Imperial College Business School | Centre for Climate Finance & Investment

Climate Infrastructure Investing:
Risks and Opportunities for Unlisted Renewables

March 2022

A Joint Report by the International Energy Agency and Imperial College London

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Executive Summary

Climate change and decarbonization objectives are driving governments and investors to consider clean energy investing. But do investments in clean energy make financial sense? This is the question that a series of joint publications by the International Energy Agency and Imperial College London have sought to answer. Our aim is to establish greater financial transparency and provide more data to help financial institutions and policymakers participate in the energy transition.

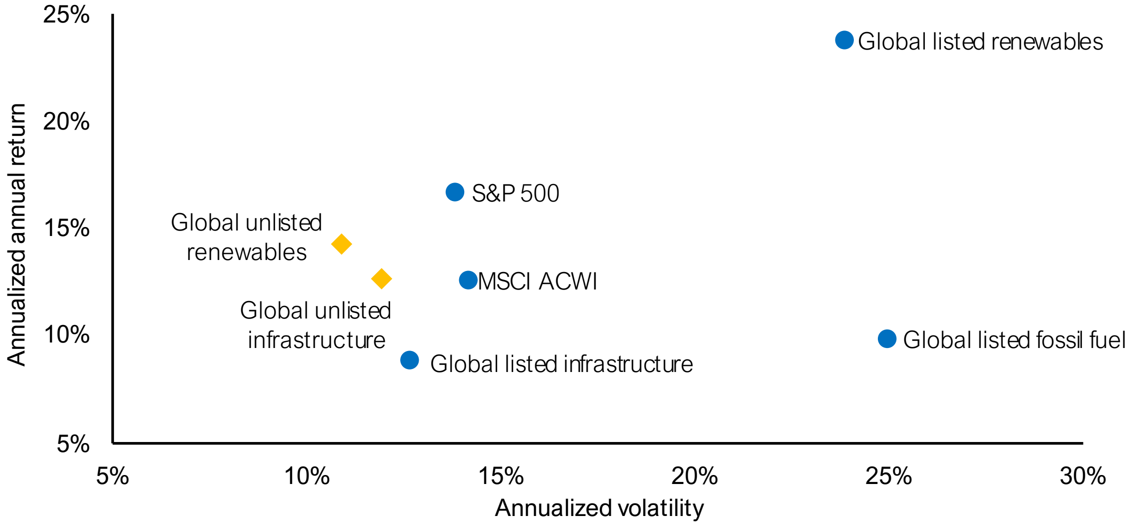
The first two reports investigated the financial performance of clean energy assets across a range of listed markets. Over a ten-year horizon, a publicly traded portfolio consisting of renewable power assets has generated generally higher investment returns and exhibited higher diversification benefits (meaning that performance was less correlated to the overall market) than a portfolio consisting of fossil fuel companies. The renewable portfolio also exhibited lower volatility in some regions and displayed greater resilience than other energy investments, especially during the market downturn triggered by the Covid-19 pandemic. These findings held across a variety of markets examined, although the indices for fossil fuels picked up considerably in 2021, as the economic recovery boosted demand and prices.

With supportive investment performance and an accommodative policy backdrop, investments in renewable power have increased rapidly over the past decade. These investments totalled 360 billion USD in 2020[1]. However, only a relatively small share of this investment has come from equity fundraising by publicly listed, pure play renewables companies. Most investments were carried out by diversified listed companies (such as utilities) and via unlisted companies and assets. Public markets alone did not provide the breadth of clean energy investments required to meet climate targets. This is exacerbated in emerging markets and developing economies due to their underdeveloped capital markets and insufficient investments.

To ensure sufficient clean energy investments, investors and policymakers need to tap into private markets. However, information gaps and short-termism continue to cause challenges for investors to originate and invest in clean energy assets. The limited availability of transparent and reliable data on unlisted asset returns, as well as asset specific and macro-financial risks, restrain investor participation. Understanding the investment case for these unlisted assets is an important aspect of the broader energy transition.

In our third joint report, we turn our attention to unlisted renewable assets to address these concerns. We examine their risks and returns globally, including in emerging markets and developing economies. Our analysis will cover the performance of an index representing global unlisted renewables, consisting of wind, solar, hydropower, and other renewables assets (biomass, geothermal, marine power, and battery storage). Wind assets, largely onshore wind, accounted for more than half of the portfolio constituents, with solar and hydropower each comprising one-fifth. We compared this with a broader unlisted infrastructure portfolio that included assets across a range of sectors, such as transport and telecommunications, as well as with various other portfolios and benchmarks.

Figure 1. Risk and return for selected private and public market portfolios and benchmarks, 2012–2021



Notes: Global unlisted infrastructure = EDHECinfra 300; Global unlisted renewables = EDHECinfra Global Broadband Renewables; Listed infrastructure = Dow Jones Brookfield Global Infrastructure Total Return Index; Global listed renewables and Global listed fossil fuel assets show the updated results of portfolios used in the joint report by IEA and Imperial (2021). All returns are calculated in local currency.

Source: The authors, based on data from Bloomberg, EDHECinfra, and IEA and Imperial (2021)[2].

[1] IEA (2021), World Energy Investment 2021. IEA.

[2] IEA and CCFI (2021), Clean Energy Investing: Global Comparison of Investment Returns. IEA and CCFI.

We found that the unlisted renewable assets outperformed the broader unlisted infrastructure assets, as well as the listed market benchmark, MSCI ACWI, over the past ten years at a diversified index level (Figure 1). Unlisted renewables exhibited lower volatility than unlisted infrastructure and the listed market benchmark over the past ten years at a diversified index level (Table 1). Both unlisted portfolios provided diversification benefits during credit events and against changes in commodity prices. Macroeconomic conditions, such as inflation and interest rates, seem negatively correlated to unlisted renewables although the relationship weakens in a higher interest rate environment. These results suggest that while both unlisted portfolios can provide attractive risk-adjusted returns, asset allocation to unlisted renewables may provide an even higher diversification benefit.

Table 1. Financial performance of unlisted renewables and broader infrastructure assets in global markets and emerging markets and developing economies

	Global Markets			Emerging Markets and Developing Economies		
	Unlisted Infrastructure	**Unlisted Renewables**	**MSCI ACWI**	**Unlisted Infrastructure**	**Unlisted Renewables**	**MSCI EM**
	10 Years			**9 Years**		
Total Return	226.86%	276.68%	223.91%	223.83%	298.76%	48.88%
Arithmetic return	127.17%	140.48%	129.37%	127.79%	156.76%	53.89%
AAR	12.57%	14.18%	12.47%	13.95%	16.61%	4.52%
Volatility	11.98%	10.92%	14.21%	14.17%	19.70%	17.58%
Sharpe Ratio	1.01	1.23	0.87	0.96	0.85	0.31
	5 Years			**5 Years**		
Total Return	47.00%	42.91%	101.12%	76.27%	70.28%	62.83%
Arithmetic return	40.75%	38.02%	78.88%	63.39%	63.16%	59.45%
AAR	8.01%	7.40%	15.00%	12.00%	11.23%	10.24%
Volatility	8.92%	9.26%	17.73%	16.25%	20.52%	20.35%
Sharpe Ratio	0.80	0.72	0.83	0.72	0.57	0.53

Notes: Total return = compounded quarterly returns; Arithmetic return = sum of quarterly returns without compounding effects; AAR = annual average return; AAR = annual average return; Volatility = annualized quarterly volatility; Sharpe ratio = the average excess return over the risk-free rate divided by the standard deviation of the excess return.

Source: The authors, based on data from EDHECinfra and Bloomberg (2022).

The geographical composition of the unlisted renewable assets portfolio is strongly weighted towards advanced economies and particularly towards European markets, with some 70% of constituents located in this region. The tilt towards Europe reflects the early actions by European governments, encouraging deployment through ambitious renewables targets and remuneration policies. Europe has also seen greater opportunities for direct investments in renewable assets by institutional investors.

A key challenge for successful energy transitions is to generate a broad based expansion in investment in clean energy projects, notably in renewable power, across emerging markets and developing economies (EMDEs). However, opportunities for institutional investors are limited by the number of investable clean energy companies in EMDEs' public equity markets and the fragility of financial data on unlisted renewable assets.

Stepping up investment in unlisted renewable infrastructure will require supportive policy frameworks in order to increase the flow of bankable projects, as well as mechanisms to reduce and manage associated risks and improve transparency. This paper addresses this deficit by shedding light on the significant opportunities as well as the real-world considerations faced by institutional investors. Allocating capital to unlisted clean energy investments across regions is needed to achieve a global sustainable future.

Introduction

Getting the world on track for net-zero emissions (NZE) by 2050 requires clean energy transition investment to accelerate to around 4 trillion USD annually by 2030[3]. Achieving rapid clean energy transitions depends on enhancing access to low-cost finance for capital intensive clean energy projects. Around 70% of clean energy investment globally will need to be carried out by private developers, consumers, and financiers, responding to market signals and the policy incentives set by governments. This means channelling retained earnings from the balance sheets of large energy companies, mobilizing capital from a range of companies and institutional investors, aligning incentives, as well as finding new investment opportunities for clean energy assets.

