. Engaging shareholders signal their disapproval and sometimes influence corporate strategy by exercising their voting rights and engaging a dialogue with the firm.[18] In the context of the energy transition, they identify firms that are significantly contributing to GHG emissions, assess their climate strategy plan with regards to the **Paris Agreement** and engage with the ones that are lagging behind [56]. Engagement can be conducted in a number of ways, going from voting, to filing shareholder resolutions, and, in last recourse, threating of divestment (Figure 7).

Engaging with the fossil-fuel sector requires both a firm-level and system-wide approach. Firms' ownership structure is an important factor to take into consideration in engagement efforts: controlled firms are less likely to answer to minority investors' requests unless they are endorsed by the controlling shareholder [56], [57]. If the controlling shareholder happens to be the state, which is often the case for fossil fuel firm, firm-level as well as system-wide engagement may be required. Firm-level engagement will focus on the specific firm's environmental performance (Section 4.1), while system-wide engagement will consider the market performance as a whole and include interactions with other market stakeholders including collaborative engagement initiatives, firms' capital providers and policy-makers (Section 4.2).

Figure 7: Example of an escalation process



Note: Investors make their engagement increasingly public and, if not already done, will try to convince other investors to join the cause to help increase pressure on the company. Investors will start by exercising their voting rights and raising their concerns with management privately or at the annual AGM. If this fails, increasingly aggressive measures may be employed, such as filing shareholder resolutions, seeking legal remedies, or ultimately threatening the company with divestment [55].

[18] Engagement generally applies to publicly-traded shares but also to private-equity holdings and, to some extend to debt holdings. The private equity model is particularly conducive to the energy transition: investors can clean the assets and operations of the polluting firm away from public markets' short-term pressures [54], [55]. Corporate bondholders can exert pressure as well, although they do not have the same rights as shareholders: they can include GHG emission targets, before issuance, into the credit contractual obligations (Section 5.2) or, after issuance, during renegotiations of contractual obligations, refinancing, or bond meetings. They can also join other investors' engagement initiatives to increase their influence and when they also own shares emitted by the issuer, leverage the greater rights they confer.

4.1 Firm-level engagement

Through firm-level engagement, the investor's goal is to improve firm-specific environmental performance. For that, the investor first needs to get an understanding of the firm's GHG emission profile, in particular their current level, their evolution over time and their position compared to industry peers, as well as the firm's climate strategic plan, that is if it has one and how, when and by how much it plans to reduce its emissions in the future [56]. This assessment requires a deep understanding of the firm's business lines and sector (Section 2) and will help prioritize climate engagement themes. Investors engaging on GHG emissions typically have on their agenda four different topics: disclosure of climate-related information (Section 4.1.1), emission reduction targets (Section 4.1.2), climate strategy plan implementation (Section 4.1.3), and climate-governance practices (Section 4.1.4).

4.1.1 Disclosure of climate-related information

Disclosure of climate-related disclosure is the starting point of engagement efforts. Investors need climate-related information for assessing a firm's environmental performance profile over time and against peers but also for setting a reference for emission reduction targets (Section 4.1.2).[19] GHG emissions data can be estimated by data providers, but information directly disclosed by firms offers better precision. As energy companies tend to shun Scope 1 and 2 emission disclosures [56], disclosure of climate-related information is generally the first topic of engagement.

4.1.2 Emission reduction targets

Setting emission reduction targets is linked to lowered emissions. Companies that have established net-zero emission targets tend to be more successful in reducing their emissions compared to those that do not have any such targets. Additionally, when firms have multiple targets, such as intermediate targets, targets for increasing renewable capacity, and targets for disclosing climate-related information, the decrease in emissions tends to be faster [59]. But acknowledging the presence of targets is not sufficient, the scope the quality, and the credibility of these targets are better indicators for investors in assessing the firm's willingness and potential to transition and the need for engagement [56], [60].

To achieve the Paris Agreement targets, investors need to request strengthened emission reduction targets. In particular, fossil-fuel firms need to 1) broaden the scope of their targets, 2) set absolute as well as intensity targets, and 3) commit to science-based targets [56], [58].

Broaden targets' scope. Fossil-fuel firms' targets should cover all emissions that stem from its business lines (Scope 1 and 2) as well as from its value chain (Scope 3) – as the latter represent the majority of their GHG footprint [56], [58]. But only a few started doing so [61]. Intermediate targets and long-term targets are also necessary to improve transparency and accountability. Having targets at different time horizon can help investors in shaping their engagement efforts [56].

[19] Comparability across firms' disclosures is necessary. Different GHG accounting frameworks exist e.g., GHG Protocol and the PCAF Global GHG Accounting and Reporting Standards, and GHG emission measurement methodology may vary across firms because of their specific activities which complexify performance and commitment comparison [58]. Standardized disclosures could facilitate assessment of performance against peers [56].

Set absolute and intensity targets. Intensity targets[20] could be met without decreasing production and therefore reducing absolute GHG emissions [58]. Requesting additional targets on absolute emissions, e.g., the firm's total emissions, could help addressing this issue.

Commit to science-based targets. Following science-based target standards could vet for the credibility of the firm's targets [61]. The Science-based Targets initiative (SBTi) provide such standards and require detailed plans, intermediate targets and at least a 90% decrease of emissions, among others. The burdensome approval process is also an indicator of the seriousness of the company in its climate strategy [56].

4.1.3 Climate strategy plan implementation

Climate strategy plans need to specify the firm's approaches in reducing carbon emission: directly, by increasing their emission-efficiency in production or by substituting the emitting energy source, as well as indirectly, through CCUS technologies and carbon credits [56]. When assessing firms' climate strategy plan and engaging, investors should consider 1) the contribution of low-carbon energy to the climate plan, 2) the sectoral approach of the firm in achieving its targets, as well as 3) the firm's openness to feedback on its strategy through say-on-climate votes.

Disclosing the contribution of low-carbon energy sources, of emission-efficiency improvements and of the use of CCUS in achieving climate targets help investors evaluating the credibility of firm's climate plan as well as its strategic vision [58], [60]. Investors should ask for more details on the share of green revenues expected compared to overall revenues.

Defining a sectoral approach could also be helpful in transitioning other sectors that are hard to decarbonize, e.g., aviation. When doing so, the firm takes into consideration the outlook of its customers, providers and other stakeholders into its climate strategy and set out how it intends to work with them to achieve its goals. The firm's efforts can however be difficult to measure for investors [58].

Putting forward regular say-on-climate votes. Say-on-climate votes allow shareholders to provide feedback on the firm's climate strategy and management and directors to understand investors' expectations. Although they have been criticized for their greenwashing potential[21], say-on-climate votes, when recurring, can create a formal way for investors to engage on climate topics with the firm [56].

4.1.4 Climate-related governance practices

Investors need to ensure that governance practices align with climate-related targets and engage on these topics, if not. In particular, they can open dialogue on executive compensation and climate governance. Executive compensation should motivate managers and directors to act in the best long-term interests of the company, which includes considering the potential risks and opportunities related to climate change. While fossil-fuel firms have started linking executives' performance-based compensation with ESG

[20] Intensity targets refers to the target volume of GHG emissions per unit of sales or of production. Sales-denominated intensities decrease with fossil fuel market prices without translating in real emission reductions. Production-denominated are generally barrels-of-oil-equivalent-denominated intensities [56].

