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Role of corporate investors in the funding and growth of clean energy tech ventures

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Abstract

Corporate investment in clean energy technology start-ups is growing and can have a significant influence in the funding of their development. However, the motivation for corporations to invest in a given technology area and the determinant of corporate investment choices remain poorly understood. In this study, we construct a global dataset and provide descriptive insights on the behaviour of corporate investors with a focus on the deployment of strategic net-zero technologies as defined by the European Commission's Net Zero Industry Act (NZIA). Our analysis shows that the collaboration between established corporations and innovative start-ups is not effective across all technology areas and that its associated impact on access to equity finance and exit opportunities differs greatly between EU-based companies and their counterparts in the US and China. In the EU, corporate investors are associated with a positive impact on the funding of EU start-ups active in emerging technology areas such as renewable hydrogen and fuel cells or batteries. EU firms active in other strategic net-zero technology areas did however not benefit from a significant number of larger later-stage deals over time unless their growth supports the activity of industry incumbents. Our analysis, at the same time, shows that EU corporate investors have steered significant shares of their venture capital and acquisition investment towards US-based companies, indicating that they could not fulfill their strategic interest in the EU.

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1 Introduction

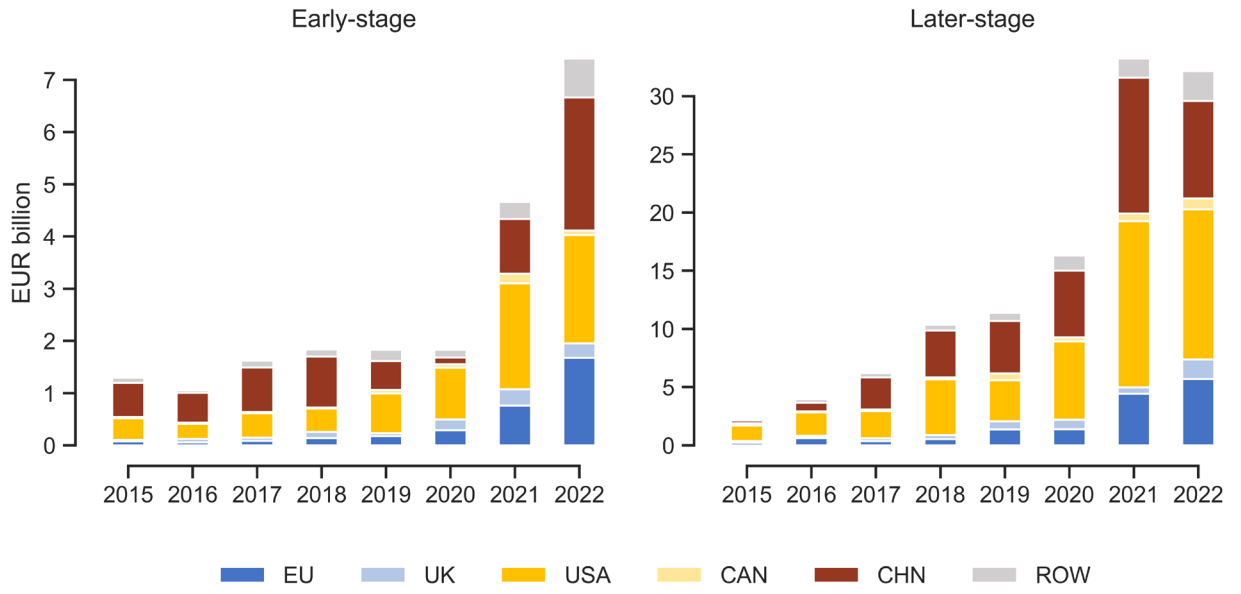
Growing policy efforts to reduce technology dependencies have driven major economies in an investment race for innovation and industrial leadership in clean energy technology (CET). Since 2015, global Venture Capital (VC) funding in CET start-ups and scale-ups[1] has increased dramatically (**Figure 1**), achieving record growth in 2021 (more than double compared to 2020 and more than 10-fold compared to 2015).

Despite the recent contraction of the VC market caused by higher inflation and interest rates (Hurley, 2023), CET companies still attracted an increasing amount of VC funding in 2022, reaching a total of EUR 39.5 billion in 2022 (+4% compared to 2021) (Georgakaki et al., 2023). Global early-stage investment[1] in CET start-ups continued to grow and reached EUR 7.4 billion in 2022 (+59% compared to 2021), confirming private investors' confidence in clean energy technologies. Compared to 2021, global later-stage investment[1] in clean energy scale-ups registered a slight decrease at EUR 32.1 billion in 2022 (-3% compared to 2021) but was still more than double that of 2020. CET also performed better than other VC segments (International Energy Agency, 2023), such as biotechnology or digital where both early-stage and later-stage investment fell in 2022.

In the EU, VC investment in CET reached EUR 7.4 billion in 2022, a 42% increase compared to 2021 and proved to be more resilient than in the rest of the world. Early-stage investment in EU CET start-ups more than doubled in 2022 compared to 2021 and grew much faster than in the US (no growth) but less than in China. Later-stage investment in EU CET scale-ups also grew in 2022 (+30% compared to 2021), in contrast to significant drops in the US and China (-10% and -29% respectively, compared to 2021).

While the EU has accounted for growing shares of the global VC investment since 2015, financing the scale-up of its CET start-ups remains a challenge (Hallmeyer et al., 2020). In 2022, the EU attracted 19% of global VC investment in CET and ranked third behind the US (38%) and China (28%), but investment – particularly at later stages – is largely concentrated in a few technology areas (mainly batteries and electric vehicles) and the competitive position of the EU varies significantly across different CET areas (Georgakaki et al., 2023).

Figure 1 – Venture capital investment in clean energy technology companies, by location, for early (left) and later-stage (right) deals.



Source: JRC elaboration based on PitchBook (Georgakaki et al., 2023)

[1] Venture capital investment consist of early and later-stage deals. Early-stage deals include crowdfunding, accelerator/incubator, angel, seed, Series A and Series B deals. Later-stage deals include all later series and private equity growth. Undisclosed series, deals occurring more than five years after the company's founding date and very large early-stage deals are re-classified as later-stage deals. Deal values are expressed in current euros.