At this stage, equity market fundraising by listed companies represents a relatively modest portion of the total clean energy universe. The prevailing landscape of renewables investment points to the importance of unlisted assets and companies. In such arrangements, investors can find a clearer route to gain exposure to the renewables sector. Moreover, investors can find a wider range of renewables investment opportunities in unlisted (private) markets today than listed (public) markets in terms of capacity, technology, geography, and investment size, allowing them to make a more tailored investment decision based on their needs and fiduciary duties.

If clean energy transitions are to be successful, then institutional investors, financial institutions, and private developers need to increase the amount of capital they allocate to clean energy transitions, as well as to emerging markets and developing economies (EMDEs) in both listed and unlisted markets. With well over 100 trillion USD of capital under management in the OECD alone, institutional investors represent a large potential source of finance for clean energy transitions[4]. Such actors play key roles in fundraising for clean energy companies, but an emerging question for policymakers is the extent to which investors can find enough investment opportunities in listed markets and more directly help finance clean energy projects in unlisted markets to meet the growing investment needs ahead.

As the costs of clean energy technologies have fallen and governments have put in place frameworks to support deployment, the nexus between clean energy transitions and financial systems has grown, with greater action by financial actors to integrate sustainability concerns into decision making. A number of central banks, such as the European Central Bank (ECB), the Bank of England, and the Bank of Japan, have pointed to plans to roll out climate portfolio stress tests. Several countries have adopted, or are developing, sustainable finance taxonomies to enable the classification of investments that align with clean energy transitions. The COP26 has bolstered efforts with the Glasgow Financial Alliance for Net Zero (GFANZ), assessing that around 130 trillion USD of private capital is now held by institutions that have pledged to meet the goals of the Paris Agreement.

All of these actions have created significant momentum in terms of financial flows, as the continued surge of sustainable debt issuance[5] shows over 1.6 trillion USD was issued in 2021, which is more than double the amount issued in 2020.

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[3] IEA (2021), World Energy Outlook 2021. IEA.

[4] OECD (2021), Mobilizing institutional investors for financing sustainable development in developing countries: Emerging evidence of opportunities and challenges. OECD.

[5] Sustainable debt = green bond, social bond, sustainability bond, sustainability-linked bond, green loan, and sustainability-linked bond.

Module 1
Drivers of clean energy investments in unlisted markets

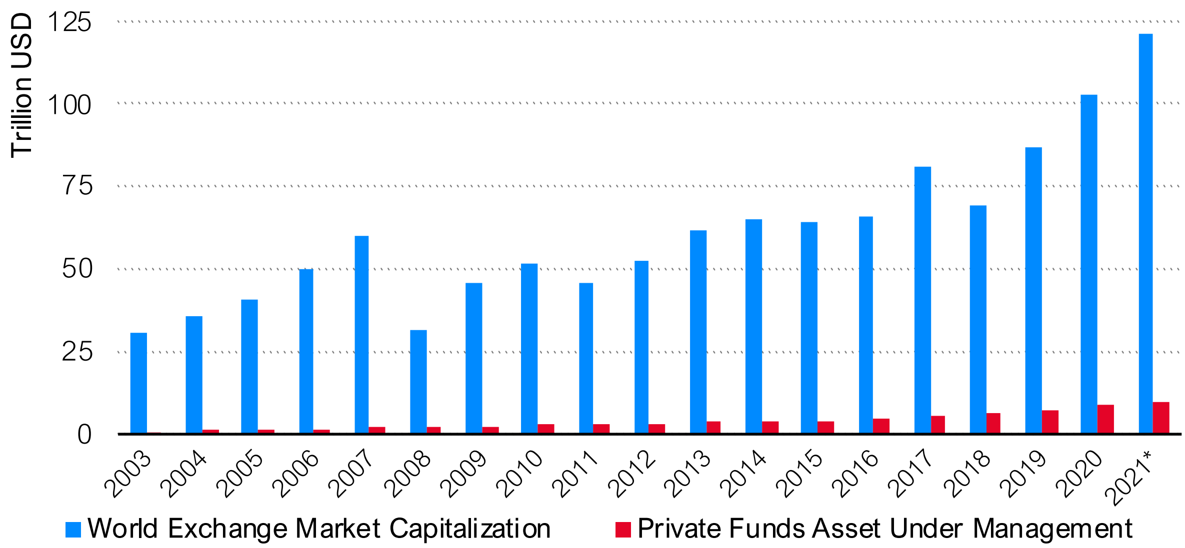
Financial allocations to unlisted renewable infrastructure assets have increased over time, as investors seek a more direct route and an attractive return to investing in clean energy transitions in private markets. This section examines recent investment trends in broader unlisted (private) markets, especially for unlisted renewables and the broader unlisted infrastructure assets by market size, fundraising capacities, and financial performance.

1.1. Fundraising, asset allocation, and performance trends

Most investing by institutional investors is carried out through listed assets in publicly traded markets. The global aggregate market capitalization of listed companies[7] has doubled over the past decade, further fuelled by the growth in equity valuations. This reflects the benefits that such strategies provide in terms of liquidity and transparency. In regard to strategic asset allocation, diversified institutional investors (i.e., those investing in both public and private markets) typically allocate most of their portfolios to listed equities and fixed income, with alternative investments[8] usually comprising only a minority share (one-fifth or less) of total holdings.

Though comprising only a fraction of public equity investments, specific assets managed by private funds – including private equity (PE), venture capital (VC), and infrastructure funds – have grown rapidly. Such funds usually have an allocation strategy that is more focused on alternative investments, and their expansion provides an indication of the growing role of such investments among investors (8% growth per annum for public markets vs. 14% growth for private markets over 2003–2021) (Figure 2).

Figure 2. Assets managed within public equity markets and private funds, 2003–2021



Notes: Bloomberg World Exchange Market Capitalization represents the market capitalization of all actively traded primary securities to avoid double counting. This does not include Exchange Traded Funds (ETFs) and American Depositary Receipts (ADRs) as they do not directly represent companies. Private funds include private equity, real estate, infrastructure, private debt, and natural resources funds. Private funds do not include fund of funds[9] and secondary funds to avoid double counting of available capital and unrealized value. The private funds asset under management data for 2021 is limited to data as of June 2021. All other values show the end-of-year value in nominal terms.

Source: The authors, based on data Bloomberg and Preqin (2022).

[7] The size of the investable universe for institutional investors.

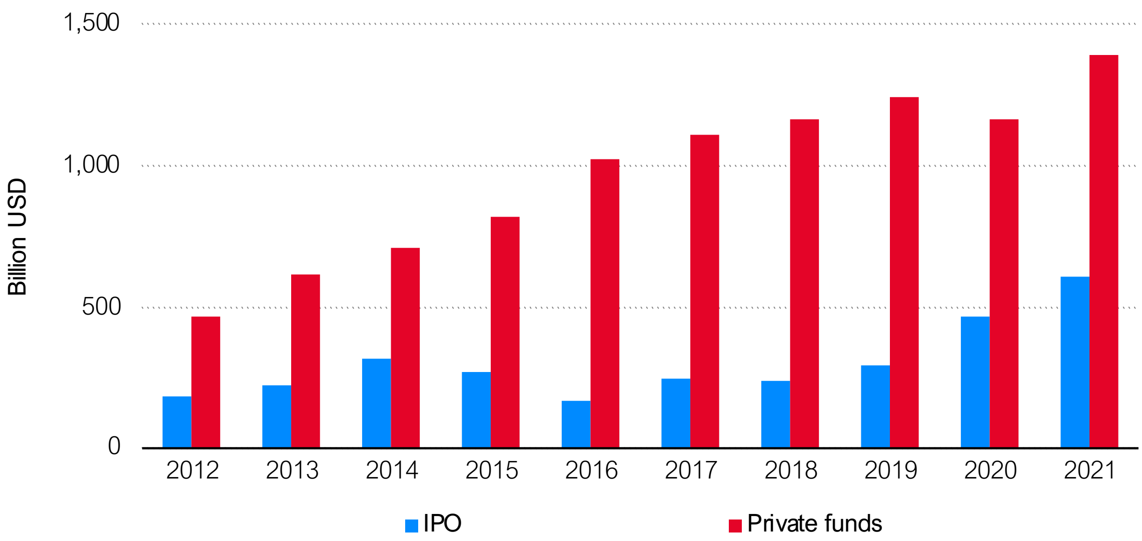
[8] Alternative investment refers to a diverse category of assets including privately-held companies, infrastructure, real estate and other types of unconventional investments that fall outside of transitional asset classes such as stocks, fixed incomes, and cash.

[9] Fund of funds refers to a pooled investment vehicle that invests in other funds.

Capital raised by private funds has outpaced fundraising from new equity listings in public markets, via initial public offerings (IPOs), consistently over the past ten years (Figure 3). This trend partly reflects growing interest in alternative investments as a route for funding new companies and assets, but it also reflects some of the changing dynamics in public equity markets. In advanced economies, especially in the United States, the number of publicly listed companies has declined over the past three decades[10]. This decline is driven by rising listing expenses and more stringent financial regulations and disclosure requirements, affecting particularly small- and medium-sized enterprises. It is further being fuelled by the growth in alternative sources of financing. Delisting has also increased in recent years because of mergers and acquisitions by private actors.

Amid a prolonged period of accommodative monetary policy and growing interest in alternative investments, there is evidence that diversified investors have gradually expanded their allocations to alternative assets, where they expect higher returns. For example, state and local government pension funds and endowments in the United States have increased their allocations towards alternative assets from 5% to 30% and 50%, respectively, over the past three decades[11].