[21] When receiving majority vote in a one-off say-on-climate, results tend to be leverage by management in further climate-related dialogue with investors, even if the strategy does not align with the Paris Agreement targets.

metrics in recent years[22], production-growth metrics are still defining part of it (Section 3.2.3). Investors should encourage the alignment of short-term executive compensation with long-term climate targets, namely by showing their opposition through a say-on-pay vote [56], [58]. Climate governance focuses on stewarding companies in the climate change crisis and refers to the decision-making responding to climate-related risks and opportunities and the governance structure enabling them [56]. Fossil-fuel firms are new to climate-governance concepts but resources on climate-governance best-practices, such as the WEF Climate Governance Principles and Guiding Questions, can be used once the firm's board has acknowledged its accountability for climate performance [56].

4.2 System-wide engagement

System-wide engagement considers the market performance as a whole and include interactions with other market stakeholders including collaborative engagement initiatives, banks that are financing firms' activities and civil society actors. System-wide engagement addresses the issue of operational and value-chain GHG emissions on multiple fronts, not just at the investor-firm level.

4.2.1 Collaborative engagement initiatives

Like-minded investors can pool their resources and coordinate engagement efforts on the fossil-fuel sector. Collaborative engagement initiatives have proved their impact potential [38], [57], [63] and can be particularly interesting for investors as they are cost-efficient, increase influential power and create a diversified pool of knowledge. Climate Action 100+ is a collaborative engagement initiative focusing on GHG emission reduction of the top 100+ most polluting firms pooling the resources and shareholder power of 700 financial institutions (USD 68 trillion of AuM).

4.2.2 Engagement with fossil-fuel creditors

Investors can also engage with banks financing fossil-fuel projects as part of a wider engagement strategy. Despite climate strategy plans and net-zero commitments, certain financial institutions continue financing the expansion of new fossil fuel fields. Shareholders of these financial firms can also engage on these topics and challenge banks' financing policies. Some initiatives have showed encouraging results. For instance, NGO ShareAction is working to improve the investment policies of financial institutions with regards to fossil fuels and has called on major banks to stop funding fossil fuel projects through collaborative engagement initiatives. As part of these efforts, ShareAction has engaged with HSBC for several years, and more recently on the content of its energy policy through a shareholder resolution filling. Following this resolution, the British bank announced that it would no longer finance new oil and gas fields, sending a strong signal to fossil-fuel firms and governments [64].

[22] Including ESG metrics into the performance-based compensation packages of executives does not necessarily imply that ESG performance will improve. Walker (2022) underlines that so far "ESG-based pay seems more like window dressing than a serious attempt to incentivize executive behavior." To make ESG incentives economically meaningful, "a company need only reduce or eliminate equity compensation elements that are linked solely to share price, like conventional stock options or restricted stock, and replace these with equity instruments that award executives a variable number of shares based on their achievement of certain goals." [62].

4.2.3 Dialogue with other civil society actors

Opening dialogue on the regulatory and political environment could also be helpful in attaining certain firm-level objectives. Government and population sentiments towards the energy transition tend to influence firms' commitments (Section 2.2) [32].[23] Engaging dialogue on how to align firms' business environment with climate objectives with policymakers and civil society actors could create incentives for firms to make necessary changes. It could result in stronger climate-related disclosure legislation, subsidies encouraging firms to meet climate targets, as well as enforced disclosure of lobbying activities and political spending [56].

4.3 Engagement outcomes in fossil-fuel firms

Successful shareholder engagement occurs when the company is receptive to the suggestions and views of engaged investors and takes concrete steps to implement them [57]. In the case of fossil-fuel firms' transition, engagement success can be that the firm accepted requests improving its environmental performance and plans to reduce its operational and value-chain GHG emissions, e.g. by setting multiple-horizon, SBTi-approved operational and value-chain emission targets or implementing climate-governance best-practices (Section 4.1).

Climate-related disclosures and climate targets are improving but a transparency gap remains. A study by the Carbon Disclosure Project (CDP) revealed that fossil-fuel companies targeted by CDP disclosure campaigns led by financial institutions had higher submission rates than firm's that were not. Although these results are encouraging, these submission rates are still low, even without considering Scope 3 emission disclosure. Only 14% of Scope 1 and 2 emissions of the companies engaged are covered [65]. Considering climate targets, among 2000 firms analysed by Accenture, only 34% announced net-zero targets but if they keep current levels of improvements most are expected to miss their targets [59]. Also, about 20% of fossil-fuel firms engaged by the Climate Action 100+ initiative have not committed to any long-, mid- or short-term climate targets [66].

The most polluting fossil companies have started establishing climate-governance practices. Among the 48 coal, oil and gas firms engaged through the Climate Action 100+ initiative, 18% are integrating climate-change performance to executive compensation schemes and have a board accountable for the climate-related risk oversight. Seven of the engaged firms, including six SOC, have integrated none of the above [66].

Firm engaged through collaborative initiatives are not yet walking the talk. In its interim report of October 2022, Climate Action 100+ reported encouraging progress in engaged companies' climate targets. However, the fossil-fuel sector has shown contrasting results: while there has been improvement in target setting, none of the 36 oil and gas companies in focus have capital allocation plans aligned with the Paris Agreement targets. Two-third of them already sanctioned projects inconsistent with Paris Agreement scenarios in 2019, 2020 and 2021 [67], [68].

[23] Firms that invest in renewable energy projects tend to start in their home-country before scaling to other locations [32], therefore local environmental agenda will impact firms' strategic approach (Box 2).

Engagement with fossil-fuel firms about GHG emissions may not be as effective as with other sectors because of the high cost and uncertainty of the requested shift in core activities. Even if a company responds positively to shareholders' climate-related requests, it may take time and recurring efforts for engagement to result in actual emission reductions and Paris-Agreement-aligned capital allocation. This is particularly true for fossil-fuel pure-players and vertically-integrated firms that are required to shift core business activities – at a significant financial cost if they want to reduce Scope 3 emissions [54]. Involving other civil society actors, such as firms' creditors or policymakers, is necessary to increase the pressure and create the adequate incentives for change.

5 FINANCE

Investments in the low-carbon energy transition need to increase to meet climate targets. While annual investments have sharply increased over the past years, from USD 254 billion in 2011 to USD 755 billion in 2021 [69][24], current levels are not enough to achieved countries' climate pledges and net-zero by 2050 [70].[25] In this context, finance has a dual role: increasing financing for clean energy projects while decreasing financing for emission-intensive projects and supporting transitions to low-emission activities. Contrary to divestment and engagement, financing has a clearer impact on firms as it directly finances projects and operations.

Energy firms, ranging from clean-tech start-ups to traditional fossil fuel companies, have different funding options available to them based on their development stage and goals (Figure 8). Early-stage tech firms, that require smaller amount of capital, may seek funding through grants, crowdfunding, or other early-stage funding options, while more established companies, like oil and gas majors and other energy incumbents, may opt for private or public debt and equity financing[26] [72]. Investors who want to support the energy transition through these firms can therefore do so through a range of instruments, including 1) early-stage financing (Section 5.1), 2) debt (Section 5.2), and 3) equity (Section 5.3). Although capital is in principle available, barriers to financing remain for each of these financial instruments [12], [73].

Figure 8: Financing sources along firm's development stages

Note: Adapted from Polzin et al. (2017) [71].

[24] These investments finance projects focusing on renewable and nuclear energy, storage, infrastructure and CCUS, but also end-consumer devices including small solar systems, heat pumps and electric vehicles

[25] "Total investment in clean energy, estimated at USD 1.4 trillion in 2022, would need to double by 2030 to be consistent with national climate pledges as reflected in the Announced Pledges Scenario (APS), and to triple over the same period to be aligned with the Net Zero Emissions by 2050 (NZE) Scenario." [70]

[26] In the context of corporate finance, private debt is issued to a specific group of investors, such as banks and other institutional investors, is not publicly traded and often comes in the form of bank loans. Public debt, on the other hand, is issued to the general public, is traded on public markets, such as stock exchanges, and usually takes the form of corporate bonds. Now considering equity financing, private equity financing refers to the sale of ownership stakes in a company to private investors, including venture capital firms, private equity firms and sometimes individual investors. It is typically used by companies that are not publicly traded, or by publicly-traded companies willing to raise capital without going through the burdensome process of issuing publicly-traded shares. On the other hand, public equity financing refers to the sale of ownership stakes in a company to the general public through the issuance of publicly traded shares. Public equity financing is typically used by publicly traded companies that are looking to raise capital by issuing additional shares of stock.