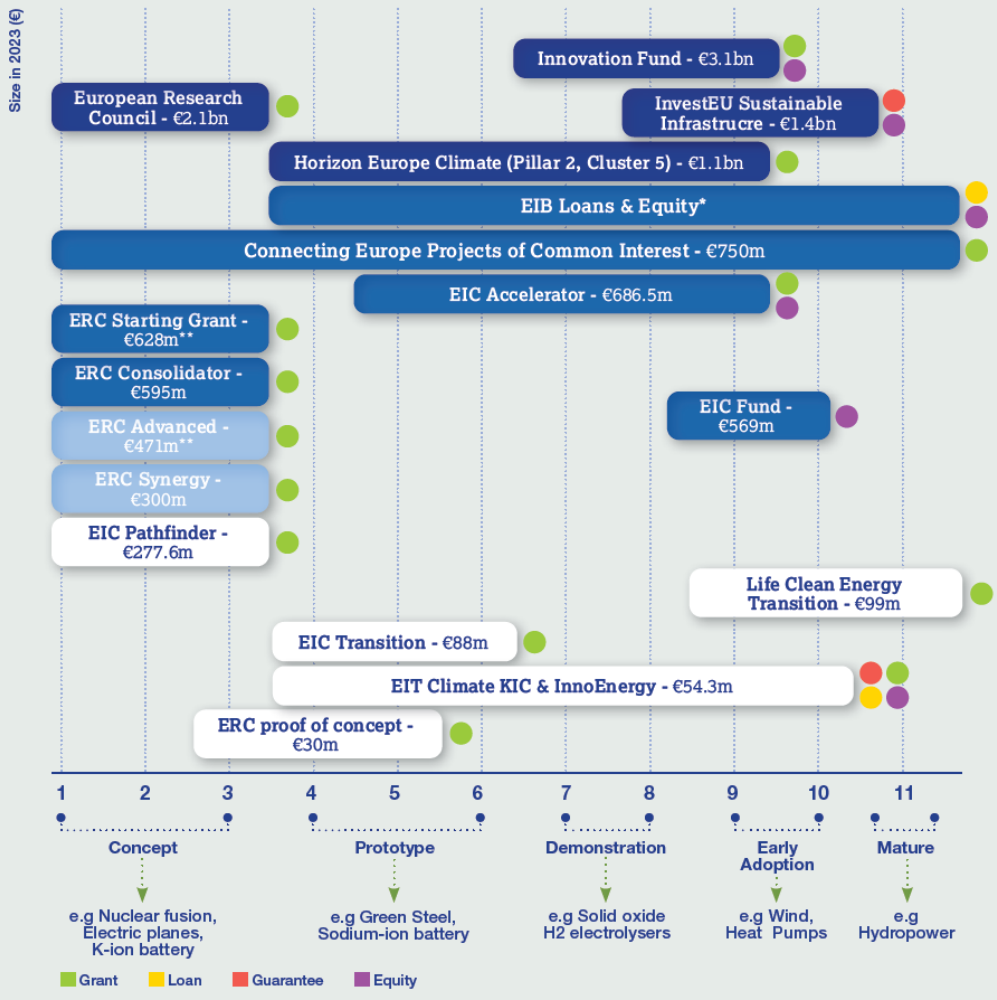
The funding of CET start-ups and scale-ups is key to developing the EU's energy resilience and technological sovereignty but also to ensure that the EU reaps the benefits of green industrialisation and seizes the opportunities of emerging clean energy technologies.

Equity finance has a central role to play in the development of innovative start-ups and the deployment at scale of clean energy technologies. It is indeed essential to finance the risks of clean energy technology investment projects traditionally associated with (1) long development cycles and capital-intensive, large-scale demonstrators, which are inherent to deep tech innovation and (2) commercial uncertainty and green premiums[2], which are inherent to the introduction of novel clean energy tech solutions on the market.

Over the years, the EU's innovation policy has expanded, and the institutional landscape has changed with it, with the aim of addressing Europe's equity gap (Quas et al., 2021; Naess-Schmidt et al., 2021), and the fragmentation of its VC market and innovation ecosystems.

This includes complementary initiatives to foster equity investment and boost the funding of innovative start-ups and scale-up companies. The creation of the European Innovation Council (EIC) fund – the EU's own venture arm – aims to fund breakthrough innovation under Horizon Europe's pillar III on "Innovative Europe" (European Innovation Council, 2018). The New European Innovation Agenda includes additional actions designed to accelerate the growth of deep-tech start-ups in the EU (European Commission, 2022). The InvestEU fund – using guarantees from the EU budget – mobilises public and private investment, including funds that provide equity financing (European Commission, 2021).

Figure 2 – The EU clean energy technology financing landscape (with reference to IEA technology readiness levels)



Source: Institute for Climate Economics (Humphreys, 2023)

[2] A green premium is the additional cost of choosing a clean technology over one that emits more greenhouse gases.

As shown in (**Figure 2**), a wide range of public EU funds – combining grant, loan, guarantee and equity instruments - are available to support the different development stages of clean energy technologies (Humphreys, 2023). Announced in 2023, the European Strategic Technologies for Europe Platform (European Commission, 2023b) will seek to reinforce, leverage and steer EU funds – existing and new – to investment in critical technologies in Europe, including clean energy technologies. By providing adequate financial support to deep tech and CET companies throughout their lifecycle, it can contribute to de-risking innovation investment, bridging the gap between project developers and corporate and institutional investors, and ultimately to channelling further private investment.

Over the past years, 3 EU-based CET companies raised very large (above EUR 2 billion) amounts of venture funding[3] to develop large-scale manufacturing facilities, thus demonstrating the capacity of the EU in mobilising public and private investors and attracting large growth deals. Beyond such success stories, the EU equity market however remains insufficiently developed to ensure a widespread access to finance to EU start-ups with investment-ready decarbonisation projects (Lechtenfeld et al., 2023).

A higher level of public and private investment is therefore needed to support the growth of more EU companies and ensure the deployment of all the CETs that are key to meeting the European Union's climate neutrality goals. This is the case for innovative solutions in emerging technology areas that require financing for commercial first-of-a-kind (FOAK) facilities. This is also the case for other technology areas reaching early adoption and maturity in which private investors have also historically invested less following a first wave of failed investment early last decade (Gaddy et al., 2017).

With the Net Zero Industry Act proposal (NZIA) (European Commission, 2023a), the EU has sent clear signals regarding the importance of a set of strategic net-zero technologies and the fact that the EU will not be able to scale CETs without a robust industrial base. Strategic net-zero technologies are diverse and not limited to technologies that are at commercial demonstration stage. They also include innovative and mature technologies on markets for which the global competition for manufacturing and deployment capacity is already intense (e.g., in wind, solar PV, heat pumps). Some of those technologies remain under-financed in the EU (as compared to other CETs and foreign counterparts) and the EU has not yet fully exploited its capacity to attract larger growth deals in those technology areas like those of the US and China (Georgakaki et al., 2023).

In this context, corporations that must transition to carbon neutrality have a specific role to play. Corporations engaging in strategic investment can represent an alternative to traditional VC investors, be strategic partners for start-ups and contribute to de-risk investments in scale-ups by providing more patient capital and VC exit options. Their collaboration with start-ups can enable innovation, channel further private investment, fast-track the deployment of technologies and strengthen the EU's energy resilience.

Start-ups need support from established corporations to scale up, grow and reach widespread adoption of their products and services. In addition to providing funding, corporate investors can be strategic partners with commercial expertise and market knowledge, and provide VC exit options. Moreover, corporate open innovation strategies relying on start-up engagement can bring insights into innovation and new business models, undercut competition, or bring novel expertise through acquisition, and support communication on green leadership.

Before discussing the potential role of corporations in unlocking private investment, it is however essential to achieve a better understanding of their strategic interest to invest in a given technology area. The objective of this study is to investigate the role of corporate investors in the funding and growth of strategic-net zero start-ups. Via an analysis of the direction of corporate investment, it aims to provide descriptive insights into the collaboration between corporations and start-ups and to address the following questions:

- Do corporate investors play a significant role in the funding and growth of strategic net-zero technology start-ups?
- What are the investment patterns of corporate investors in strategic net-zero technologies?

[3] Namely the battery manufacturers Nortvolt in Sweden and Verkor in France, and the steel producer H2 Green Steel in Sweden.