Figure 3. New equity listings in public markets vs. capital raised in private markets, 2012–2021



Notes: IPO = initial public offering and represents the amount of capital raised on the IPO effective date. All values are nominal.
Source: The authors, based on data from Bloomberg and Preqin (2022).

The reasons for this shift stem from the superior financial performance when compared with the broader markets. In general, private funds handled the 2020 crisis better than public market benchmarks. Among private funds, infrastructure and real estate funds have delivered lower returns than other private funds, but they also fared the crisis better (Figure 4).

[10] The number of listed companies in the US almost halved from 8,090 companies in 1996 to 4,266 in 2019.

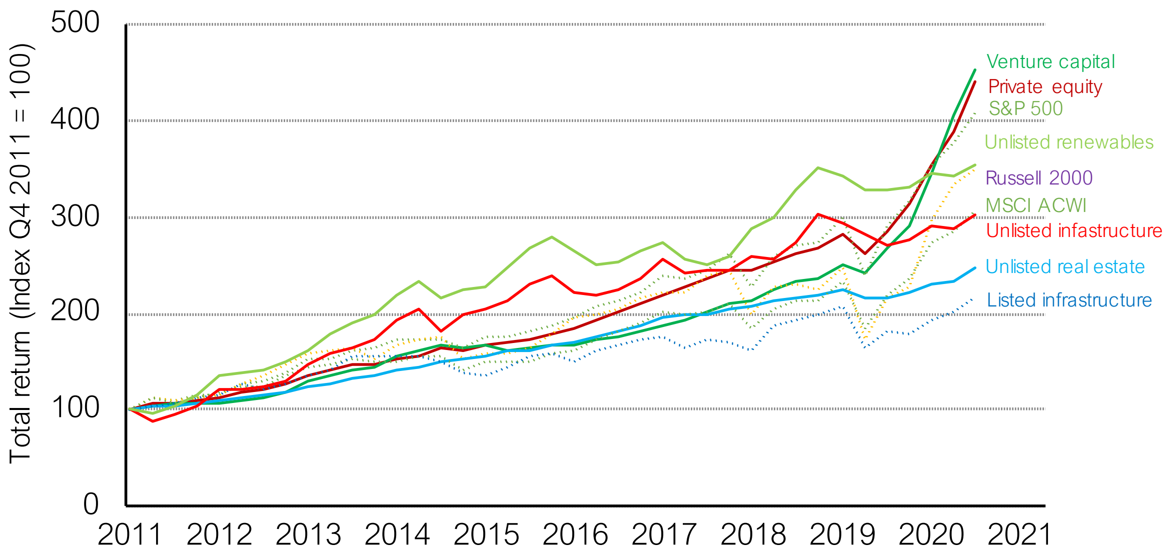
[11] Mauboussin, M., & Callahan, D. (2020), Public to Private Equity in the United States: A Long-Term Look. Morgan Stanley Investment Management.

1.2. Unlisted infrastructure as an investable asset class

Infrastructure markets consist of a wide range of industries and sub-sectors (e.g., energy, telecommunication, military, and social services) with various definitions of "infrastructure" by industry. In this paper, infrastructure refers to an investable alternative asset class, which encompasses a wide range of economic and social infrastructures as a project or a holding company. Renewable infrastructure is a sub-set of the infrastructure asset class and includes renewable power generation assets such as solar, wind, biomass, tidal, geothermal, battery storage and offshore transmission technologies.

At an asset level, unlisted infrastructure is often characterized by a lower risk and a lower return profile than other unlisted assets or companies sought after by PE or VC funds. Among private infrastructure assets analyzed in this paper, renewable power tends to exhibit a higher Weighted Average Cost of Capital (WACC), lower expected returns, and lower EV to EBITDA multiples than the broader unlisted infrastructure market. However, there is a high level of regional variation across these metrics[12]. There are also uncertainties on how allocations may evolve with changing interest rates and evolving risks and returns, including those associated with the illiquidity premium for holding less tradable assets.

Figure 4. Financial performance (arithmetic returns) of public and private market benchmarks, 2012–2021



Notes: Private funds include private equity, venture capital, real estate, and infrastructure. The financial performance of private funds is net of fees and carry (excluding the called %) and calculated based on the quarter-to-quarter changes in the returns on invested capital. Public index returns are gross of fees and of trading costs.

Sources: The authors, based on data from Bloomberg and Preqin (2022).

[12] This is calculated based on the mean value of 300+ unlisted renewables and 2000+ unlisted infrastructure assets. Source: Analysis based on EDHECinfra (2021).

Looking more closely at strategies by investor type, pension funds in OECD member countries manage approximately 35 trillion USD, investing the majority of their capital in public equities and fixed income. The top 10 pension funds by asset under management (AUM) invest on average 45% of their assets in public equities and around 18% in alternative investments. Infrastructure represents around 10% within the alternative investment category, and nearly 40% of infrastructure holdings are renewables projects. However, the share of investments in alternative assets can vary considerably by fund, with the largest allocation approaching 50% and the lowest just 1% (Table 2).

Table 2. Top 10 public pension funds' portfolio allocation by asset class

	Firm Name	Country	Equities	Fixed Income	Alternative Investment	AUM (USD BN)
1	Government Pension Investment Fund	Japan	49%	50%	1%	1,754
2	National Pension Service	South Korea	46%	44%	11%	792
3	ABP	Netherlands	33%	39%	29%	586
4	California Public Employees' Retirement System (CalPERS)	US	52%	29%	19%	480
5	CPP Investment Board	Canada	29%	23%	48%	474
6	CDPQ	Canada	51%	31%	18%	317
7	California State Teachers' Retirement System (CalSTRS)	US	49%	11%	41%	311
8	Pensioenfonds Zorg en Welzijn	Netherlands	39%	36%	25%	296
9	New York State Common Retirement Fund	US	49%	23%	28%	268
10	Florida State Board of Administration	US	53%	18%	29%	250

Note: Alternative investment includes private equity, hedge fund, real estate, infrastructure, and other unconventional investments.

Sources: The authors, based on the latest annual and quarterly reports available on each pension funds' website as of 31 December 2021.

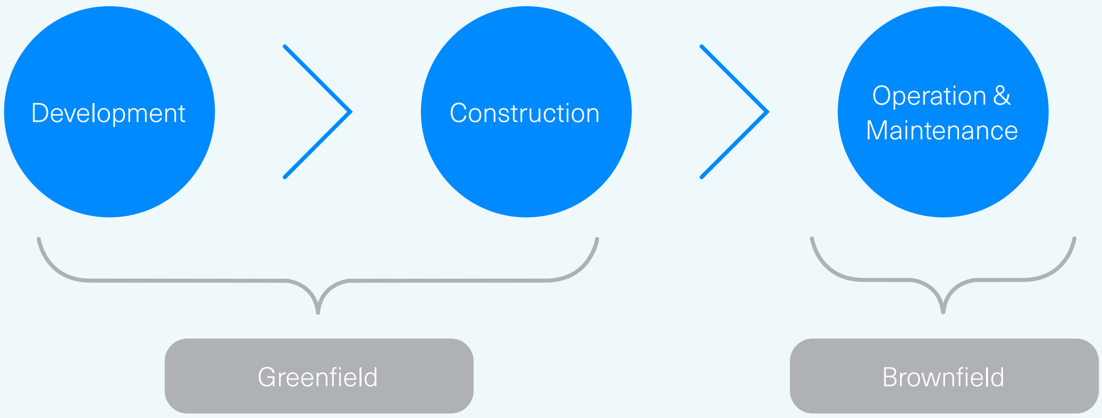
Across investor types, pension funds are the largest investor in unlisted infrastructure, having invested over 70% in 2020[13]. In contrast, asset management companies allocate the majority of their assets to public equities and fixed income. Moreover, asset management companies are often the largest investors in listed infrastructure investment vehicles such as real estate investment trusts, infrastructure investment trusts, and yield companies. This suggests considerable room for asset managers to increase allocations towards renewable power projects and other unlisted infrastructure.

[13] OECD (2020), Green Infrastructure in the Decade for Delivery: Assessing Institutional Investment. OECD.

Box 1: Investment stages within the infrastructure asset class

Infrastructure, such as roads, airports, hospitals, and power plants, are pillars of economic growth that provide essential goods and services. Increased privatization of assets over the last two decades and the ability to generate stable, long-term cash flows have increased their investment appeal. Figure 5 depicts the three stages of an asset's lifecycle, each of which is classified as either greenfield or brownfield.

Figure 5: Infrastructure asset lifecycle



Greenfield investments occur prior to assets achieving commercial operations and have a higher risk profile than brownfield investments due to the development and construction risk. During the development stage, land required for a project needs to be secured, project funding needs to be obtained, and construction permits/contracts need to be finalized. During the construction stage, cost overruns, project delays, and environmental issues may prevent projects from being completed on time or at all. Although, construction premia have recently shrunk as risks have been passed down to sub-contractors. Brownfield investments occur once an asset has achieved commercial operations and is generating cash flow; hence they are less risky because the hurdles associated with development and construction are eliminated.