5.1 Early-stage financing: Supporting new technologies

Low carbon early-stage players are key to achieve the rapid transformation needed to meet the Paris Agreement's climate targets and requires various forms of financing as they grow and develop [74]. Early-stage investments are typically deemed risky and illiquid and would require high reserves if invested by banks and institutional investors. This makes them unattractive and underfunded [71]. Research, development, and demonstration (RD&D) grants and prizes, crowdfunding and early-stage investors such as business angels help overcome parts of these challenges.

RD&D grants and prizes are typically offered by both public and private institutions [12] and are designed to help address financing gaps during the early stages of a company's development [74] and maintain its cash flow [12]. RD&D grants can differ in terms of who is eligible to apply, the types of expenses that are eligible, and how solvency risks are managed. Prizes, on the other hand, provide recognition to the winners and are less administratively burdensome [75]. One example of an energy transition-focused early-stage prize is the ClimateLaunchpad competition organized by the European Commission's Climate-KIC initiative. This competition encourages and rewards innovative solutions to tackle climate change, with the winner receiving EUR 10,000 [75].

Crowdfunding is an equity or debt-based type of financing and solicits a large number of investors, typically individual investors, via an internet platform. It offers new financing opportunities to innovative start-ups that have limited collateral, fixed assets, or financial track-record. Some platforms, like Trine, specifically focus on energy transition technologies in emerging markets [76]. In crowdfunding, debt financing is dominant[27] but liquidity issues for investors persists [12], [76], [77].

Early-stage investors, such as business angels, are a type of private-equity investors who invest in early-stage firms and provide advice in exchange of an ownership stake and/or control rights. These investors take on a higher level of risk rising from a lack of a lending track record and technological and regulatory uncertainty. To mitigate these risks and establish trust with the firm, these early-stage investors may rely on soft information and strong relationships [71].

Despite the benefits of early-stage financing, barriers for investors remain, which raises the question of how policy can help address them. Lack of uniform regulation across countries and of confidence in crowdfunding platform, especially in transnational funding, prevent them from scaling [77], [78]. Policy and market uncertainty, perception of public support dependency, and failure rates of early-stage start-ups may drive risk-averse investors away [12]. As public funding cannot finance the transition alone, private investors need to engage. To incentivize them, policymakers need to create a more supportive environment to lower barriers to financing for early-stage companies and increase the size of the urgent investments needed for the energy transition [12]. This could include creating incentives for investors to take on the higher

[27] Start-ups that have taken on debt may be viewed as less attractive to future investors due to the potential need for additional capital to pay off these loans [75].

risks associated with early-stage investments by improving exit opportunities through a strengthening of public equity markets and increasing the role of state-investment banks (Box 3). Entrepreneur-friendly tax regime and bankruptcy legislation for early-state firms could also be beneficial [12].

Box 3: State investment banks as enablers

While policy makers help fix market failures through regulation and incentive schemes, state investment banks help shape and create markets [72]. The role of state investment banks (SIB) in fostering the energy transition is two-fold: de-risking projects by providing upfront capital and creating trust. State investment banks (SIB) are public institutions whose goal is to facilitate private investments into desirable projects using a variety of tools such as guarantees and subordinated debt and equity financing.[28] By de-risking projects and creating trust, they can support both innovative tech firms and mature renewable energy developers [12], [73].

De-risking projects by providing upfront capital. Supporting the sometimes-high upfront costs of risky cleantech projects can lower structural barriers to scale and make them investable [73]. As such, SIB can help de-risk projects by bringing them a track-record, which can in turn lower the associated cost of capital and their financial feasibility. SIB can provide guarantees to ensure the repayments to lenders in case the firm cannot [77], [79].[29] SIB can also invest in junior-tranche instruments while allowing private investors to take on senior, investment-grade tranches. This implies that private investors would be first repaid in case of default, which effectively transferring risk and making the investment more attractive [80].

Creating trust. Aside from de-risking projects, SIB can help create trust by signalling, educating, and being a first mover. As financial leaders with technical and financial expertise, SIB can stimulate investment in a firm's project when vouching for it, pass on expertise of new de-risking financial products[30] and create an investment track-record for the firm, facilitating funding of future projects [73], [77]

[28] Others include concessional loans, securitization i.e. bundling small investments into a larger investment vehicles e.g. yieldcos, and insurances [12].
[29] The InvestEU fund which namely support climate investments for instance has a guarantee budget of EUR 26.2 billion [79].
[30] Financial innovation is an important component of energy transitions [81]. SIB can bundle smaller projects, which otherwise would not investable, in one single security (i.e. securitization) or fund [77]. This can help reducing investors' due diligence costs and increase the volume of investments in these projects [12].

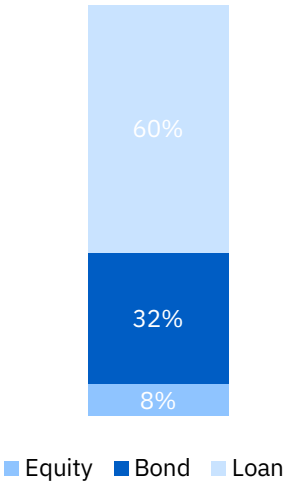
5.2 Debt financing: Promoting the transition

Debt investors have an important role in encouraging energy firms to support the transition to low-carbon energy sources. As with equity financing, debt financing is typically available to firms that have reached the fully commercial phase and are expected to be profitable [12]. Energy firms are primarily funded through debt financing and more specifically through loans (Figure 9) [12], [40]. In this context, banks and other financial institutions can incentivize energy firms to support the transition by, first, stopping investments funding fossil fuel extraction projects and, second, offering alternative, pro-transition forms of debt financing, i.e., sustainable debt products. The sustainable debt market has experienced rapid growth over the past years [31], increasing from USD 1.5 trillion in 2020 to USD 4.5 trillion in 2022, and essentially consists of green debt and sustainability-linked debt [82]. However, barriers to financing, stemming from the fear of greenwashing – in particular from the lack of credibility, of official reporting standards and of ambition – as well as from debt financial characteristics, persist and they are often common to both green and sustainability-linked debt. The following section will focus on these two types of debt financing and the barriers that can hinder their uptake.

5.2.1 Green debt

Green debt finances specific green projects, meaning that the capital provided to the firm is exclusively used to finance or refinance expenses meeting pre-defined green eligibility criteria or green-project categories.

Figure 9: Financing type of energy firms in 2021



Note: Energy firms include firms active in the fossil fuel, nuclear and renewable energy sector. Financing amounts are in 2015 USD. Source: Thomson Reuters.

In the energy transition context, issuers can use the proceeds to finance renewable energy projects, energy efficiency, as well as carbon capture and storage projects. Green debt can take the form of green bonds (in the public market) and green loans (in the private market).

Green bonds are the predominant sustainable debt instrument. Since the first issuance of green bonds by the World Bank in 2007, green bonds have become the most popular form of sustainable-debt instrument. End of 2022, the total market size for green bonds amounted to 1.6 trillion, representing 37% of the global sustainable debt market and the first type of sustainable-debt instrument issued, while green

[31] Sustainable-debt market saw a slower growth between 2021 and 2022 due to the ongoing geopolitical tensions, inflationary pressures and increased borrowing costs. The recently-enacted US Inflation Reduction Act is expected to reinvigorate the sustainability debt market in the US, as it focuses on financially support climate and energy security [82].

loans represented 10% of the sustainable debt market [82].