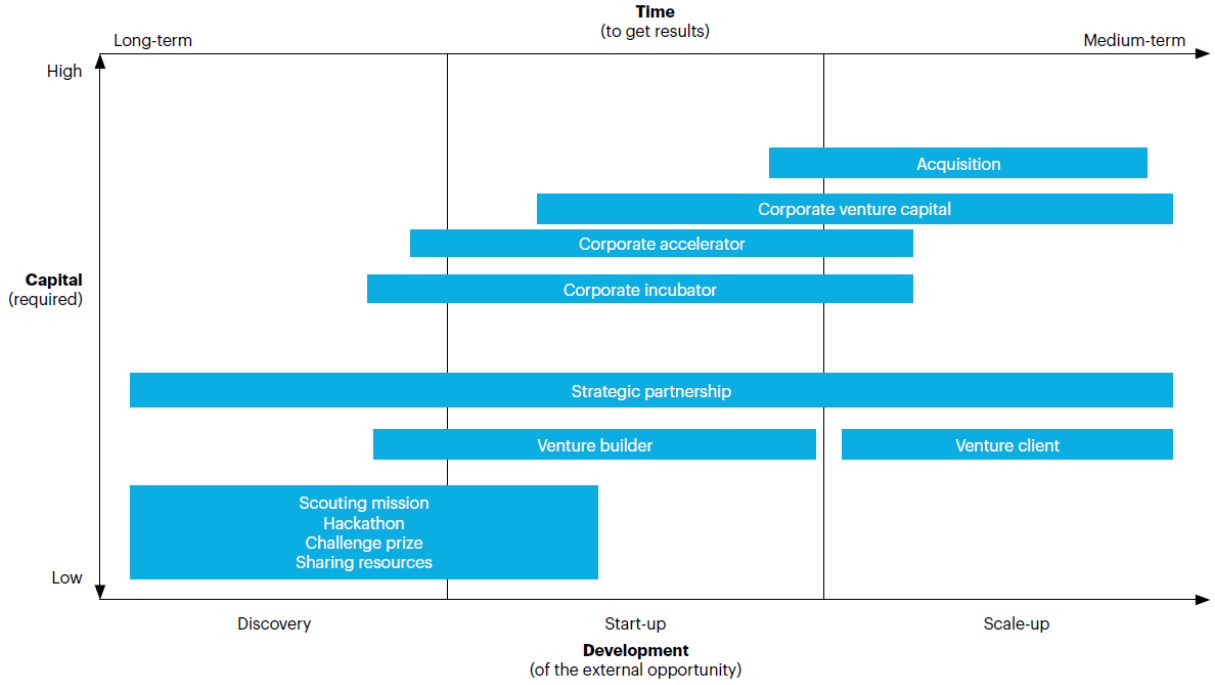
2 Analysing corporate investment in clean energy technology start-ups

2.1 Literature

Collaboration between established corporations and innovative start-ups is an effective means to extract value from technology, accelerate the cycle of innovation and develop new business capabilities (Siota et al., 2020). It can contribute to accelerating the development and deployment of clean energy technologies by combining the innovation capacity of start-ups with the scaling potential of large industry players.

The different mechanisms (***Figure 3***) that support such collaborations are generally referred to as corporate venturing. Corporate venturing constitutes an additional innovation tool for corporations to pursue their strategic interests by accessing and accelerating forms of innovation that are difficult to produce internally. Corporations usually engage in corporate venturing to gain awareness of novel technologies, develop a broad awareness of market developments, or identify start-ups for potential acquisition. Funding[4] constitutes an important and traditional way to engage with start-ups that need such resources to overcome the "valley of death" and scale-up.

Figure 3 - Corporate Venturing Mechanisms by Capital, Time and Opportunity



Source: (Siota et al., 2020)

There is, however, limited research on the priorities of private investors such as corporations when investing in clean energy technology start-ups, on how that influences the direction or speed of technological innovation and adoption, and on how public policy can incentivise such practices in alignment with the climate objectives that it sets.

(Hockerts et al., 2010) stated that new entrants are more likely than incumbents to pursue sustainability-related opportunities in the early stages of an industry's transformation and that incumbents react to the activities of new entrants by engaging in corporate sustainable entrepreneurship activities. It also suggested that smart innovation policies should try to leverage cooperation and competition between incumbents and entrepreneurial start-ups.

[4] In the form of in-kind support, procurement, grants, loan, minority equity investments or acquisitions

(Mazzucato et al., 2018) studied the 'direction' that investors create when financing innovation in, and the deployment of, renewable energy technologies. It called for a better understanding of the relationship between different types of finance and their willingness to invest to avoid the over-financing of some areas and the under-financing of others.

(Hegeman et al., 2021) investigated the different motivations that corporations have for investing in clean energy technology start-ups. It noted that corporate investors are diverse in size, ownership, and ways of managing their investment – suggesting that focusing on large, listed companies with dedicated corporate venture capital (CVC) entities leaves out many other types of active investor. It also concluded that the principal reason for large companies to invest corporate venture capital in clean energy technologies is to promote corporate greening to maintain competitiveness.

Disclosure limitations make it impossible to determine the exact contribution of an investor to an equity investment deal. Some initiatives have, however, adopted a practical approach to assessing the magnitude of corporate investment in CET start-ups by splitting evenly the value of deals across the contributing investors.

In its World Energy Investment report series, the International Energy Agency reports growing corporate VC investment in clean energy start-ups by technology area (International Energy Agency, 2023). Based on the same data, (Surana et al., 2023) report a similar trend for the wider climate-tech domain, provide further analysis of the business sector of corporate investors and suggest the leveraging of corporate investment in start-ups as an indicator for technological change.

2.2 Method

Our analysis relies on a selection of clean energy technology start-ups and scale-ups monitored by the European Commission's Joint Research Centre in support of the Clean Energy Technology Observatory (Georgakaki et al., 2023) and Climate Neutral Industry Competitiveness Scoreboard (Kuokkanen et al., 2023). This selection captures around 4 250 companies with global coverage and provides a representative description of the clean energy technologies that start-ups and scale-ups contribute to develop.

This selection is derived from the PitchBook Financial Database (PitchBook, 2023), which provides a detailed description of the companies, the deals they have realised over time and the investors that contributed. For this study, we have selected a supporting dataset of 5 483 deals realised between 2013 and 2022 in 1 888 companies located in the EU, the US, China, Canada, and the UK. This ensures a representative description of VC investment realised after the first clean tech wave and in the countries that account for more than 90% of global investment over the period.

The dataset aims to analyse the growth of start-ups and focuses on companies from the pre-venture and venture capital universes. This includes companies that are less than two years old and have not received funding, have received angel or seed funding, or have – at some point – been part of the portfolio of a venture capital firm. Consequently, this excludes companies that have only been part of the portfolio of a private equity firm.

The dataset focuses on companies developing strategic net-zero technologies as defined by the European Commission's Net Zero Industry Act (NZIA). This includes solar photovoltaic and solar thermal, onshore, and offshore renewables, energy storage and batteries, heat pumps and geothermal energy, electrolysers and fuel cells, sustainable biogas/bio-methane, carbon capture and storage, and grid technologies. It excludes infrastructure project (e.g., developers and operators of wind and solar farms).

Deals are related to (1) grants, (2) venture capital and private equity and (3) VC exits. The dataset does not include debt-related deals. Venture capital and private equity investment consist of early-stage and later-stage deals. Early-stage deals include crowdfunding, accelerator/incubator, angel, seed, Series A and Series B deals. Later-stage deals include all later series and private equity growth. Undisclosed series, deals occurring more than five years after the company's founding date and very large early-stage deals are re-classified as later-stage deals. VC exits cover corporate acquisitions (M&A) and initial public offerings (IPO) but exclude all buyout types.

The combined analysis of companies, deals and investors however presents several challenges stemming from the limitation of investment databases:

— The size of deals is not systematically disclosed. We work with the assumption that deals with a disclosed value (which represent 76% of the numbers of completed deals), include all the largest deals (in size) and thus account for most of the total funding.

— The investors taking part in a deal are not systematically disclosed or identified by a corresponding investor entry in the database. In the dataset supporting this analysis, the 4 331 deals (out of a total of 5 483) which include information on identified investors cover 95% of the cumulative investment. Most of the investors that are not disclosed or identified correspond to angel, IPO, or crowdfunding deals.

Moreover, even if deal sizes and investors are provided, the share of each investor participating in each deal is never disclosed. To overcome this limitation, the following analysis adopts a practical approach to assessing the contribution of each investor in an investment. In line with (International Energy Agency, 2023; Surana et al., 2023), it relies on fractional deal sizes. In the absence of a more representative distribution key, our approach consists of allocating an equal share of the deal value to all investors participating in each deal and mapping the different investor types to broader categories, as defined in (**Table 1**).