The choice of investment varies according to an investor's capital structure and risk appetite. For example, a risk-averse pension fund might prefer to purchase an asset that has achieved commercial operations, whereas an investor with a higher risk tolerance and execution capability may be more willing to take on development/construction risk and, therefore, command a higher return on the project. Certain investors may prefer to invest in greenfield projects to fulfil additionality principles, requiring investments to create a positive external outcome, such as decarbonization. Purchasing an operating project would not create that additionality.

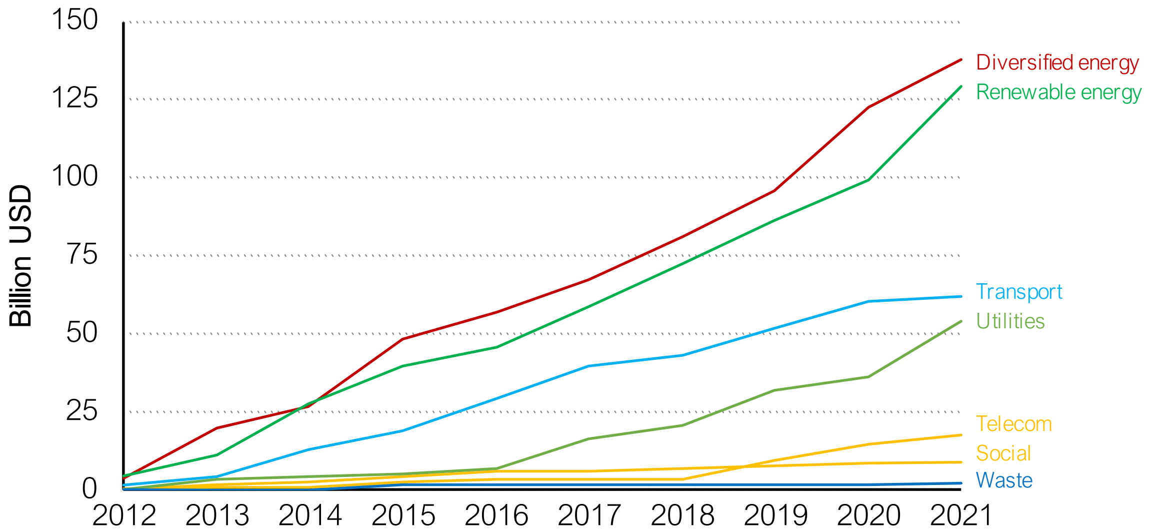
1.3. Fundraising for clean energy

Investments in greenfield renewable power have increased dramatically over the last decade, surpassing 360 billion USD in 2020[14]. Only a relatively small share of this investment has come from equity fundraising by publicly-listed, pure-play renewables companies, with most investments carried out by diversified listed companies (such as utilities) and via unlisted companies and assets[15]. Looking ahead, some estimates point to around 70% of the investable renewables market over the next decade to be concentrated in unlisted/privately held assets[16].

Such trends reflect, in part, the recent growth observed in fundraising for greenfield and brownfield unlisted infrastructure funds. Cumulative fundraising by diversified energy funds expanded to a near 140 billion USD in 2021, from around 10 billion USD at the start of the decade, and funding for renewable energy dedicated funds approached 130 billion USD – these two sectors accounted for 70% of the growth observed across infrastructure sectors. Annual capital raising by renewables funds surged in 2020 and was the most robust among sectors during the economic downturn caused by the Covid-19 pandemic (Figure 6).

Infrastructure is set for another fundraising record in 2021 by raising over 120 billion USD, of which half comes from clean energy sectors[17]. Global private equity and infrastructure fund managers raised around 30 billion USD of clean energy infrastructure funds, demonstrating the strength of clean energy funds as an increasingly sought after asset class for unlisted market investors[18]. This fundraising is geographically concentrated, with over 90% of raised capital for infrastructure funds and clean energy funds coming from advanced economies in Europe, North America, and Asia.

Figure 6. Cumulative fundraising by unlisted infrastructure funds, Q1 2012 – Q2 2021



Source: The authors, based on Preqin (2021) data.

[14] This investment spending captures capital expenditures on renewable power assets as defined in the IEA's World Energy Investment Methodology document. https://www.iea.org/reports/world-energy-investment-2021

[15] IEA and CCFI (2021), Clean Energy Investing: Global Comparison of Investment Returns. IEA and CCFI.

[16] McKinsey & Company (2018), The Market for Unlisted Renewable Energy Infrastructure: External perspective developed for the Norwegian Ministry of Finance. McKinsey & Company.

[17] Infrastructure Investor (2021), Q1-Q3 hints at the record year for infra fundraising. Infrastructure Investor.

[18] Actis, BlackRock, Copenhagen Infrastructure Partners, Macquarie, and Stonepeak raised over 23 billion USD combined for clean energy funds in 2021 (based on the final date of fundraising). Infrastructure funds raised around 63 billion USD dollars in 2021.

Currently, major unlisted renewable investors include pension funds, sovereign wealth funds, endowments, insurance companies, foundations, and family offices[19]. While some institutional investors, such as large pension funds, invest significant amounts into unlisted infrastructure, the average allocation to unlisted infrastructure equity is only around 1%–2%. This reinforces the notion that investors are allocating only a small fraction of their investments to unlisted infrastructure[20].

Portfolio allocations also remain conservative with regards to geographical exposure, especially in emerging and developing economies (EMDEs). Such limitations stem partly from a lack of granular data, appropriate valuation benchmarks, and uninformed perceptions of investment risk.

Box 2: Financial performance of public vs. private markets

Researchers have long debated whether investments in private equity generally outperform those in public equity markets. Historically, conducting such an exercise has been challenging due to inherent difficulties in obtaining private equity returns data. However, some have successfully procured such data from both private equity General Partners (GPs) and Limited Partners (LPs), allowing for further exploration of the topic.

Prime examples include work by Steve Kaplan, which uses data from Burgiss, a provider of record keeping and performance monitoring services for investors, to obtain private return data. Kaplan devised the PME method, which compares the distributions from private equity to those of public markets over the lifetime of the fund, assuming similar amounts invested.[21a] The analysis concluded that private equity funds outperformed public market benchmarks, such as the S&P 500, net of fees and carried interest over the decades of the 1980s, 1990s, and 2000s. This outperformance was primarily driven by private equity investments being more illiquid and bearing some form of commitment risk. The illiquidity premium of private investments represents the excess return over a more liquid asset or a benchmark. Investors with a long-term term horizon can harvest illiquidity premia. However, it is challenging to observe such premia, as they vary over time.

Another study estimates private equity to have a roughly 80 basis points higher excess return, net of fees. In this instance, outperformance is not attributed to an illiquidity premium, but the premium associated with the higher equity risk of the investments. Additionally, private assets have greater exposure to other factors, like leverage and size, than public assets.[22a]

More recently though, studies have suggested that the performance gap between private and public equity has narrowed over time, especially after 2006, perhaps owing to declining illiquidity premiums.[21b] Additionally, interest in private equity stems from the appeal of artificially smooth return profiles and lower perceived risk. Private equity firms are able to use multiple measures to boost returns, such as higher starting yields through deal selection, higher earnings growth through operational improvements, multiple expansion through opportunistic timing of entries and exits, as well as leverage.[22b]

According to recent reports, several factors could slowly erode the performance of private assets over time. While the allure of private markets has resulted in more cash being directed their way, increased competition could lead to a compression in returns. Other factors include rising interest rates and the threat of legislation that could change tax benefits such as interest rate deductibility and the ability to classify profits as capital gains.[23]

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[19] Analysis based on Preqin data (2021).

[20] Amenc, N., & Blanc-Brude, F. (2021), Strategic Asset Allocation with Unlisted Infrastructure. EDHECinfra.

[21a] Harris, R., Jenkinson, T., & Kaplan, S. (2021). How do Private Equity Investments Perform Compared to Public Equity? Darden Business School Working Paper No. 2597259, DOI: 10.2139/ssrn.2597259.

[22a] Ilmanen, A., Chandra, S., & McQuinn, N. (2019), Demystifying Illiquid Assets: Expected Returns for Private Equity. AQR.

[21b] Harris, R., Jenkinson, T., & Kaplan, S. (2021). How do Private Equity Investments Perform Compared to Public Equity? Darden Business School Working Paper No. 2597259, DOI: 10.2139/ssrn.2597259.

[22b] Ilmanen, A., Chandra, S., & McQuinn, N. (2019), Demystifying Illiquid Assets: Expected Returns for Private Equity. AQR.

[23] The Economist (2022, March 13). Investors have come to see private markets as a cash cow. The Economist.

Module 2
Defining risks and returns on unlisted renewables

Valuing unlisted renewable energy projects is critical for both policymakers and investors to make well informed investment decisions. In this paper, we recognize that significant dispersion in valuation methodologies is problematic and can lead to economic losses, especially because many clean energy technologies require significant upfront capital expenditures and are sensitive to the discount rates applied[24]. Therefore, we look to valuation methodologies employed in the markets today to understand how investments in unlisted renewables are priced and the issues that emerge when using such methods.

2.1. Financial valuation approaches for unlisted investments

When valuing unlisted assets and companies, investors apply three common approaches, namely: the market approach, the income approach, and the replacement cost approach, the use of which will vary depending on the maturity, sector, and type of assets.