Although green bonds may comply with standards providing green credentials, this does not necessarily mean that the issuer is fully aligned with climate-friendly practices. To make informed investment decisions, green-bond investors generally rely on industry voluntary frameworks. The Green Bond Principles (GBP), introduced by the International Capital Market Association (ICMA), are the industry standard and provide a voluntary framework for green-bond issuance and, as such, more transparency on green credentials.[32] Nonetheless, issuers are not required to have climate-aligned activities to benefit from green bond financing, which is why one might find high-emitting firms within green-bond issuers. In 2018, strongly-aligned climate issuers, i.e. issuers that are deriving at least 75% of their revenues from climate-aligned business lines, represented only a fourth of the capital issued through green bonds [83].

5.2.2 Sustainability-linked debt

Sustainability-linked debt is a behaviour-based type of debt, which means that it finances projects which are meant to achieve a measurable firm-level sustainability performance target. This target is embedded in the debt legal agreement and, if not reached, can trigger a coupon step-up, i.e., an increase in the interest to be paid to the investors.[33] Most of primary targets of recently-issued sustainability-linked debt relate to the energy transition, such as GHG emissions reduction and renewable energy capacities targets (Environmental Finance, 2022). Sustainability-liked debt can take the form of sustainability-linked bonds or SLB (in the public market) and sustainability-linked loans or SLL (in the private market).

As proceeds are not tied to specific projects, sustainability-linked debt has become particularly attractive to firms willing to transition. The sustainability-linked loan market is the fastest growing among the sustainable debt instruments. With Europe dominating the market (Environmental Finance, 2022), SLL market has reached USD 958 billion end of 2022, while it amounted to USD 637 billion the previous year[34]. The SLB market has also experienced high growth over the past years but is still less developed, with USD 182 billion of market size in Q3 2022 [82], [85]. This appetite for sustainability-linked debt is particularly observable in high-emitting sectors[35] [88] and can be explained by the flexibility of the use-of-proceeds compared to green debt [82]. Sustainability-linked debt offers firms the opportunity to link their climate targets to access to financing.

[32] When following these principles, issuers generally disclose (1) a document called a Green Bond Framework, which develops the use and management of proceeds of the bond, as well as (2) a third-party external review, which assesses the green bond's overall sustainability quality and its alignment with the green bond standard.

[33] Although most sustainability-linked bonds (SLB) and sustainability-linked loans (SLL) typically have one single target metric, certain can have multiple ones. This is more likely to be the case for SLL. Issuers and investors may set multiple target metrics to reflect different sustainability outcomes that they are seeking to achieve through the financial instrument [84].

[34] Value for Q3 2022 vs. Value for Q4 2021 [82], [85]

[35] Eni is an example of how sustainability-linked debt issuance in the fossil fuel sector is done in practice. In 2021, the Italian oil and gas firm issued the first sustainability-linked bond for a nominal amount of EUR 1 billion, maturity of 7 year and coupon rate of 0.375%. The bond is linked to two sustainable performance targets that are part of Eni's overall sustainability-linked financing framework and, if not achieved, will trigger an increase of 0.25% of the coupon rate. The targets are 1) an increase of renewable energy capacity of 5 GW (compared to 0.3 GW in 2020) and 2) a 50% decrease of upstream Scope 1 and 2 GHG emissions compared to 2018 [86]. In 2022, Eni signed a sustainability-linked revolving credit line of EUR 6 billion linked to similar targets [87].

5.2.3 Barriers to financing

Despite the rapid sustainable-debt market growth, barriers to scale remain and could impede the financing of the energy transition. Main barriers relate to the fear of greenwashing, through the lack of credibility, of official reporting standards and of ambition, as well as to financial performance.

Credibility of sustainability credentials. In a world where current CO_2 emissions must be reduced by 45% by 2030 to reach the 1.5°C Paris Agreement goals, granting "green" or "sustainability" credentials to businesses whose primary activities are heavily using up the global carbon budget can raise credibility issues. This lack of credibility stems from the lack of materiality in the objectives of certain instruments[36] as well as from the vague terminology employed in the instruments' prospectus [92]. Also, meeting transition objectives through sustainable debt support can sometimes come at the cost of other sustainability topics, such as human rights or product responsibility [93]. To counteract these credibility issues, market actors are starting to launch credibility assessment tools aiming at supporting the sustainable-debt market growth and deliver meaningful outcomes.[37]

Official reporting standards and regulations. Pre- and post-issuance reporting, and their associated external reviews help increase sustainable-debt products' credibility and transparency for the investors. But because of the lack of legal definition and official reporting standards, sustainable-debt securities can be subject to scepticism and greenwashing. Industry standards, such as the Green Bond Principles, have set reporting recommendations but broad implementation is often limited to the prevalent green-bond market and such standards and certifications are only nascent for sustainability-linked debt securities.[38]

Ambition of the sanctions. Even if green-bond issuers are providing post-issuance reporting, as it is often the case[39], there is no such thing as a "green default" when the issuer is not satisfying its sustainability promises. Some sovereign and corporate issuers have even explicitly indicated in the instrument's contract that there is no insurance that the proceeds will be allocated to the said green projects [92], [95]. A "green-defaulting" issuer will therefore be paying through its reputation and cut its access to the growing sustainable-finance market – which could ultimately be somehow costly. On the sustainability-linked debt market side, target metrics and sanctions also lack ambition. First, SLB could still come at a profit even if the targets are missed. In a study from Kölbel & Lambillon

[36] For instance, the recent issuance of the Airport Authority Hong Kong has caused controversies in the climate finance space. The USD 1bn green tranche issued by the airport will fund energy efficiency, green buildings and other environmental and social eligible projects, but the remaining three other traditional tranches will be used to finance an airport extension (Three-Runway System Project) [89]. As it is, the Airport Authority Hong Kong is emitting as much as three coal plants through its activities [90]. The extension planned would be equivalent to build another airport next to the existing one. On the sustainability-linked debt side, Aeroporti di Roma recently issued a sustainability-linked bond aiming at reducing, among others, Scope 3 emissions per passenger [91]. The contract however excludes emissions from aircraft sources, which represent the majority of the airport's emissions.

[37] The Climate Bonds Initiative is establishing a credibility assessment tool which is defining credibly transitioning companies as companies "whose transition is rapid and robust enough to align with the global goal to nearly halve emissions by 2030 and reach net zero by 2050, in line with the Paris Agreement". It considers five characteristics that firms must have: Paris-aligned targets, robust plans, implementation action, internal reporting, and external reporting [88].

[38] After publishing the Green Bond Principles back in 2014, the ICMA published the Sustainability-Linked Bond Principles in 2020. On the private-market side, the Loan Market Association published the Sustainability-Linked Loan Principles in 2019.

[39] In 2020, 77% and 57% of green-bond issuers respectively provided use-of-proceeds and impact reporting [94].

(2020), SLB issuers benefit from a sustainability premium at issuance of about 0.29% compared to traditional bond issuers, i.e., they pay lower interests. At the same time, the average coupon step-up triggered if SLB issuers miss their target is of 0.25% [96]. Second, even if sanctions were more important, issuers generally have a low risk of missing their target (BBG - Greenwashing, 2022).[40] "Both the carrot (a low interest rate) and the stick (the sanction from missing targets) need to be made bigger" [97].