Table 1 – Classification of investor types

Category	**PitchBook investor type**[1]
Accelerator/Incubator	Accelerator/Incubator
Angel	Angel individual, Angel group
Venture Capital	Venture Capital,
Private Equity	Growth/Expansion, PE/Buyout, Other Private Equity
Corporation	Corporate Venture Capital, Corporation, Holding Company, PE-Backed Company, VC-Backed Company
Government/University	Government, University, Not-For-Profit Venture Capital
Investment manager / fund	Asset Manager, Hedge fund, Family office, Impact investing, Small business investment company Funds of Funds, Limited partner, Sovereign wealth fund, Mutual fund
Banks	Investment bank, lender/debt provider, Merchant banking firm
Other	Infrastructure, Real estate

[1] This is not an exhaustive mapping and only includes the PitchBook investor types that are represented in the current dataset.

Source: JRC elaboration based on PitchBook

3 Results

3.1 VC investment trends in strategic net-zero technologies

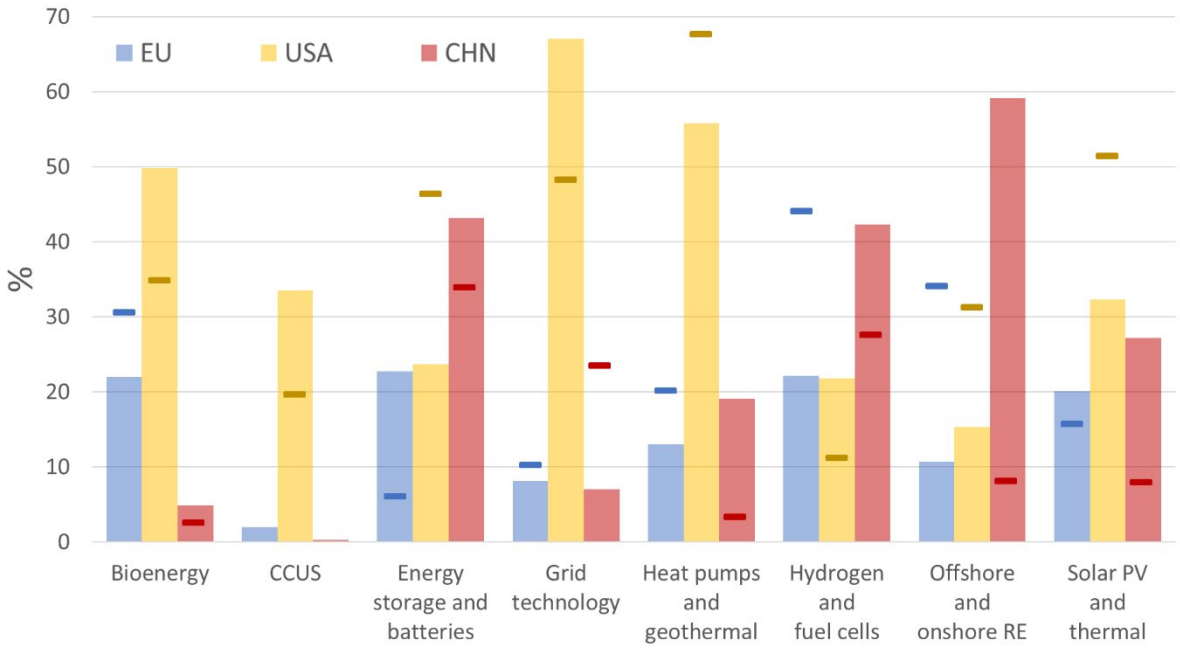
Strategic net-zero technologies, as defined in the Net-Zero Act (NZIA), accounted for 70% of the total VC investment in EU clean energy tech firms between 2015 and 2021 (compared to 34% in the US and 40% in China). In 2022, however, VC investment in NZIA technologies in the EU registered a much lower increase (+2% compared to 2021) than the total VC investment in EU clean energy technology companies (+42% compared to 2021).

The slowdown of VC funding led to a decrease of later-stage investment in EU NZIA technology companies (-2% compared to 2021). This contrasts with the +28% increase in 2022 (compared to 2021) of later-stage investment in EU clean energy technology companies and is mostly due to the drop of VC investment in battery manufacturing and recycling[5]. Early-stage investment in EU strategic net-zero technology companies increased in 2022 (+53% compared to 2021) but much less than early-stage investment in all EU clean energy technology companies (+120% compared to 2021). This growth is also much lower than that seen in the US (+41% compared to 2021), where early-stage investment in hydrogen and fuel cells, and later-stage investment in solar PV and thermal, bioenergy, and heat pumps and geothermal rose in 2022.

In 2021 and 2022, VC investment in hydrogen and fuel cell firms in the US and China has outpaced that of the EU – despite the sustained growth of the latter. As shown on (***Figure 4***), the EU only accounts for 22% of VC investment realised in this technology area between 2019 and 2022 (compared to 44% between 2015 and 2019). Similarly, EU's attractiveness in technology areas such as wind and bioenergy has been overshadowed by recent large private equity growth deals realised in China and the US respectively.

Since 2021, the growth of VC investment in EU-based companies is also accompanied by a growth of foreign investment in technology areas such as hydrogen and fuel cells, bioenergy, heat pumps and geothermal. This has grown much faster than local EU investment and represents more than half of the funding of EU firms in each of those technology areas in 2022 (against 15% overall in 2021).

Figure 4 – Share of venture capital investment in NZIA tech companies by region – A comparison between deals realised between 2019 and 2022 (bars) and deals realised between 2015 and 2018 (dashes).



Source: JRC elaboration based on PitchBook data.

[5] The Swedish company Northvolt accounts for 35% of all VC investment realised in EU clean energy tech firms between 2017 and 2022. As the company raised less venture capital in 2022 (EUR 1.12 billion compared to EUR 2.26 billion in 2021), VC investment in the energy storage and battery technology area dropped by 31% in the EU in 2022.

3.2 Who invested?

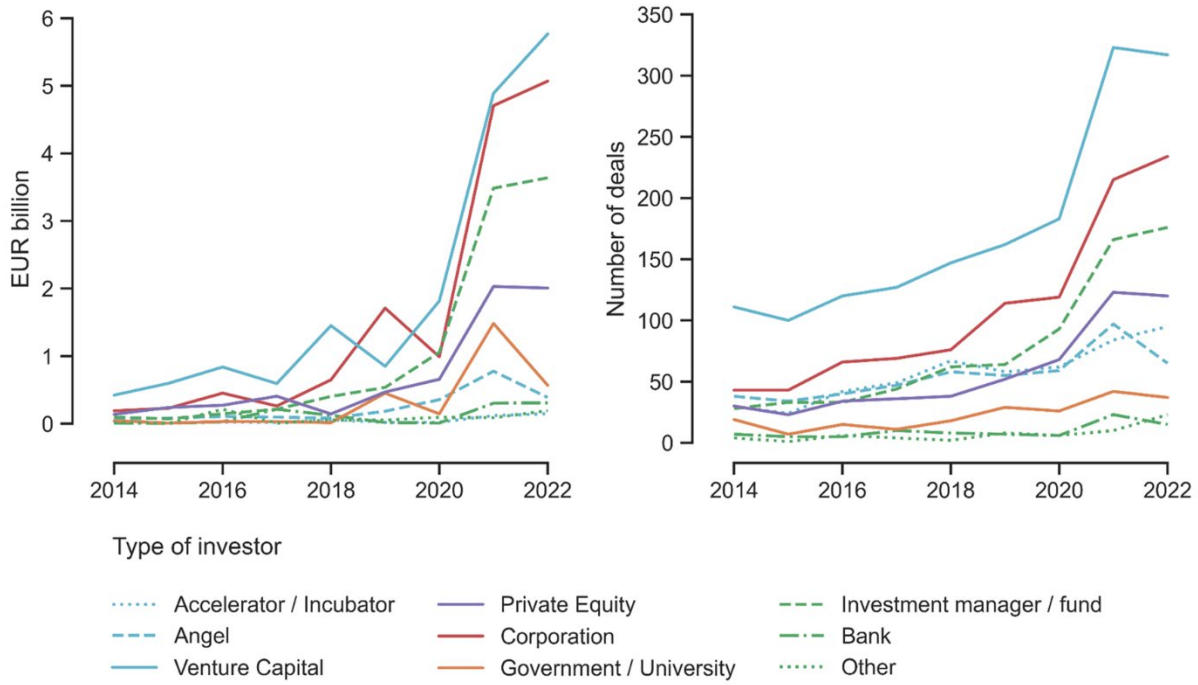
As shown in (**Figure 5**), the sharp increase in the number of deals and of the global VC funding in NZIA technology companies over recent years is associated with a growing contribution of traditional and corporate venture capital investors.