The market approach looks at the prices of comparable assets according to commonly derived multiples such as P/E (Price-to-earnings) ratios and Enterprise Value/EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization) multiples. These ratios are straightforward to calculate for listed assets or companies because their underlying financials are publicly available, and transactions occur frequently enough to create an ample supply of comparable data. However, using the same approach for privately held assets is challenging as financial data is difficult to obtain. Some investors will also apply a discount to the Enterprise Value of comparable assets in public equity markets to reflect the lower liquidity of privately held assets for comparison. In the case of unlisted infrastructure, the heterogeneous nature of assets and infrequent transactions make using a market based approach particularly challenging.

The income or discounted cash flow approach allows fund managers to value an asset based on the future cash flows expected to be generated over the asset's lifetime. The cash flows are discounted to the present using a rate that represents an investor's WACC or investment hurdle rate. This approach is most applicable to unlisted infrastructure assets due to the predictability of future cash flows along with the ability to factor in asset specific risks in the discount rate. For example, a solar PV plant that is backed by a long-term contract or power purchase agreement will receive fixed pricing over its operating life, making it easier to apply an income based approach to value the asset. Based on its geographical location, a country risk premium could be added to the discount rate if necessary. It is worth noting, however, that unlisted investments in diversified portfolios (containing both operating and development pipelines) could be valued on a multiples-based approach, especially during a structured bidding process, whereas investments in operational projects would be better suited to a discounted cash flow approach.

The cost approach estimates the price that should be paid for an asset by determining the cost of building the asset from scratch, using current market prices. Although less commonly used than the income and market approaches, this approach works best when valuing start-up companies with negative EBITDA or pre-operational infrastructure assets that do not have existing contracts in place. Using real estate as an example, one could estimate the value of a property by individually calculating the land and construction costs, less any depreciation.

[24] Donovan, C., & Corbishley, C. (2016), The cost of capital and how it affects climate change mitigation investment. Grantham Institute.

2.2. Performance metrics for unlisted investments

Fund managers can utilize several metrics to determine asset or fund performance. The two most common are the multiple on invested capital (MOIC) and internal rate of return (IRR). The public market equivalent (PME) is another metric used by select investors.

The MOIC measures the absolute performance of funds and is a ratio of the realized and unrealized value of an investment to the total amount initially invested, typically expressed as a multiple.

$$MOIC = \frac{(Realized\ value + Unrealized\ value)}{(Total\ dollar\ amount\ invested)}$$

Despite its simplicity, it does not factor in the time value of money, nor does it account for the capital committed by investors. Instead, it considers the capital invested – hence the so -called "dry powder[25]" is not integrated into the calculation.

The most common metric used by asset owners and fund managers to measure an investment's performance or deal attractiveness is the internal rate of return (IRR). More specifically, the IRR net of management fees and carried interest (share of profits distributed to GPs). Based on the formula below, it is the rate (r) that sets the NPV of cash flows to 0.

$$NPV = 0 = \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t}$$

Despite widespread usage, IRRs can be misleading because they are affected by the magnitude and timing of cash flows. Consequently, asset managers can enhance IRRs by carefully timing when funds are accessed (Ilmanen, Chandra, and McQuinn, 2020). IRRs also assume that capital paid out can be reinvested immediately, at an identical rate, and with no additional cost. However, this rarely occurs because fund distributions can be unpredictable, and reinvestment is subject to prevailing fund strategies, which can shift every two to three years[26].

The PME was designed to address some of the shortcomings of the aforementioned methods and allow for a comparison of PE fund investments with public markets. It measures the return of a theoretical investment on a public index, such as the S&P 500, by reflecting the financial environment of the PE investments. For instance, PME assumes buying the same amount of the listed index when GPs calls capital from LPs, and selling the same amount of the index when GPs distributes to LPs. The PME shows the financial return of the equivalent investment in the public markets. However, this approach simultaneously makes the calculation sensitive to that index.

[25] Dry power refers to the amount of capital raised but not disbursed by fund managers.

[26] Demaria, C., Pedergnana, M., He, M., Rissi, R., & Debrand, S. (2021), Asset Allocation and Private Markets: A Guide to Investing with Private Equity, Private Debt, and Private Real Assets. Wiley.

2.3. Analytical approach and metrics

The objective of this report is to assess unlisted renewables assets available to institutional investors that can provide a benchmark for strategic asset allocation. Some bottom-up, appraisal based sources attempt to provide such analysis on a sector or geographical basis. However such products may not be sufficient for the processes of investment practitioners, who require comparable financial performance metrics on 1) a mark-to-market basis, 2) a representative universe of infrastructure projects, and 3) an avoidance of selection and survivorship biases[27]. At the same time, listed benchmarks may not provide a suitable proxy and often exhibit a significant correlation with broader equity market performance.

There are relatively few offerings that aggregate asset level performance into an index product designed to facilitate strategic asset allocation. This report incorporates metrics from EDHECinfra, which aims to provide performance data based on an index of unlisted infrastructure assets with global coverage. The EDHECinfra index and metrics provide a standardized way of understanding risks and returns for unlisted infrastructure and renewable power.

EDHECinfra employs the income based/discounted cash flow (DCF) approach to value unlisted infrastructure assets and calculate financial returns at the index level. For a given asset, it computes a cash flow forecast and discounts these cash flows based on a term structure of interest rates and an equity risk premium, after which an asset price is calculated. The term structure of interest rates is computed using bond yields in the country of investment, the duration of which is equal to the remaining life of the asset being valued. The total return for each company is calculated in the local currency to produce a unitless return. This means that FX fluctuations do not affect relative returns, and the portfolio behaves as if it were FX-hedged.

To compute an equity risk premium, it employs a bottom-up approach whereby it collects financial data and uses it to estimate five risk factor loadings. Each of these factors (Annex B) ultimately feed into a firm specific, mark-to-market equity risk premia, which alongside the term structure of interest rates, allows assets to be valued at any point in time[28].

2.4. Data Initiatives

To channel the billions of investments needed to plug the infrastructure funding gap, investors and policymakers need better tools to benchmark against other assets. In the last few years, several initiatives have been developed to help bridge this data gap. The G20's Roadmap to Infrastructure as an Asset Class is one such initiative designed to develop infrastructure as an asset class and promote its investment characteristics. By focusing on data transparency, greater standardization, and risk mitigation instruments, the initiative aims to facilitate infrastructure investments globally.

Another is the Private Infrastructure Modelling Service, launched by MSCI and The Burgiss Group, which allows investors to understand how integrating infrastructure holdings affect portfolio performance and risks. With the increased integration of ESG scores and other non-financial data into investment decisions, investors need tools that can reliably assess these metrics and benchmark performance against their peers. The GRESB's Infrastructure Asset Assessment does this by allowing investors to self report asset level data, after which it is validated internally before being published.

In 2019, the CDP and ICLEI partnered to create Matchmaker, a platform allowing local and regional governments to publicize climate initiatives to the financial sector and draw attention to the ones that need funding. The GRI's Sustainable Infrastructure Tool, TCFD, SASB, and WACI provide additional platforms that infrastructure investors can use to aid infrastructure reporting and disclosure. There is also a variety of other pilot initiatives run by different organizations, aiming to improve transparency around key investment metrics, such as the cost of capital.

[27] Amenc, N., & Blanc-Brude, F. (2021), Strategic Asset Allocation with Unlisted Infrastructure. EDHECinfra.

[28] This risk factor-based approach is parsimonious and allows computing the risk premia of hundreds of assets, whether they trade or not, based on the latest observable market transactions and what they reveal about the price of risk in the market at that time. This mark-to-market approach predicts actual asset prices in secondary sales with a 5% margin of error.

Box 3: Cost of Capital Observatory

According to the IEA's NZE, 40% of future global clean energy investments need to occur in emerging economies, which currently hold only 10% of global financial wealth. Investment levels in these economies have historically paled in comparison to those in developed economies because of their underdeveloped and opaque capital markets, weaker regulatory landscapes, higher financing costs, and perceived levels of investment risk. Reductions in capital costs and stronger government initiatives to prioritize renewables over thermal generation are crucial for these economies to achieve higher levels of clean technology deployment, faster emissions reductions, and improved resilience to the physical effects of climate change.

To help increase transparency on the cost of capital, the World Economic Forum, in collaboration with the International Energy Agency (IEA), Imperial College London, and ETH Zurich, is leading an effort to build a Cost of Capital Observatory. By synthesizing key indicators and providing easily accessible, high-quality data, the observatory is being developed as a platform that will create a better view of the cost of capital for clean technologies. Primary data will be collected via interviews, surveys, and consultations from current and potential investors (such as financial institutions, project developers, corporate buyers, and institutional investors) to understand their approach to estimating the cost of capital and help reveal if there are systemic issues in how technologies are priced. Given the well documented link between information efficiency and the cost of capital[29] and by improving access to good quality data, the observatory aims to help expand the pool of capital directed towards emerging economies and help them achieve their climate ambitions.

[29] Easley, D., & O'Hara, M. (2004). Information and the Cost of Capital. The Journal of Finance. 59 (4), 1553-1583. DOI: 10.2139/ssrn.300715.

Module 3
Key characteristics of unlisted renewables assets

This report compares the financial performance of unlisted renewable power assets and broader unlisted infrastructure assets in both global and emerging markets and developing economies (EMDEs). Each index is constructed based on a specialized infrastructure taxonomy[30], which classifies an infrastructure asset by industry, geography, corporate structure, and business risk. It includes both greenfield and brownfield assets regardless of the corporate structure. All index constituents are equally weighted and report financial data on a quarterly basis.