Green premium. Although academics are still debating, some findings suggests the presence of a green premium for sustainable-debt products compared to traditional debt [96], [98], [99]. Traditional investors, as opposed to responsible investors, are not likely willing to sacrifice this income, especially if the debt product does not have specific and verifiable objectives, a monitoring mechanism and credible contractual sanctions if objectives are not satisfied [92]. Other financial characteristics such as ticket size or investment horizon mismatch can also be funding barriers for investors.

The market is finding its way. The sustainable-debt market still remains young and fairly small. Outstanding sustainable-debt securities amounted to USD 2.3 trillion in 2021, while the global fixed income market amounted to USD 126.9 trillion [100], [101]. The barriers mentioned above can be lowered with support of policymakers and industry associations in setting credible reporting and monitoring standards for avoiding greenwashing risk. As the risk-return profile of clean energy investments can be deemed unattractive, policy makers could also put in place more structural measures, e.g. increasing the risk weights of polluting firms' loans, and send clear environmental and policy signals to incentivize and channel investments into clean energy [12].

5.3 Equity financing: Fostering clean-energy projects

Investors can also get exposure to the energy transition through equity financing. Although it is less often employed than debt financing[41], equity financing can take place through traditional private equity and public market offerings, yield companies and special purpose acquisition vehicles (SPAC). Equity financing could play an important role in financing capital-intensive renewable projects, which are too large for venture capitalists and too risky for traditional banks [72].

5.3.1 Traditional equity financing

Traditional energy equity financing include private equity and public offerings. Private-equity funds are investment vehicles managed by private-equity firms. These firms use the capital provided by investors to acquire late-stage private companies or public companies in their entirety. They manage them with the objective to improve their financial and operational performance before ultimately selling their stake. Private equity investments in the energy sector have sharply increased in 2022, amid the Russian-Ukrainian war and the related energy crisis. As a result, the aggregate deal value for renewable energy firms increased significantly, soaring to about nine times compared to 2021 values [102]. Public equity offering occurs when a company sells its stock to

[40] A Bloomberg analysis underlined that more than half of targets set in European SLB have already been achieved in the past and can be considered as "business-as-usual" [97].
[41] Equity deals only represents about 8% of the sector's funding (Figure 9).

the public through an initial public offering (IPO) – when it first becomes public – or a follow-on offering – when the firm has already issued stocks. Both IPOs and follow-on offerings can be conducted by companies of all sizes, including young, growing companies seeking capital to expand as well as more established, privately-held firms looking to go public. Public offerings in the energy sector are not always attractive because of timing issues and barriers to entry such as economic downturn, industry market-perception and associated lower valuation, as well as administrative costs[42].

5.3.2 Yield companies

Yield companies are an alternative instrument to fund capital-intensive renewable-energy projects. Yield companies, or yieldcos, are companies which own operating assets, e.g., solar or wind energy infrastructures, and finance them by issuing shares. Yieldcos are created as a separate publicly-traded entity by a parent firm, typically a large energy developer with a mix of renewable and non-renewable energy-generating assets. The parent firm transfers the renewable operating assets to the yieldco which finance it through its equity issuance. The cash flows generated by the yieldcos' assets are then redistributed as dividends to shareholders. In 2020, yieldcos were the first channel of investments towards green infrastructures and diversified renewable portfolios in OECD and G20 countries and over 70% of asset managers' investments in green infrastructure were executed through yieldcos [106].

Yields are attractive for both energy investors and developers. From an investor perspective, yieldcos offer a predictable yield and liquidity and therefore tend to be low risk [12], [77].[43] From a parent-firm perspective, yieldcos are often eligible to tax benefits [107] and can reduce the cost of capital of renewable energy projects, namely thanks to a broaden investor base and improved liquidity [106], [108], [109].[44] The parent firm can move operations off their balance-sheet and use yieldcos as a sort of revolving credit [77], [106].

Better governance and aligned growth expectations are needed to allow the viability of yieldcos. Yieldcos' success largely relies on its ability to grow sustainably and deliver steady cash flows, which in turn maintain a high stock price and high proceeds in subsequent share issuance [12]. To deliver on these objectives, the yieldco needs to have constant project acquisition and access to capital. The parent firm, which usually partially owns the yieldco, tends to be its main sources of projects, and access to capital highly relies on investor sentiment. These are likely to create counterproductive incentives, bad governance practices between the yieldco

[42] Due to the economic uncertainty caused the Russian-Ukrainian war, inflation and rising interest rates, the IPO market has experienced a major downturn in 2022 [103]. Fossil fuels firms also tend to shun IPO as they tend to be undervalued [104]. Going public can finally be complex and costly, which can create barriers to entry for young renewable companies. Companies that have established a significant presence in the renewable sector thanks to operations and infrastructure in place may however an advantage over newer, smaller companies that are trying to enter the market [105].

[43] In theory, yieldcos provide stable cash flows thanks to its operating assets, are publicly traded, hence liquid, and can diversify from traditional equity allocations in a niche renewable-energy market. They are also expected to be less risky as it only invests in operating assets rather than in the full range of projects the parent firm is developing and the associated market, R&D and operational risks [12], [77].

[44] Assuming that the risk associated with renewable plant operations is lower than the parent's core business.

and the parent firm and short-sighted growth strategies [110].[45]

5.3.3 SPAC

Cleantech firms are using ad-hoc intermediaries, called SPAC, to access public markets more easily. SPAC are publicly-traded companies that raise funds through an IPO. The proceeds generated are used to acquire assets that aligned with the SPAC stated-objectives within a specific timeframe.[46] SPAC has become popular alternative for climate-tech firms willing to go public but that do not necessarily want to follow the more burdensome IPO route [69]. SPAC tend to focus on clean tech companies that can achieve growth with relatively low capital expenditures rather than on large energy developers with capital-intensive projects [111]. In recent years, EV and other clean transport infrastructure firms have been particularly active in the SPAC space. Contrary to yieldcos, which focus on distributing dividends to investors SPAC allow involved firms to reinvest heavily in their growth [111].

[45] They have gained popularity beginning of 2010s but valuations declined following the bankruptcy of yieldcos' parent firm SunEdison and stock prices plummeted [110].
[46] If it fails to identify and acquire the assets within the timeframe, the proceeds are returned to the investors.

6 Glossary

Anthropogenic greenhouse gas emissions – "Emissions of greenhouse gases (GHGs), precursors of GHGs and aerosols caused by human activities. These activities include the burning of fossil fuels, deforestation, land use and land-use changes (LULUC), livestock production, fertilisation, waste management and industrial processes. See also Anthropogenic and Anthropogenic removals." [112].

Energy transition – Process of transitioning away from already established energy sources. In this context, it refers to the transition from fossil-fuel based energy sources to low-carbon ones.

Paris Agreement – Agreement reached at the 2015 United Nations Climate Change Conference (COP21) to tackle climate change and its negative impacts. It sets long-term goals for all signatory nations, namely "substantially reduce global greenhouse gas emissions to limit the global temperature increase in this century to 2°C while pursuing efforts to limit the increase even further to 1.5°C"[113].

Precipitation patterns – Distribution of rain, snow, hail, sleet or mist, geographically, temporally, and seasonally

Remaining carbon budget – "Estimated cumulative net global anthropogenic CO2 emissions to the time that anthropogenic CO2 emissions reach net zero that would result, at some probability, in limiting global warming to a given level, accounting for the impact of other anthropogenic emissions." [112].

Syndicated loans – Loans with multiple lenders sharing the default risk.