Until 2017, this trend was accompanied by the creation of an increasing number of new ventures active in the development and deployment of NZIA technologies. As those technologies are reaching commercial demonstration, early adoption or are already on the market, the number of new ventures has decreased since (by half in 2021 compared to 2017). On the other hand, the number of companies that raised venture capital each year has continuously increased (doubling in 2022 compared to 2019 and quadrupling compared to 2015), indicating the increased confidence of private investors and, with the growth of later-stage investments, a shift in their interest to the deployment of such technologies.

In 2019, corporations became the second most involved type of investor (in number of deals) behind traditional VC investors. Corporate investors have also and largely been more active in the later stages of the investment cycle (both in number of deals and total investment), which accounted for a larger share of the total over recent years. Their contribution to the total VC investment in NZIA technology firms increased drastically in 2021 and indicates that the 2021 investment burst was accompanied by an increased participation of corporate investors in the largest deals.

This evolution was also accompanied by a diversification of the types of investors involved and larger average contributions for several types of investors (including venture capital and private equity, corporate and investment manager/fund). (**Figure 5**) highlights the increased participation of investment managers and funds over the past years, with an appreciable acceleration since 2019. The contribution of private equity (PE) investors – which invest to fund the growth of already established businesses – also increased until 2021 but to a lesser extent and slowed in 2022 as a possible result of the contraction of VC/PE markets. The contribution of government/university investors to the investment total – as well as their average contribution – has also increased since 2018. It however displays a higher volatility that can be due to public investors contributing to very large deals in 2019 or 2021 (where their contribution is likely to be overestimated).

Figure 5 - Evolution of the total VC investment (left) and number of deals (right) realised worldwide in strategic net-zero technologies, by type of investor.



Source: JRC elaboration based on PitchBook data. Total VC investment corresponds to the sum of fractional deal sizes for equity deals (both early and later stage), excluding deals with undisclosed investors and crowdfunding deals.

While traditional VC investors remained central to the investment process, considering the numbers of deals and companies that they were involved in, the contribution of corporate investors to the investment total has become at least as important. The development of groups of co-investors also indicates that traditional VC investors sought to expend resources to help develop opportunities related to NZIA technologies. Between 2019 and 2022, 53% of companies received investment from venture capital (representing 27% of the total investment) and 39% of companies received investment from corporations (representing 30% of the total investment) whereas 30% received grant or equity funding from government/universities (representing 9% of investment).

Between 2015 and 2022, EU investors (of all types) invested largely in EU-based companies, which captured 83% of their total investment, but also in US-based companies (13%). Similarly, the funding of EU-based companies is mostly performed by EU-based investors, which account for 68% of the capital that they raised, and to a lesser extent by US-based investors (11%).

Overall capital flows between the EU and the US are similar in size but differ greatly in nature and by the type of investors they involve. Investments by EU investors in US-based companies are largely performed by corporations, which account for 69% of the total, and traditional VC investors (18%). On the other hand, investment by US investors in EU-based companies is primarily realised by investment managers or funds, such as private equity funds (which respectively account for 31% and 35% of the total).

3.3 A look at the focus of corporate investors

Corporate VC (CVC) investment in NZIA technology firms is growing (**Figure 6**) and significant. Corporate investors have been involved in an increasing number of deals in US-based companies (+24% CAGR between 2015 and 22), EU-based companies (+22%) and China-based companies (+56%).

Corporate investors are most active in the later stages of investment (which accounted for 69% of deals involving a corporation and 86% of total CVC investment since 2015). They focused their effort on technology areas such as batteries (accounting for 33% of the number of later-stage deals involving a corporate investor since 2015), solar PV (20%) and grid infrastructure (16%).

Early-stage CVC investment is lower due to the smaller size of early-stage deals but also because corporate investors are involved in a much lower share of early-stage deals (18% of all early-stage deals since 2015 involve corporate investors) than of later-stage deals (37%). While this is also true for traditional VC investors and accounts for the more diverse investor types involved in early-stage deals[6], this indicates that corporate investors are looking to achieve more strategic benefits from NZIA technology companies that are scaling up their business than from companies in the early stages of technology development.

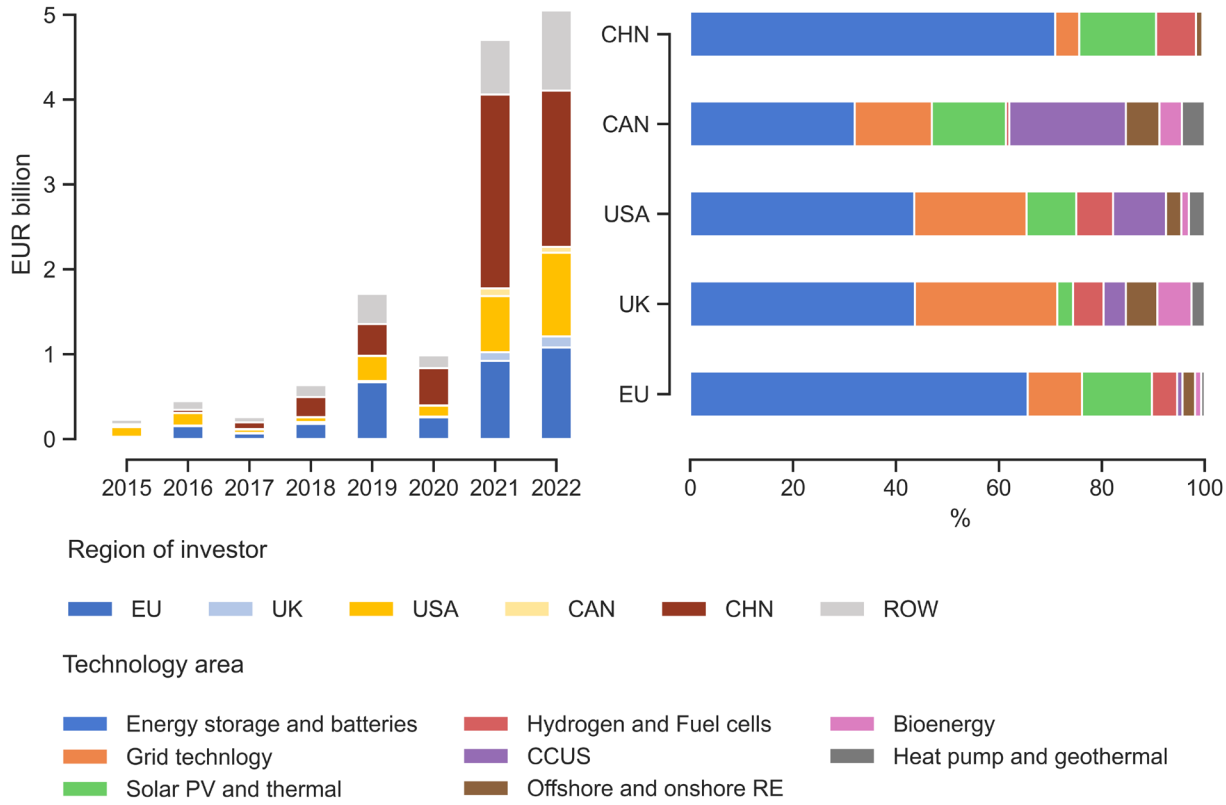
Nearly a third of corporate investors in NZIA technologies are in the EU (30% of corporate investors), ahead of the US and China (accounting for 22% and 19% of the total respectively). EU and US-based investors are involved in a larger number of deals (39%, and 32% deal count since 2015 respectively) than Chinese investors (17%).