3.1. Index profile

The analysis of the financial performance of the unlisted renewables and the broader unlisted infrastructure assets is conducted by using EDHECinfra indices[31]. The global unlisted infrastructure index (EDHECinfra 300 index) consists of 300 unlisted companies and assets with a total market capitalization of over 250 billion USD (Table 3). The global unlisted renewables index (Broadmarket Renewable Power unlisted infrastructure equity index) consists of 130 constituents, some of which are included in the global unlisted infrastructure index. When conducting our macro analysis, we also rely on InfraGreen, which is a subset of the global unlisted renewable index and includes only solar and wind generation assets. When conducting our macro analysis, we also rely on InfraGreen, which is a subset of the global unlisted renewable index and includes only solar and wind generation assets. Viewed separately, the infrastructure and renewables indices can be further broken down by sub-sector, geography, type of business model, and underlying risk factors.

Table 3. Characteristics of the EDHECinfra indices used in this report

	Global unlisted infrastructure	Global unlisted renewables
Market Cap (billion USD)	255.76	25.77
Constituent Count	300	130

Source: The authors, based on EDHECinfra (2022).

3.2. Index composition by industry

The global unlisted infrastructure index consists of four sectors: renewable energy, other energy sources, transport, and other types of infrastructure in the social and data sectors. Over the past decade, energy (including both renewable and non-renewable assets) has accounted for the largest part of this index, while transport (at around 30%) is the second-largest single sector among the first level of TICCS categories, followed by renewables. The transport sector contributed the most to the total returns at the index level (highest index move contribution[32]).

The global unlisted renewables index consists of wind, solar, hydropower, and other renewables assets (biomass, geothermal, marine power, and battery storage). Wind assets (largely onshore wind) accounted for more than half of the portfolio constituents, with both solar and hydropower comprising nearly one-fourth. Wind power contributed the most to the total returns at the index level, followed by hydro and solar (highest index move contribution). The index weighting has remained relatively consistent since its inception (Figure 7).

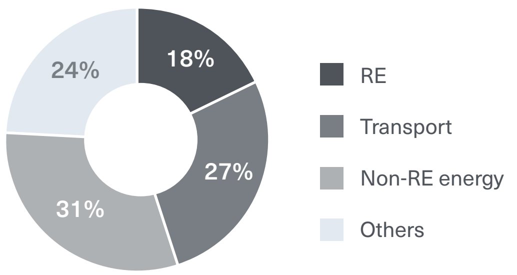
[30] The Infrastructure Company Classification Standard (TICCS).

[31] This report uses six EDHECinfra indices as a proxy to unlisted renewables and the broader unlisted infrastructure assets. Some constituents are included in more than one index.

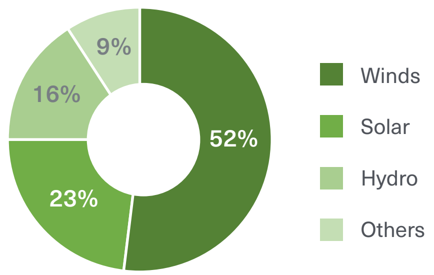
[32] Index move contribution = $\sum(w_{i,t} \times t_{i,t})$, where $w_{i,t}$ is the weight of asset i at time t and $t_{i,t}$ is the total returns of asset i at time t.

Figure 7. Industry breakdown of unlisted global indices by the number of constituents, 2012–2021

Global unlisted infrastructure



Global unlisted renewables



Source: The authors, based on EDHECinfra (2022).

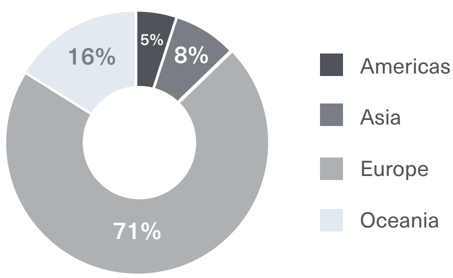
3.3. Index composition by geography

Both indices are heavily exposed to European markets, with more than 70% of constituents located in this region. The remainder of constituents are located in the Americas, Asia, and Oceania, with no significant difference in the ratio of geographical breakdown between the two indices. This implies that geography is likely not to act as a primary differentiating factor for total returns at the index level. Moreover, it does not account for potential differences in the locations of investments within these broad regions and the underlying differences in country level risk factors. When considering for example the past decade in Europe, the evolution of factors such as renewables policy strategies, remuneration schemes, and levels of system integration have varied considerably across markets despite the expansion of regional deployment.

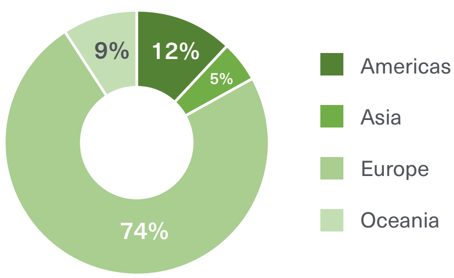
The geographical composition of the renewables index suggests a heavy regional bias, dominated by advanced economies (AEs) (Figure 8). The tilt towards Europe reflects the early actions by European governments to put in place ambitious renewables targets and remuneration policies, which led to an accelerated market deployment in the first half of the decade. Europe has also been the source of greater opportunities for direct investments by institutional investors.

Figure 8. Geographical breakdown of unlisted global indices by market capitalization, 2012–2021

Global unlisted infrastructure



Global unlisted renewables

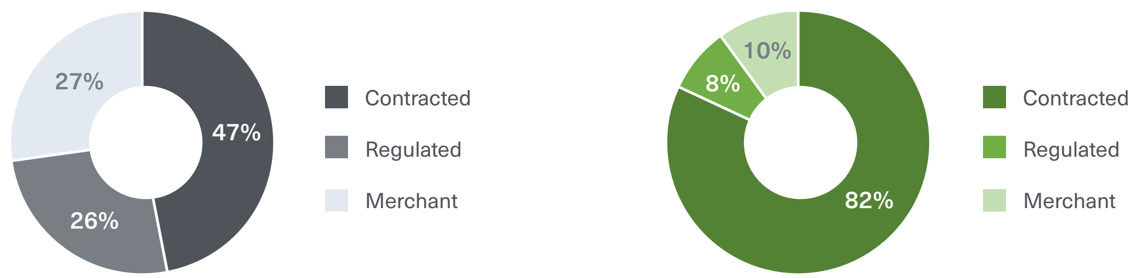


Source: The authors, based on EDHECinfra (2022).

However, such bias may not accurately reflect the landscape of new investments today, which have become increasingly global in nature. For example, over half of energy investments today occur in emerging and developing economies (EMDEs) and a quarter of them are placed in China. While advanced economies (AEs) do account for the majority of today's renewable power investments, the contribution of Europe to global renewables investment (20%)[33] is significantly smaller than that implied by the EDHECinfra composition (74%), consisting of only 130 active private renewable infrastructure assets in around 20 countries.

3.4. Index composition by business model

Figure 9. Business model breakdown of unlisted global indices by market capitalization, 2012–2021



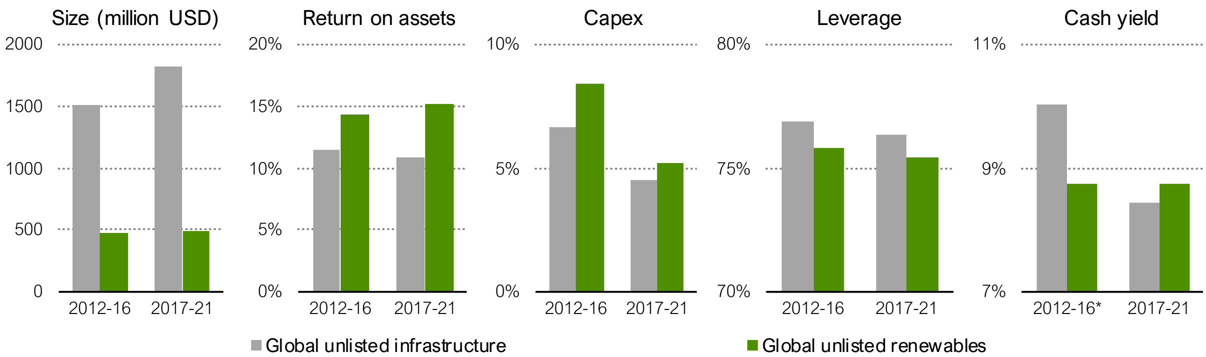
Source: The authors, based on EDHECinfra (2022).

The global unlisted infrastructure and renewable indices include assets with different business models where revenues are determined by contracted, regulated, or merchant pricing arrangements (Figure 9). Similar to fixed income assets, regulated and contracted businesses tend to generate more stable, long-term cash flows and are less affected by volatile macro and market conditions. Considering their capital intensive nature and the growing role of deployment of supporting policies for power related infrastructure, it comes as no surprise that contracting arrangements dominate both the renewables and infrastructure sector. For instance, over 80% of renewables are underpinned by revenue support measures such as feed-in tariffs, power purchase agreements, and contracts for differences.

The share of merchant assets, where the cash flows are affected by changing wholesale prices, is relatively small in both indices, though in reality it does play an important role in some markets with high electricity system prices. While such assets contribute more towards index volatility than those with contracted and regulated assets, they also exhibit more equity-like risk, with the ability to capture upside, as well as downside, in market pricing.