7 References

[1] H. Ritchie and M. Roser, 'Energy Production and Consumption', *Our World Data*, Nov. 2020, Accessed: Feb. 21, 2022. [Online]. Available: https://ourworldindata.org/energy-production-consumption

[2] H. Ritchie, M. Roser, and P. Rosado, 'CO_2 and Greenhouse Gas Emissions', *Our World Data*, May 2020, Accessed: Jul. 25, 2022. [Online]. Available: https://ourworldindata.org/greenhouse-gas-emissions

[3] IEA, 'Greenhouse Gas Emissions from Energy Data Explorer', 2021. https://www.iea.org/data-and-statistics/data-tools/greenhouse-gas-emissions-from-energy-data-explorer (accessed Dec. 20, 2022).

[4] R. Roson and M. Sartori, 'Estimation of Climate Change Damage Functions for 140 Regions in the GTAP9 Database', p. 42.

[5] M. C. Urban, 'Accelerating extinction risk from climate change', *Science*, vol. 348, no. 6234, pp. 571–573, May 2015, doi: 10.1126/science.aaa4984.

[6] B. Tawatsupa, V. Yiengprugsawan, T. Kjellstrom, J. Berecki-Gisolf, S.-A. Seubsman, and A. Sleigh, 'Association between Heat Stress and Occupational Injury among Thai Workers: Findings of the Thai Cohort Study', *Ind. Health*, vol. 51, no. 1, pp. 34–46, 2013, doi: 10.2486/indhealth.2012-0138.

[7] IPCC, 'Climate Change 2021: The Physical Science Basis', p. 2409, 2021.

[8] P. Friedlingstein *et al.*, 'Global Carbon Budget 2022', *Earth Syst. Sci. Data*, vol. 14, no. 11, pp. 4811–4900, Nov. 2022, doi: 10.5194/essd-14-4811-2022.

[9] Carbon Tracker Initiative, 'Unburnable Carbon: Ten Years On The financial markets are still enabling a carbon bubble', Jun. 2022.

[10] IPCC, 'Summary for policymakers In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change', 2022, doi: 10.1017/9781009157926.001.

[11] V. Smil, 'Examining energy transitions: A dozen insights based on performance', *Energy Res. Soc. Sci.*, vol. 22, pp. 194–197, Dec. 2016, doi: 10.1016/j.erss.2016.08.017.

[12] F. Polzin and M. Sanders, 'How to finance the transition to low-carbon energy in Europe?', *Energy Policy*, vol. 147, p. 111863, Dec. 2020, doi: 10.1016/j.enpol.2020.111863.

[13] R. York and S. E. Bell, 'Energy transitions or additions?: Why a transition from fossil fuels requires more than the growth of renewable energy', *Energy Res. Soc. Sci.*, vol. 51, pp. 40–43, May 2019, doi: 10.1016/j.erss.2019.01.008.
[14] MSCI, 'Global Industry Classification Standard (GICS®) Methodology', 2020.
[15] Kearney, 'Challenging the integrated oil and gas model', May 13, 2011. https://www.kearney.com/energy/article/-/insights/challenging-the-integrated-oil-and-gas-model (accessed Dec. 14, 2022).
[16] McKinsey, 'How oil and gas is navigating the energy transition', Mar. 10, 2021. https://www.mckinsey.com/industries/oil-and-gas/our-insights/the-big-choices-for-oil-and-gas-in-navigating-the-energy-transition (accessed Oct. 28, 2022).
[17] IEA, 'The Oil and Gas Industry in Energy Transitions', 2020.
[18] A. Larson, 'Oil and Gas Majors Focus on Renewable Energy, Hydrogen, and Carbon Capture', *POWER Magazine*, Apr. 01, 2021. https://www.powermag.com/oil-and-gas-majors-focus-on-renewable-energy-hydrogen-and-carbon-capture/ (accessed Jan. 03, 2023).
[19] H. Lu, L. Guo, and Y. Zhang, 'Oil and gas companies' low-carbon emission transition to integrated energy companies', *Sci. Total Environ.*, vol. 686, pp. 1202–1209, Oct. 2019, doi: 10.1016/j.scitotenv.2019.06.014.
[20] E. Asmelash and R. Gorini, 'International oil companies and the energy transition', IRENA, 2021.
[21] McKinsey, 'Ørsted's renewable-energy transformation', Jul. 10, 2020. https://www.mckinsey.com/capabilities/sustainability/our-insights/orsteds-renewable-energy-transformation (accessed Dec. 15, 2022).
[22] Energy Intelligence, 'Green Utilities Report 2022', Nov. 2022.
[23] IRENA, 'International oil companies and the energy transition', 2021.
[24] TotalEnergies, 'Brésil : TotalEnergies s'associe à Casa dos Ventos pour développer un portefeuille d'énergies renouvelables de 12 GW', Dec. 2022. https://totalenergies.com/fr/medias/actualite/communiques-presse/totalenergies_sassocie_a_casa_dos_ventos_pour_developper_portefeuille_denergies_renouvelables (accessed Dec. 19, 2022).
[25] Clearway Energy Group, 'Clearway Enterprise's Sponsor, Global Infrastructure Partners, Announces Strategic Partnership with TotalEnergies', May 25, 2022. https://www.clearwayenergygroup.com/press-releases/clearway-enterprises-sponsor-global-infrastructure-partners-announces-strategic-partnership-with-totalenergies/ (accessed Dec. 19, 2022).
[26] Adani, 'Adani and TotalEnergies to create the world's largest green hydrogen ecosystem', Jun. 22, 2022. https://www.adanienterprises.com/newsroom/media-releases/adani-and-totalenergies-to-create-the-worlds-largest-green-hydrogen-ecosystem (accessed Dec. 19, 2022).
[27] A. Spatuzza, 'Brazilian oil giant Petrobras exits renewables business | Recharge', *Recharge | Latest renewable energy news*, Aug. 05, 2019. https://www.rechargenews.com/transition/brazilian-oil-giant-petrobras-exits-renewables-business/2-1-649136 (accessed Jan. 04, 2023).
[28] Petrobras, 'Sustainability Report 2021', 2021.
[29] Upstream Online, 'Petrobras bucks renewables trend as Brazilian oil giant exits wind farm projects', 2021. https://www.upstreamonline.com/energy-transition/petrobras-bucks-renewables-trend-as-brazilian-oil-giant-exits-wind-farm-projects/2-1-971915 (accessed Jan. 04, 2023).
[30] B. Cahill, 'Pathways for National Oil Companies in the Energy Transition', 2021. https://www.csis.org/analysis/pathways-national-oil-companies-energy-transition (accessed Dec. 16, 2022).
[31] R. C. Berg, 'The Role of the Oil Sector in Venezuela's Environmental Degradation and Economic Rebuilding', CSIS, 2021.
[32] J. Hartmann, A. C. Inkpen, and K. Ramaswamy, 'Different shades of green: Global oil and gas companies and renewable energy', *J. Int. Bus. Stud.*, vol. 52, no. 5, pp. 879–903, Jul. 2021, doi: 10.1057/s41267-020-00326-w.
[33] A. Prag, D. Röttgers, and I. Scherrer, 'State-Owned Enterprises and the Low-Carbon Transition', OECD, Paris, Apr. 2018. doi: 10.1787/06ff826b-en.
[34] P. Griffin, 'CDP Carbon Majors Report 2017', p. 16, 2017.
[35] A. Ansar, B. Caldecott, and J. Tilbury, 'Stranded assets and the fossil fuel divestment campaign: what does divestment mean for the valuation of fossil fuel assets?', p. 81, 2013.
[36] Fossil Free Divestment, 'Divestment Commitments', 2022. https://divestmentdatabase.org/
[37] Institute for Energy Economics and Financial Analysis, Stand.earth, C40, and Wallace Global Fund, 'Invest-Divest 2021: A Decade of Progress Towards a Just Climate Future', Oct. 2021.
[38] J.-P. Danthine and F. Hugard, 'Divesting: for what impact?', Enterprise for Society, E4S White Paper, Dec. 2021.
[39] W. Beyene, M. D. Delis, and S. R. G. Ongena, 'Fuelling fossil fuel: Bond to bank substitution in the transition to a low-carbon economy', *UN PRI Blog*, 2020.
[40] T. Cojoianu, F. Ascui, G. L. Clark, A. G. F. Hoepner, and D. Wojcik, 'The Economic Geography of Fossil Fuel Divestment, Environmental Policies and Oil and Gas Financing', *SSRN Electron. J.*, 2019, doi: 10.2139/ssrn.3376183.
[41] T. F. Cojoianu, F. Ascui, G. L. Clark, A. G. F. Hoepner, and D. Wójcik, 'Does the fossil fuel divestment movement impact new oil and gas fundraising?', *J. Econ. Geogr.*, vol. 21, no. 1, pp. 141–164, Feb. 2021, doi: 10.1093/jeg/lbaa027.
[42] A. Edmans, D. Levit, and J. Schneemeier, 'Socially Responsible Divestment', *SSRN Electron. J.*, 2022, doi: 10.2139/ssrn.4093518.
[43] IEA, 'Methane Tracker 2020', 2020.
[44] M. O'Connor, 'Crude Intentions: How oil and gas executives are still rewarded to chase fossil growth, despite the urgent need to transition', Carbon Tracker Initiative, Analyst Note, Nov. 2022.
[45] Alvarez & Marsal, 'Oil and Gas Exploration & Production (E&P) Compensation Report: Analysis of Compensation Arrangements Among the Largest U.S. E&P Companies', 2021.
[46] N. Bergman, 'Impacts of the Fossil Fuel Divestment Movement: Effects on Finance, Policy and Public Discourse', *Sustainability*, vol. 10, no. 7, Art. no. 7, Jul. 2018, doi: 10.3390/su10072529.