Chinese corporate investors are, however, the largest contributors to the investment total, as they accounted for 38% of global CVC investment since 2015. 98% of the total VC investment by Chinese corporations was realised in Chinese companies that are mostly active in batteries (which accounts for 69% of the venture capital invested by Chinese corporations since 2015), solar PV (15%) and hydrogen and fuel cells (8%). China has indeed become a major location for the scale-up of energy storage and electric vehicle companies, which contribute to the structuring of the Chinese automotive sector. This is accompanied by higher levels of involvement and contribution from corporate investors and larger deals in energy storage and batteries.

EU-based corporate investors have accounted for 24% of global CVC investment since 2015 and directed 69% of their investment effort towards EU-based companies. The EU-based companies they invested in are mostly active in energy storage and batteries (which accounts for 45% of the venture capital invested by EU corporations since 2015), solar PV and thermal (12%) or grid infrastructure (5%). Between 2015 and 2022, corporate investors based in the EU also steered 24% of their investment effort towards US-based companies, mostly active in energy storage and batteries (15%) or grid infrastructure (4%). This indicates that EU-based corporate investors were seeking potential access to the US market or to acquire competitive knowledge or companies that they do not find in the EU.

[6] Namely, accelerator / incubator, angel, government / university.

Figure 6 – Corporate venture capital investment (both early and later stage) in NZIA tech companies by region of investor (left) and technology focus of corporations by region of investor (right)



Source: JRC elaboration based on PitchBook data. Total VC investment corresponds to the sum of fractional deal sizes for equity deals by corporate investors. Excludes acquisitions.

US-based corporate investors have accounted for 17% of global corporate VC investment since 2015 and 81% of the total VC investment by US corporations benefited US-based companies. The US-based companies they invested in are mostly active in energy storage and batteries (which accounts for 41% of the venture capital invested by US corporations since 2015), grid infrastructure (18%) or solar PV and thermal (8%).

US-based corporations have invested less than 4% of their total CVC effort since 2015 in EU-based companies. This amounts to 8.6 times less than the total CVC investment from EU corporations in US-based companies over the same period. This indicates corporate investors' higher confidence in the US venture capital ecosystems and US-based start-ups to achieve their strategic objectives.

VC investment and acquisitions are traditional ways for an established corporation to collaborate with start-ups and scale-ups to explore new markets or tackle specific challenges already identified by the corporation. While corporate acquisitions of NZIA technology start-ups only concern 4% of all identified companies, they represented most of the corporate investment effort between 2015 and 2018 (accounting for 74%, 81% and 71% of the total invested by EU, US, and Chinese corporations respectively), far ahead of corporate VC investment.

The relative weight of acquisitions in total corporate investment has however dramatically decreased over recent years, in particular in the EU and China. Between 2019 and 2022, they accounted for 3%, 73% and 7% of the total invested by EU, US, and Chinese corporations respectively. Overall, most corporate acquisitions targeted start-ups active in solar PV (26% of acquisition deals since 2015), grid infrastructure (21%), energy storage and batteries (20%) and wind (16%). They predominately involved US and EU-based companies (39% and 22% of deals respectively). Most of the total investment value, however, benefited solar PV companies in the US and Canada (accounting for 56% of total of corporate acquisitions since 2015) and US-based companies active in grid infrastructure (22%).

Corporate acquisitions of EU-based companies are limited in size and account for 6% of the global corporate acquisition total since 2015. Moreover, the size of corporate acquisitions in EU-based companies is 2.5 times

lower than the size of corporate VC investment between 2015 and 2022. This contrasts sharply with the situation in the US where the size of corporate acquisitions is 2.9 times higher than the total corporate VC investment between 2015 and 2022, which is itself 1.5 times higher than in Europe.

Moreover, corporate EU investors allocated 88% of their acquisition effort – an amount that is equivalent to the total size of corporate acquisitions of EU-based companies – to US-based companies mostly active in solar PV and thermal (77%) and energy storage and batteries (10%), only providing limited exit opportunities for EU-based companies. This again indicates that the prospect of accessing the US market and / or of acquiring companies that do not exist (or are not as developed) in the EU are among the main motivations for EU-based corporations to invest.

3.4 Impact associated with the participation of corporate investors.

Corporations have the financial means, commercial know-how, and market knowledge to deploy and scale new innovations on the market. As shown in previous sections, they can allocate capital to develop opportunities either by supporting large later-stage equity rounds or acquiring start-ups where it serves their strategic objectives.

Collaborating and partnering with established corporations can have a large impact on start-ups and scale-ups that goes beyond funding. As an illustration, among the 160 companies active in the development of NZIA technologies that went out of business since 2015, 134 did not have a corporate equity investor involved and only 26 did. Similarly, the contribution of a CVC investor in the funding of a NZIA technology firm leads to a larger amount of capital raised via IPOs on average, but those are associated with longer lead times.

Start-ups and scale-ups that collaborate or partner with corporations do not, however, equally benefit from better access to equity finance. While the involvement of corporate investors can channel larger deal sizes, the following section shows that there are significant variations depending on the location of the company and the technology areas that it addresses.

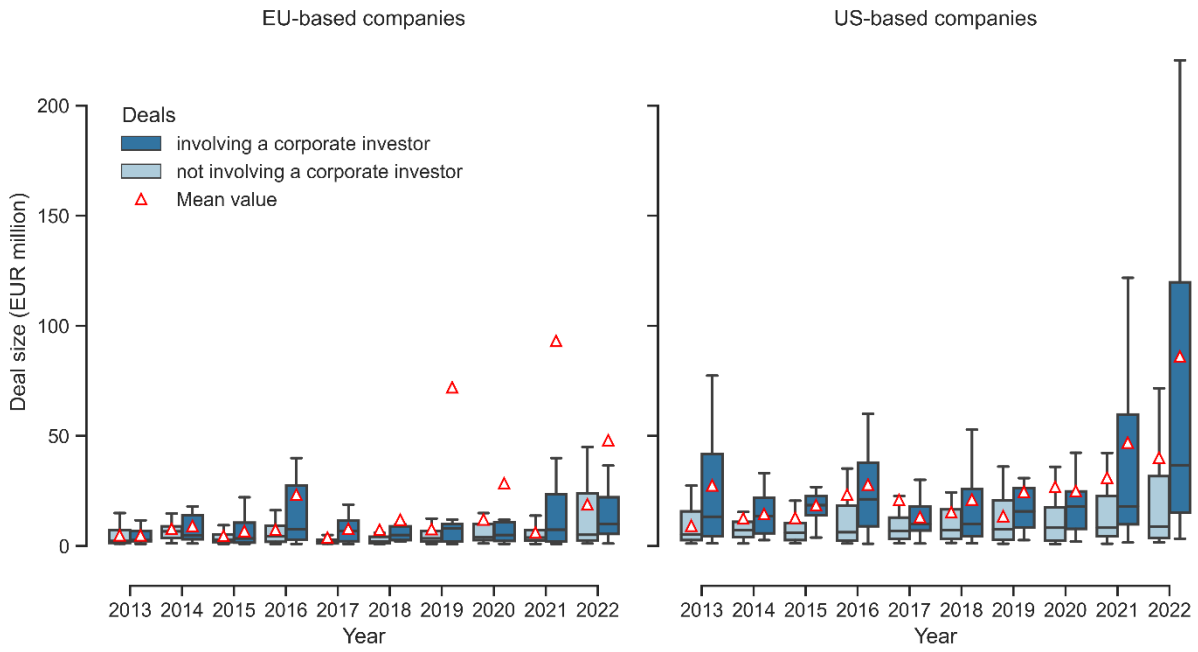
(**Figure 7**) depicts the evolution of the size distribution of later-stage deals in NZIA technology start-ups based in the EU and the US. It shows that in US companies, deals with a size above the median value have increasingly larger sizes over time and that this trend is much more pronounced for deals that involve a corporate investor. In 2022, more than 75% of deals involving a corporate investor had larger sizes than 50% of deals not involving a corporate investor. Conversely, more than 75% of deals not involving a corporate investor had smaller sizes than 50% of deals that involve a corporate investor. While larger deal sizes have a significant impact on the total VC investment in US-based companies, the joint evolution of the median and mean values of the distribution indicates a structural growth trend in 2021 and 2022.