3.5. Key characteristics of unlisted renewables and the broader infrastructure assets

Figure 10. Key financial metrics for global unlisted indices, 2012–2021



Notes: Size = total assets in book value; Return on assets = return on assets before tax; Capex = capital expenditures / total assets; Leverage = total senior liabilities / total assets; Cash yield = 5 year moving average cash yield, measuring the income received in relation to the initial value of the assets. For renewables, cash yield data is available from 2013.

Source: The authors, based on EDHECinfra (2022).

[33] IEA investment data (2022).

In line with the methods section above, we also compared the underlying risk factor exposures and the performance metrics of the two indices across five parameters (size, return on assets, capital expenditures, leverage, and cash yield). Overall, these factors suggest that the global unlisted renewable index has a lower risk premium compared with the wider unlisted infrastructure index (Figure 10).

The average asset size for the global unlisted renewables index is more than three times smaller than the average size for global unlisted infrastructure assets, implying a lower illiquidity risk premium than global unlisted infrastructure index. Unlisted renewables exhibit higher returns on assets than unlisted infrastructure, despite having a higher capital intensity on average. Both the unlisted renewables and the broader unlisted infrastructure assets are highly leveraged with debt to asset ratios of over 75%, though the renewables assets maintain slightly lower leverage over time. The renewables index outweighed the broader infrastructure index in terms of the five-year average cash yield in the past five years, which directly contributes to the asset valuation in the discounted cash flow (DCF) method.

Box 4: Emerging clean energy assets for institutional investors

While renewable power represents the most common route for institutional investment in clean energy, achieving net zero emissions by 2050 (NZE) depends on scaling up allocations in other critical areas. Some emerging assets for institutional investment include:

Electric vehicle charging infrastructure: As costs for electric vehicles (EVs) continue to decline and governments and auto manufacturers commit to phasing down internal combustion vehicles (ICEs), EVs are becoming more accessible to the average consumer. However, a lack of adequate charging infrastructure is still a major barrier to adoption. Even though most EV users tend to charge their cars at home, the lack of public charging stations still induces range anxiety amongst would-be adopters. Meeting NZE goals would require investment in public utility chargers to increase from 3 billion USD today to over 60 billion USD by 2030.

To date, most institutional approaches to investing in EV charging have come through strategic acquisitions or equity stakes in private charging companies, early stage growth EV start-ups, investment in large scale charging projects, or through listed equities. Scaling up investment will depend in part upon the aggregation of charging assets – whose cash flows are subject to local electricity tariff design – into investable portfolios.

Battery storage: To support the system integration of solar PV and wind at higher shares, as well as the roll out of EVs and the electrification of building and industrial sectors, in order to meet NZE goals, investment in utility battery storage would need to rise to around 80 billion USD by 2030, from 2 billion USD today. Although current global storage capacity is mainly pumped hydropower, batteries will play a more prominent role in part due to the limitations in hydropower deployment, and their economics are improving rapidly. Lithium-ion battery costs have fallen by 90% between 2010 and 2019, reaching $150/kWh; a further 50% reduction is possible by 2040.

Institutional approaches primarily involve strategic acquisitions or equity stakes in private companies involved in battery technology development or through listed equities. Battery assets are versatile and capable of providing multiple services simultaneously, but the ability of asset owners to monetize various revenue streams from storage depends on the regulatory framework and market design. Such designs are especially lacking in emerging markets that price dispatchable energy without necessarily considering the benefits of power availability. Scaling up institutional investment will depend in part upon the aggregation of batteries (especially distributed assets) into investable portfolios that have a degree of cash flow predictability.

Green buildings: Green buildings incorporate highly efficient and environmentally friendly processes throughout their construction and operating lifecycles. The investment landscape is likely to improve as regulations around building codes and standards become more stringent. Many advanced economies are developing strategies for zero carbon building codes, but 80% of the projected increase in residential floor space to 2050 is expected to take place in emerging markets. To meet NZE goals, the buildings sector requires an annual investment of over 700 billion USD by 2030 in energy efficiency, electrification, and the direct use of renewables.

Institutional approaches to investment most commonly include joint ventures with real estate developers in commercial or residential buildings development, as well as allocating capital to listed instruments, such as real estate investment trusts. Similar to the cases presented above, scaling up institutional capital will depend on the ability of developers to aggregate properties into investable portfolios (such as green mortgage-backed securities). Like most investments in efficiency, however, cash flows are dependent on the ability of developers to monetize and standardize cash flows from energy savings in a robust and reliable way.

Industrial decarbonization: Reaching NZE goals will also depend on financing early projects in new technologies, such as low emission hydrogen, which are critical for decarbonizing emissions-intensive sectors, such as heavy industry. Direct investments by institutional investors in new industrial technology companies, such as those developing low-carbon materials, have risen rapidly but totaled less than 10 billion USD over the past five years.

Considering the example of low emission hydrogen, the upscaling of related projects will rely on the presence of contracts with creditworthy off-takers to absorb pricing risks. Furthermore, it will require infrastructure development that has the potential to support further development of a tradable market. The development of industrial clusters around infrastructure for carbon capture and hydrogen is also critical to laying the groundwork for financing those technologies at scale. Investors are likely to play important roles in continuing to fund technology companies as well as partnering with large industrial players and utilities in project development.

Module 4
Quantitative analysis on unlisted renewables assets

This section examines historical risks and returns on investing in unlisted renewable assets globally and in emerging and developing economies. Our analysis shows risk and return characteristics, a correlation analysis and the renewable index-level movement under changing macro environments such as credit conditions, commodity prices, interest rate regimes and inflationary periods.

4.1. Global Markets Results

Figure 11. Global unlisted assets 10-year quarterly returns

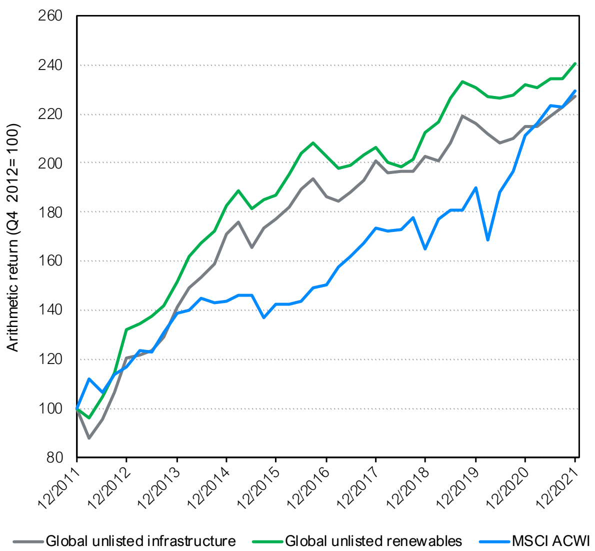


Table 4. Key results for global unlisted

Global Markets			
	Unlisted Infrastructure	Unlisted Renewables	MSCI ACWI
	10 Years		
Total Return	226.86%	276.68%	223.91%
Arithmetic return	127.17%	140.48%	129.37%
AAR	12.57%	14.18%	12.47%
Volatility	11.98%	10.92%	14.21%
Sharpe Ratio	1.01	1.23	0.87
	5 Years		
Total Return	47.00%	42.91%	101.12%
Arithmetic return	40.75%	38.02%	78.88%
AAR	8.01%	7.40%	15.00%
Volatility	8.92%	9.26%	17.73%
Sharpe Ratio	0.80	0.72	0.83

Notes: Total return = compounded quarterly returns; Arithmetic return = sum of quarterly returns without compounding effects; AAR = annual average return; AAR = annual average return; Volatility = annualized quarterly volatility; Sharpe ratio = the average excess return over the risk-free rate divided by the standard deviation of the excess return.

Sources: The authors, based on EDHECinfra (2022) and Bloomberg (2022) data.

The returns of the two global unlisted infrastructure indices are plotted against the global listed market benchmark, MSCI All Country World Index (ACWI)[34] (Figure 11). Over the past decade, we also observed the rise of intangible assets, capturing a disproportionate share of economic profits (technology stocks). Tech companies surged in value with only a small amount of tangible assets, significantly contributing to the MSCI ACWI index performance. A confluence of other sector, macro and fundamental factors also contributed to the MSCI ACWI index performance. At the same time, sectors such as energy and materials significantly lost market capitalization, and their index weight decreased.