[47] T. Schifeling and A. J. Hoffman, 'Bill McKibben's Influence on U.S. Climate Change Discourse: Shifting Field-Level Debates Through Radical Flank Effects', Nov. 2017. https://journals.sagepub.com/doi/epub/10.1177/1086026617744278 (accessed Jan. 04, 2023).
[48] H. H. Haines, 'Radical Flank Effects', in *The Wiley-Blackwell Encyclopedia of Social and Political Movements*, John Wiley & Sons, Ltd, 2022, pp. 1–3. doi: 10.1002/9780470674871.wbespm174.pub2.
[49] G. O'Donovan, 'Environmental disclosures in the annual report: Extending the applicability and predictive power of legitimacy theory', *Account. Audit. Account. J.*, 2002.
[50] L. Verheecke, 'Stop the Revolving Door: Fossil Fuel Policy Influencers', *Corporate Europe Observatory, Friends of the Earth Europe and Food and Water Action Europe*, 2021.
[51] E. Plec and M. Pettenger, 'Greenwashing Consumption: The Didactic Framing of ExxonMobil's Energy Solutions', *Environ. Commun.*, vol. 6, no. 4, pp. 459–476, Dec. 2012, doi: 10.1080/17524032.2012.720270.
[52] R. J. Brulle, M. Aronczyk, and J. Carmichael, 'Corporate promotion and climate change: an analysis of key variables affecting advertising spending by major oil corporations, 1986–2015', *Clim. Change*, vol. 159, no. 1, pp. 87–101, Mar. 2020, doi: 10.1007/s10584-019-02582-8.
[53] Union of Concerned Scientists, 'Smoke, Mirrors & Hot Air: How ExxonMobil Uses Big Tobacco's Tactics to Manufacture Uncertainty on Climate Science', 2007.
[54] S. Murray, 'To engage or divest: How should investors clean up the world's dirtiest companies', *FT Moral Money Forum*, Jun. 2022.
[55] J.-P. Danthine and F. Hugard, 'Active ownership: by whom and how?', Enterprise for Society (E4S) Center, Apr. 2022.
[56] C. Cote and H. Tufford, 'Net-Zero Alignment: Engaging on Climate Change', MSCI, 2022.
[57] J.-P. Danthine and F. Hugard, 'Active ownership: the keys to success', Enterprise for Society (E4S) Center, Apr. 2022.
[58] S. Dietz, D. Gardiner, V. Jahn, and J. Noels, 'Carbon Performance of European Integrated Oil and Gas Companies: Briefing paper', Transition Pathway Initiative, 2020.
[59] Accenture, 'Accelerating global companies toward net zero by 2050', 2022.
[60] Reclaim Finance, 'Our demands for shareholder engagement', *Reclaim Finance*, 2022. https://reclaimfinance.org/site/en/our-demands-for-shareholder-engagement/ (accessed Dec. 30, 2022).
[61] Carbon Tracker Initiative, 'Absolute Impact 2022: Why Oil and Gas Companies Need Credible Plans to Meet Climate Targets', May 2022.
[62] D. I. Walker, 'The Economic (In) Significance of Executive Pay ESG Incentives', *SSRN Electron. J.*, 2022, doi: 10.2139/ssrn.4034877.
[63] J.-P. Danthine and F. Hugard, 'Active ownership: For what impact?', Enterprise for Society (E4S) Center, Apr. 2022.
[64] ShareAction, 'HSBC announces it will no longer finance new oil and gas fields', Dec. 14, 2022. https://shareaction.org/news/hsbc-announces-it-will-no-longer-finance-new-oil-and-gas-fields-shareaction-response (accessed Jan. 02, 2023).
[65] F. Ainslie and H. Mansfield, 'CDP Non-Disclosure Campaign: 2021 Results', CDP, 2021.
[66] Climate Action 100+, 'Net Zero Company Benchmark Data', Oct. 2022. https://www.climateaction100.org/net-zero-company-benchmark/ (accessed Jan. 03, 2023).
[67] H. Jeppesen, 'CA100+ a long way from destination', *Carbon Tracker Initiative*, Mar. 28, 2022. https://carbontracker.org/ca100-a-long-way-from-destination/ (accessed Jan. 03, 2023).
[68] Climate Action 100+, 'Climate Action 100+ Net Zero Company Benchmark: Interim assessments', Oct. 2022.
[69] BloombergNEF, 'Energy Transition Investment Trends 2022', Jan. 2022.
[70] IEA, 'World Energy Outlook 2022', 2022.
[71] F. Polzin, M. Sanders, and F. Täube, 'A diverse and resilient financial system for investments in the energy transition', *Curr. Opin. Environ. Sustain.*, vol. 28, pp. 24–32, Oct. 2017, doi: 10.1016/j.cosust.2017.07.004.
[72] M. Mazzucato and G. Semieniuk, 'Public financing of innovation: new questions', *Oxf. Rev. Econ. Policy*, vol. 33, no. 1, pp. 24–48, 2017.
[73] A. Geddes, T. S. Schmidt, and B. Steffen, 'The multiple roles of state investment banks in low-carbon energy finance: An analysis of Australia, the UK and Germany', *Energy Policy*, vol. 115, pp. 158–170, Apr. 2018, doi: 10.1016/j.enpol.2018.01.009.
[74] R. Owen, G. Brennan, and F. Lyon, 'Enabling investment for the transition to a low carbon economy: government policy to finance early stage green innovation', *Curr. Opin. Environ. Sustain.*, vol. 31, pp. 137–145, Apr. 2018, doi: 10.1016/j.cosust.2018.03.004.
[75] IEA, *How Governments Support Clean Energy Start-ups: Insights from selected approaches around the world*. IEA, 2022. doi: 10.1787/291727bb-en.
[76] Energy4Impact, 'Crowd Power - Crowdfunding Energy Access: State of the Market Report 2021-2022', 2022.
[77] C. McInerney and D. W. Bunn, 'Expansion of the investor base for the energy transition', *Energy Policy*, vol. 129, pp. 1240–1244, Jun. 2019, doi: 10.1016/j.enpol.2019.03.035.
[78] Commission Européenne, 'Proposition de règlement du parlement européen et du conseil relatif aux prestataires européens de services de financement participatif pour les entreprises', Mar. 2018.
[79] Climate Bonds Initiative, 'Accelerating the fossil gas transition to net zero', 2022.
[80] T. Adrian, P. Bolton, and A. M. Kleinnijenhuis, 'The Great Carbon Arbitrage', International Monetary Fund, Jul. 2022.
[81] R. Pathania and A. Bose, 'An analysis of the role of finance in energy transitions', *J. Sustain. Finance Invest.*, vol. 4, no. 3, pp. 266–271, Jul. 2014, doi: 10.1080/20430795.2014.929000.
[82] E. Tiftik, M. Khadija, and S. Gibbs, 'Sustainable Debt Monitor - Financing the Transition', Institute of International Finance, Nov. 2022.
[83] Climate Bond Initiative, 'Bonds and Climate Change - The State of the Market 2018', 2018.
[84] Environmental Finance, 'Sustainability-linked bonds and loans - Key Performance Indicators', Mar. 2022.