This contrasts with the distribution of later-stage deal sizes in EU-based companies where the median size has not significantly evolved, whether a corporate investor is involved or not. The potential impact of corporate investors suggested by the wider interquartile ranges observed in 2016 and 2021 remains sporadic and is only due to a limited number of deals in energy storage, solar power integration and the manufacturing of solar PV products. In 2022, the involvement of corporate investors is not associated with greater deal sizes, despite a higher number of larger deals involving corporate investors that year. As indicated by the spread between the mean and median values, the total VC investment in EU-based start-ups developing NZIA technologies is to a large extent due to the very large outlying deals realised every year since 2019 in the Swedish battery manufacturer Northvolt.

(**Figure 8**) describes the distribution of the total amount of grants and capital raised (via VC investment or initial public offerings) by start-ups across the different NZIA technology areas and highlights significant differences between EU-based and US-based companies.

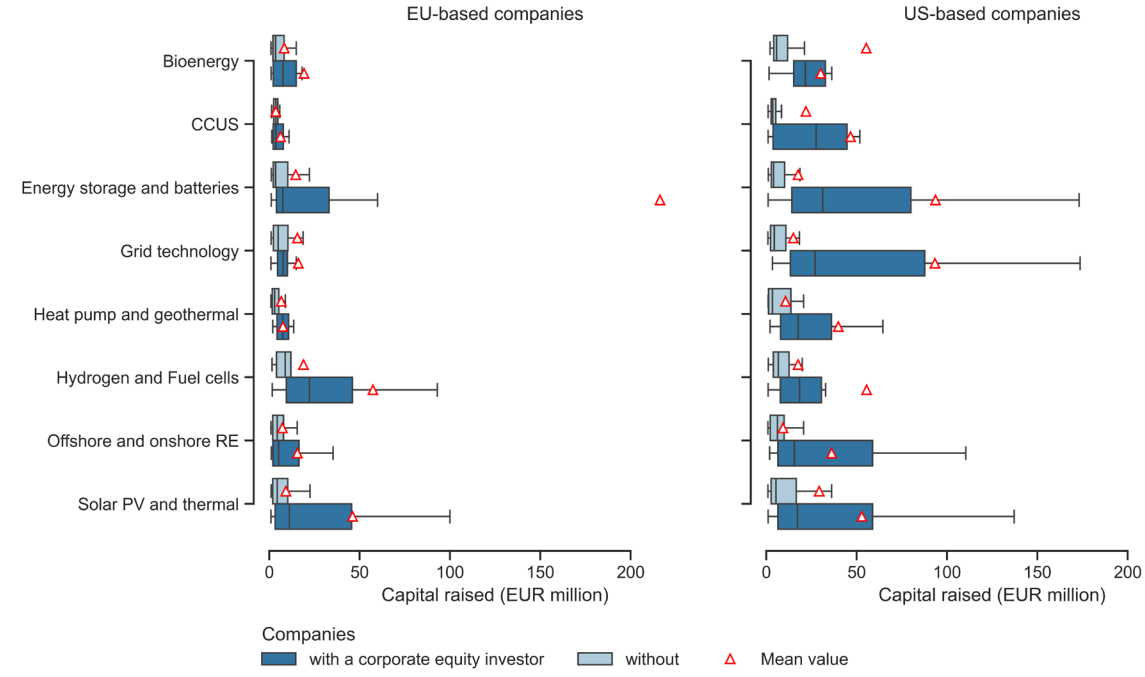
Emerging technology areas such as energy storage and batteries, hydrogen production or fuel cells are reaching large-scale demonstration or early-adoption and can have a wide range of applications across multiple industry sector (such as energy, transport, and buildings). To that extent, the development and growth of start-ups in those technology areas can support the effort of established corporations in their transition. In order to maintain their competitiveness, those corporations can have a strategic interest in investing in such start-ups as a quicker way to acquire knowledge, new technologies and business models – where such companies exist.

Figure 7 - Distribution of later-stage deal sizes in EU-based companies (left) and US-based companies (right) – A comparison between deals that involve corporate investors and deals that do not.



Source: JRC elaboration based on PitchBook data. Based on 430 and 649 observations (deals above EUR 1 million) for EU and US-based companies respectively. 45% of observations in EU-based companies and 39% of observations in US-based companies involve a corporate investor. Deals below EUR 1 million (representing 20% of observations and less than 1% of the investment total) are excluded. 82% and 95% of deals below EUR 1 million in EU and US-based companies respectively do not involve a corporate investor.

Figure 8 - Distribution of the total of grants and capital raised in EU-based (left) and US-based companies (right), by strategic net-zero technology – A comparison between companies involving corporate investors and companies that do not.



Source: JRC elaboration based on PitchBook data. Based on 389 and 610 observations (companies that raised more than EUR 1 million) for EU and US-based companies respectively. 47% of EU-based companies and 40% of US-based companies that raised more than EUR 1 million involve a corporate investor. Companies that raised less than EUR 1 million (representing 27% of observations and less than 1% of the total capital raised) are excluded. 93% and 98% of companies that raised less than EUR 1 million in EU and US-based companies respectively do not involve a corporate investor. The average capital raised by EU-based companies in Energy storage and batteries is displayed out of range due to large outliers and is equal to EUR 216.3 million.

The involvement of a corporate investor is associated with a larger amount of capital raised in those technology areas. This is the case for EU-based hydrogen and fuel cell companies where it led to higher levels of VC investment and IPOs on average, allowing them to compete with their US counterparts. Similarly, corporate investors from various sectors contributed to the outstanding amount of capital required for the scaling up of the company Northvolt, enabling the development of large-scale battery factories in the EU. But as the spread between the median and mean value indicates, the corporate investment effort in EU-based companies is very concentrated and only benefited a limited number of companies.

As seen in (**Figure 8**), corporations have a similar incentive to invest in US-based companies developing CCS solutions that can contribute to the decarbonisation of hard-to-abate sectors in industry and transport. In the EU, the VC investment in start-ups developing CCS solutions is very limited due to a low number of companies which only started to attract smaller early-stage deals since 2021.

On the other hand, industry incumbents have limited interest in partnering with – or supporting – the development of start-ups whose solutions may undermine their operating or business models or do not add to their corporate greening effort. Similarly, start-ups can be wary of incumbents that may potentially be seeking to gather intelligence to compete against them and that can prove challenging for start-ups to leapfrog. Corporations may however seek to achieve competitive gains by investing in or acquiring start-ups that develop innovative solutions and services that are partially aligned with, and can support, their core activity. This is the case, for example, for solar PV in the EU, where the larger average capital raised by companies involving a corporate investor is due to the larger deals that companies specialised in solar installation, operation and maintenance services have raised since 2020.

(**Figure 8**) indicates that, in the EU, the involvement of a corporate investor is not associated with better access to equity finance for start-ups active in a set of technology areas including wind, heat pumps and grid technologies. These technologies address mature markets where industry incumbents or utilities play a central role in the innovation and adoption processes. Those are usually driven by in-house technology development with longer lead times and investment in improvements in products or processes.

But the sharp contrast with the situation in the US, where the involvement of a corporate investor is associated with better access to equity finance, and the fact that corporate investors are involved in a significant share of deals in EU-companies in those technology areas, suggests that the collaboration between EU start-ups and corporations could be further developed for the deployment of those technologies.

Globally, the involvement of a corporate investor has also led to an increase in the number of IPOs and in the amount of capital raised by start-ups in public markets.

This evolution is to a very large extent driven by the number of IPOs achieved since 2020 by Chinese companies active in energy storage and batteries (accounting for 15% of the global number of IPOs and 40% of the total capital raised via IPOs since 2015) and solar PV (accounting for 18% of the global number and 19% of the total capital raised). Overall, 70% of the 33 Chinese companies that achieved an IPO since 2015 (accounting for 79% of the capital raised via an IPO by Chinese companies) had a former VC deal involving a corporate investor.

In the EU, 19 companies developing NZIA technologies have raised capital through an IPO since 2015. 2021 saw the realisation of a significant number of related IPOs across all technology areas (with the notable exception of solar PV – where several IPOs were achieved between 2015 and 2019, and energy storage and batteries). Seven of those IPOs were indeed realised in 2021 and 2022, in companies where a corporate equity investor was previously involved, and active in hydrogen and fuel cells (2), offshore and onshore RE (2), grid infrastructure (2) and bioenergy (1). Those IPOs are associated with larger amounts of capital raised (compared to IPOs realised between 2015 and 2019) and accounted for 65% of the capital raised via an IPO by EU-based companies.

4 Conclusions

The successful financing of innovation in clean energy technologies calls for a better understanding of the relationship between the different types of investors and their willingness and strategy to invest in the development and deployment of clean energy technologies.

This research provides an evidence base analysis of the role of private investors in the funding and growth of start-ups developing clean energy technologies (CET). Corporate investment is particularly important as it tends to focus on technologies reaching commercial demonstration and adoption. They are also essential to unlocking and channelling further private investment as they can create directionality in the innovation and adoption processes or provide better exit opportunities and hence, incentives for investors driven by the prospect of financial return. Conversely, corporations can prove challenging for start-ups to leapfrog and therefore hinder the growth of start-ups that do not support their strategic objectives.

We constructed a global dataset to support the combined analysis of companies, deals and investors in CET start-ups and scale-ups and to provide insights on the role and behaviour of corporate investors. We performed an analysis of the direction of corporate investment in start-ups and scale-ups with a focus on the deployment of strategic net-zero technologies as defined by the European Commission's Net Zero Industry Act proposal (NZIA). This includes identifying where corporate investment is contributing to the funding and growth of NZIA technology firms and assessing how the EU performs against its main counterparts. While this research cannot establish a direct causal relation, it provides granular insights into the impact associated with the involvement of corporate VC investors on start-ups' access to equity finance and exit opportunities.

Over the period 2015-2022, NZIA technologies accounted for most of the venture capital (VC) investment in CET and a higher share of VC investment in CET firms in the EU than in the US and China. In the EU, such investment was concentrated in a few technology areas (mostly in batteries and to a lesser extent solar PV) and others remained under-financed (as compared to the former and to foreign counterparts) (Georgakaki et al., 2023).

In 2022, VC investment in EU NZIA technology firms was less resilient to the contraction of the VC market than VC investment in US companies, and less resilient than the overall VC investment in EU CET firms. In technology areas such as hydrogen and fuel cells, VC investment in the US and China has outpaced that of the EU – despite the sustained growth of the latter. Moreover, the growth of VC investment in EU NZIA firms in 2022 was accompanied by an increase in the share of foreign investment in technology areas such as hydrogen and fuel cells, bioenergy, heat pumps and geothermal.

Between 2015 and 2022, corporate investors have been involved in an increasing number of deals in US-based companies (+24% CAGR), EU-based companies (+22%) and China-based companies (+56%). While it is not possible to determine the exact size of corporate contributions, this work suggests that corporate VC (CVC) investment in NZIA technology firms is growing and constitutes the second source of equity funding for NZIA technology firms (behind traditional VC). Corporate investors focused most of their effort (in the number of deals and investment totals) in the later stages of investment. This evolution was accompanied by a diversification of the types of investors, a global increase in the number of large deals (in particular in batteries) and larger average contributions for several types of investors.

Our analysis shows that the involvement of a corporate equity investor in US-based firms is associated with better access to equity finance across all NZIA technologies. It is also associated with greater exit opportunities for US-based companies (via corporate acquisitions) and for Chinese-based companies raising capital in the public market. Conversely and despite the involvement of corporate equity investors (as indicated by the share of deals in which a corporate investor is involved), EU-based companies do not benefit from better access to equity finance (beyond specific technology areas), the overall size of later stage deals in EU-based companies has not increased (beyond large singular deals) and the exit opportunities for EU-based start-ups remain limited.

The growth of later-stage investment in EU firms is driven by an increasing number of deals and a few very large deals. As opposed to their US counterparts, EU-based firms active in markets such as wind, heat pumps and grid technologies did not benefit from a significant number of larger later-stage deals over time. The involvement of a corporate equity investor is, however, associated with better access to equity finance for EU-based start-ups active in emerging technology areas – such as battery, hydrogen and fuel cells – and in markets where their growth can support the activity of industry incumbents (e.g., the installation of solar panels).

Our analysis also shows that number and magnitude of exit opportunities for EU-based start-ups remain limited. Between 2015 and 2022, EU-based companies only accounted for 6% of the global amount of corporate acquisitions (far behind the US which accounted for 62% of the total, but on par with China which accounted for 6%). Despite an acceleration of IPOs in 2021 (not confirmed in 2022), EU-based companies only accounted for 9% of the global amount of capital raised via IPOs (far behind China which accounted for 80% of the total, but on a par with the US which accounted for 10%).

At the same time, our analysis shows that corporate EU investors have steered significant shares of their investment (via CVC or acquisitions) towards US-based companies between 2015 and 2022. The amount of corporate venture capital that EU investors allocated to US-based companies is equivalent to 28% of the total CVC investment in EU-based companies and 58% of the CVC investment gap between the US and the EU between 2015 and 2022. Similarly, the amount of funding that corporate EU investors allocated to the acquisition of US-based companies is equivalent to the total amount of corporate acquisitions of EU-based companies.

This research suggests that in the EU, the collaboration between large industry players and innovative start-ups for the development and deployment of clean energy technologies is not effective across all technology areas and that even where it seems to be, its associated impact is often more limited. It also suggests that fostering their strategic collaborations could contribute to the development of start-ups with a higher strategic value for corporate investors, of better exit opportunities, and consequently to increasing the incentive for private companies to invest and re-directing outward investment flows towards EU-based companies.

Assessing if and how corporate investors can further contribute, as well as how policy can support, however requires to develop further our understanding of the nature of EU scale-up gaps across clean energy technologies and of where corporate investors have a strategic interest to invest in start-ups.

In order to provide further insights for policymakers, research should focus on analysing investment flows and bottlenecks across all clean energy technologies. This includes in particular the comprehensive analysis of:

- The origin and activities of corporate private investors,
- The overall corporate innovation investment strategies via a combined portfolio analysis of patents, internal R&D and corporate venturing investment,
- The role of equity in the financing of clean energy deployment and infrastructure projects,
- The funding of innovative firms' and their growth beyond equity (e.g. with a focus on venture debt),
- Clean energy industrial ecosystems in the EU.

Such analysis will extend the findings of this work by informing on the motivation for, capacity of and options available to corporations to invest in the development and deployment of a given clean energy technology area. It can in turn provide further inputs to policy makers to support to the discussion on the business model of the transition and help identify where to further incentivize corporate investments and where public investment may be unavoidable to fill the gap.

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