[85] E. Tiftik and M. Khadija, 'Sustainable Debt Monitor: Boom Time!', Institute of International Finance, Jan. 2022.
[86] Eni, 'Eni successfully placed the first Euro-denominated sustainability-linked bond in its sector', Jun. 2021. https://www.eni.com/en-IT/media/press-release/2021/06/eni-successfully-placed-first-euro-denominated-sustainability-linked-bond.html (accessed Dec. 28, 2022).
[87] Crédit Agricole CIB, 'Crédit Agricole CIB signs EUR6bn Sustainability-Linked loan with Eni', Jul. 2022. https://www.ca-cib.com/pressroom/news/credit-agricole-cib-signs-eur6bn-sustainability-linked-loan-eni (accessed Dec. 28, 2022).
[88] A. Creed, 'Transition finance for transforming companies: Tools to assess companies' transitions and their SLBs', Climate Bonds Initiative, Sep. 2022.
[89] Airport Authority Hong Kong, 'Airport Authority Hong Kong Prices US$4.0 Billion Multi-Tranche Regulation S/Rule 144A Senior Notes Offering with Debut Green Tranche', Jan. 06, 2022. http://www.hongkongairport.com/en/media-centre/press-release/2022/pr_1579 (accessed Oct. 14, 2022).
[90] 'Airport Tracker', *Airport Tracker*, 2022. https://airporttracker.org/ (accessed Oct. 14, 2022).
[91] Sustainalytics, 'Second-Party Opinion: Aeroporti di Roma Sustainability-Linked Financing Framework', 2021.
[92] P. Bolton, L. Buchheit, M. Gulati, U. Panizza, B. Weder di Mauro, and J. Zettelmeyer, 'Climat and Debt', International Center for Monetary and Banking Studies & Centre for Economic Policy Research, 2022.
[93] Ö. Dursun-de Neef, S. Ongena, and G. Tsonkova, 'Green versus sustainable loans: The impact on firms' ESG performance'. Rochester, NY, May 20, 2022. doi: 10.2139/ssrn.4115692.
[94] Climate Bonds Initiative, 'Post-issuance reporting in the green bond market', 2021. Accessed: Jul. 20, 2022. [Online]. Available: https://www.climatebonds.net/resources/reports/post-issuance-reporting-green-bond-market-2021
[95] M. Wirz, 'Green Junk Bonds May Not Deliver Green Results', *WSJ*, 2021. https://www.wsj.com/articles/green-junk-bonds-may-not-deliver-green-results-11623236581 (accessed Dec. 28, 2022).
[96] J. F. Kölbel and A.-P. Lambillon, 'Who Pays for Sustainability? An Analysis of Sustainability-Linked Bonds', *SSRN Electron. J.*, 2022, doi: 10.2139/ssrn.4007629.
[97] Bloomberg, 'Empty ESG Pledges Ensure Bonds Benefit Companies, Not the Planet', Oct. 04, 2022. Accessed: Dec. 28, 2022. [Online]. Available: https://www.bloomberg.com/news/features/2022-10-04/greenwashing-enters-a-22-trillion-debt-market-derailing-climate-goals
[98] S. MacAskill, E. Roca, B. Liu, R. A. Stewart, and O. Sahin, 'Is there a green premium in the green bond market? Systematic literature review revealing premium determinants', *J. Clean. Prod.*, vol. 280, p. 124491, Jan. 2021, doi: 10.1016/j.jclepro.2020.124491.
[99] M. Liberadzki, P. Jaworski, and K. Liberadzki, 'Spread Analysis of the Sustainability-Linked Bonds Tied to an Issuer's Greenhouse Gases Emissions Reduction Target', *Energies*, vol. 14, no. 23, p. 7918, Nov. 2021, doi: 10.3390/en14237918.
[100] Climate Bonds Initiative, 'Sustainable Debt Global State of the Market', 2021. Accessed: Jul. 20, 2022. [Online]. Available: https://www.climatebonds.net/files/reports/cbi_global_sotm_2021_02h_0.pdf
[101] SIFMA, '2022 Capital Markets Fact Book', Jul. 2022.
[102] S&P Global, 'Private equity investment in European energy soars in 2022', 2022. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/private-equity-investment-in-european-energy-soars-in-2022-72437949 (accessed Dec. 30, 2022).
[103] World Economic Forum, 'The IPO market plummeted in 2022. Here's why', Dec. 2022. https://www.weforum.org/agenda/2022/12/ipo-plummet-company-finance/ (accessed Dec. 30, 2022).
[104] Bloomberg, 'Energy Is the Market's Only Winning Group. Here Come the IPOs', *Bloomberg.com*, Sep. 22, 2022. Accessed: Dec. 30, 2022. [Online]. Available: https://www.bloomberg.com/news/articles/2022-09-22/energy-is-the-market-s-only-winning-group-so-here-come-the-ipos
[105] S&P Global, 'Renewable IPO surge could subside in 2022 as window for transactions closes', 2022. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/renewable-ipo-surge-could-subside-in-2022-as-window-for-transactions-closes-68587999 (accessed Dec. 30, 2022).
[106] OECD, *Green Infrastructure in the Decade for Delivery: Assessing Institutional Investment*. OECD, 2020. doi: 10.1787/f51f9256-en.
[107] E. Katz and M. Masri, 'How Yieldcos are Re-Shaping the Tax Equity Market'.
[108] S. La Monaca, M. Assereto, and J. Byrne, 'Clean energy investing in public capital markets: Portfolio benefits of yieldcos', *Energy Policy*, vol. 121, pp. 383–393, Oct. 2018, doi: 10.1016/j.enpol.2018.06.028.
[109] B. Steffen, 'The importance of project finance for renewable energy projects', *Energy Econ.*, vol. 69, pp. 280–294, Jan. 2018, doi: 10.1016/j.eneco.2017.11.006.
[110] M. F. Mitidieri, 'The Evolution of the YieldCo Structure in the United States', 2020.
[111] CohnReznick, 'SPACs for Clean Energy IPO: Better Option or Bubble?', 2021.
[112] IPCC, *Global Warming of 1.5°C: IPCC Special Report on impacts of global warming of 1.5°C above pre-industrial levels in context of strengthening response to climate change, sustainable development, and efforts to eradicate poverty*, 1st ed. Cambridge University Press, 2022. doi: 10.1017/9781009157940.
[113] United Nations, 'The Paris Agreement', *United Nations*, 2022. https://www.un.org/en/climatechange/paris-agreement (accessed Jan. 05, 2023).