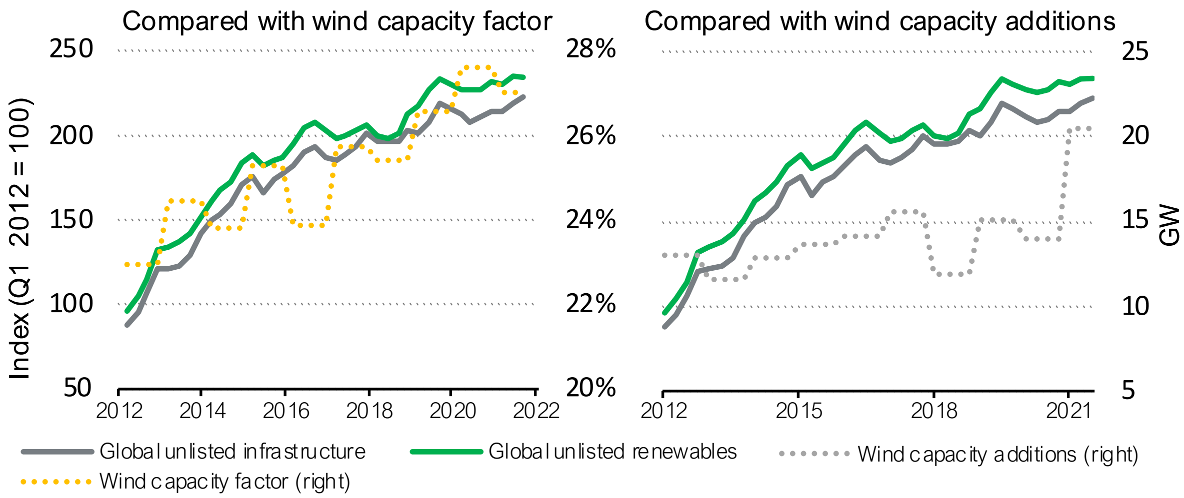
In the past ten years, the global unlisted renewable assets outperformed both the broader global unlisted infrastructure assets and the MSCI ACWI with lower annualized volatility (10.92%) and higher annualized Sharpe ratio (1.23) (Table 4). From 2012 to 2016, global unlisted indices almost doubled, outperforming the global listed market benchmark. The observed growth for renewables can be attributed to a significant increase in demand for such assets on the part of investors. Other significant drivers of growth were major

[34] The MSCI ACWI Index consists of large and mid-cap stocks across 23 developed and 25 emerging markets, and 11 sectors, with roughly 85% of the free float-adjusted market capitalization in each market. Nearly a quarter of the index is in technology stocks, and more than 60% of its constituents are domiciled in the US.

cost declines through maturing renewable energy technologies, strong policy support from governments, large-scale deployment of renewable power (particularly in advanced economies) as well as improving performance of assets in terms of capacity factors (Figures 12 and 13). The global unlisted infrastructure index offered equally strong total returns, supported by the robust performance of unlisted renewable power assets and the steady growth of unlisted transport markets (e.g., road and airports).

From 2016 onwards, the MSCI ACWI outperformed the global unlisted infrastructure indices with an acceleration in 2020 after the initial stages of the Covid-19 pandemic. The global unlisted renewables index stagnated from 2016 to 2018, which coincides with a period of relatively stable wind capacity factors and additions (Figure 12), resulting in a weak total return contribution by wind to the index (Figure 13). From mid-2018, the unlisted renewables index picked up, reaching its second-highest peak in 2019. This came at a time of rising capacity factors, as well as strong demand from institutional investors for assets with sustainability credentials and predictable cash flow profiles.

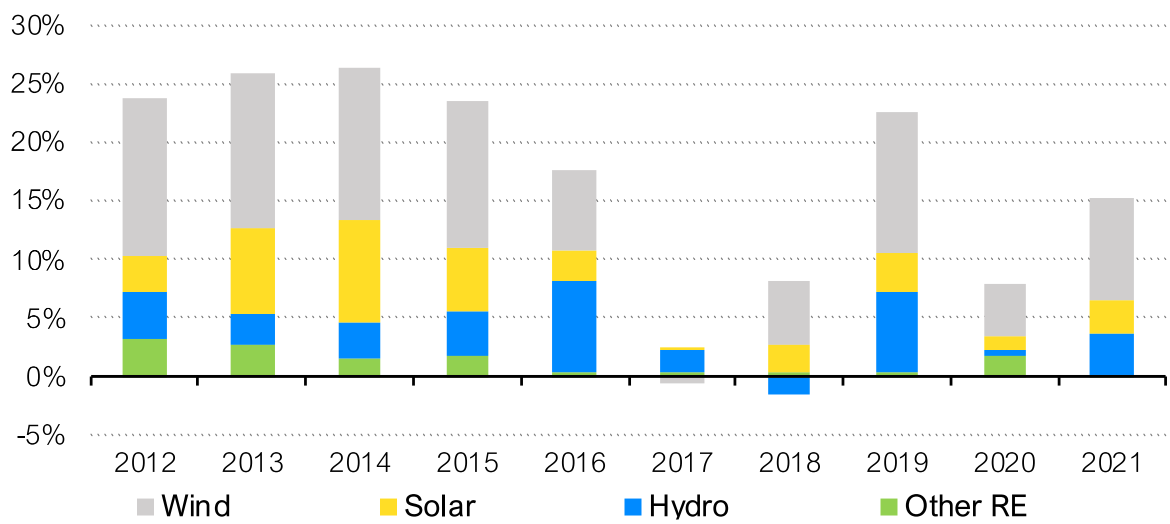
Figure 12. Global indices compared with annual wind performance and capacity additions, 2012–2021



Notes: Wind capacity factors and additions reflect a geographical composite of Europe and North America, weighted according to their roles in the unlisted renewables index.

Source: The authors, based on IEA data (2022).

Figure 13. Year-over-year total returns contribution by industry, Global unlisted renewables assets



Source: The authors, based on EDHECinfra data (2022)

4.2. Correlation Analysis

Correlation is the strength of a relationship between two variables, such as a stock or portfolio. It is a statistical figure that measures how two securities move relative to each other. The range for correlation coefficients is -1.0 to 1.0. The higher the value is, the stronger the relationship between the two variables. A strong negative correlation of -1.0 means that variables move in the opposite directions, zero means there is no relationship, and 1.0 indicates that variables move in the same direction.

Table 5. Cross-asset correlation matrix with global unlisted indices

	Global unlisted infrastructure	Global unlisted renewables	Global listed fossil fuel index	Global listed renewables index	MSCI ACWI	Bloomberg Global Aggregate Index	Oil	Gas	Coal
Global unlisted infrastructure	1.00	0.88	-0.19	-0.10	-0.11	0.24	-0.26	0.11	-0.03
Global unlisted renewables	0.88	1.00	-0.11	-0.04	-0.06	0.31	-0.20	0.01	-0.20
Global listed fossil fuel index	-0.19	-0.11	1.00	0.68	0.87	0.15	0.86	0.30	0.33
Global listed renewables index	-0.10	-0.04	0.68	1.00	0.71	0.30	0.51	0.16	0.12
MSCI ACWI	-0.11	-0.06	0.87	0.71	1.00	0.24	0.75	0.07	0.07
Bloomberg Global Aggregate Index	0.24	0.31	0.15	0.30	0.24	1.00	0.18	-0.04	-0.17
Oil	-0.26	-0.20	0.86	0.51	0.75	0.18	1.00	0.31	0.14
Gas	0.11	0.01	0.30	0.16	0.07	-0.04	0.31	1.00	0.58
Coal	-0.03	-0.20	0.33	0.12	0.07	-0.17	0.14	0.58	1.00

Notes: Correlations are calculated based on quarterly returns and local return currency.
Sources: The authors, based on data from Bloomberg and EDHECinfra (2022), and IEA and Imperial College portfolios (2021).

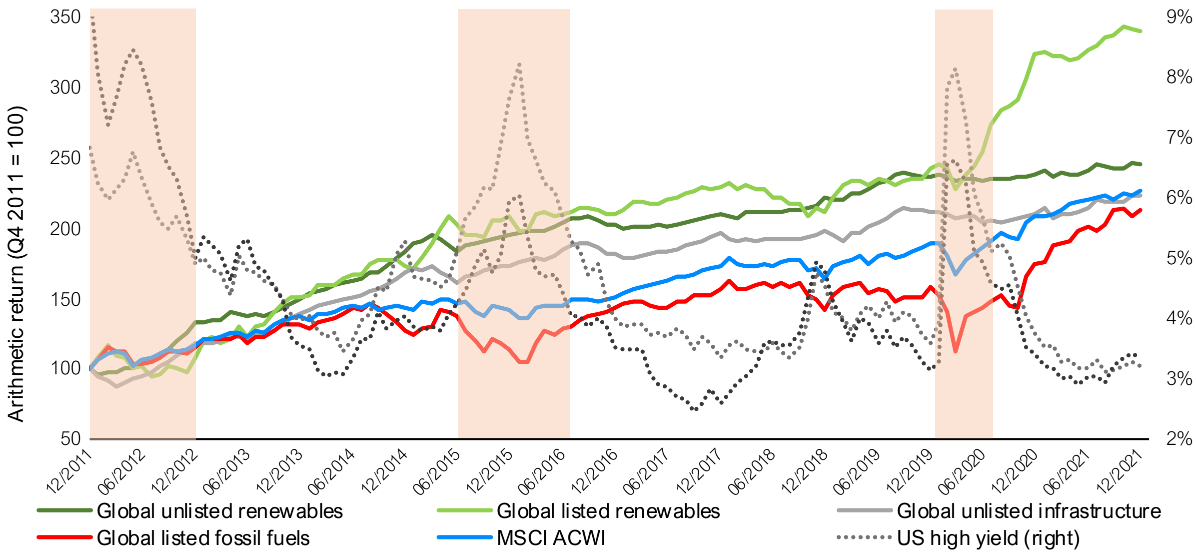
The correlation of the global unlisted renewables assets and the MSCI ACWI is close to zero, highlighting a potential diversification benefit of adding unlisted renewables assets to the listed equity market portfolio. The broader unlisted infrastructure assets exhibit a higher negative correlation to MSCI ACWI (p = -0.11) than the unlisted renewables assets (p = -0.06), offering a slightly greater diversification benefit when added to a portfolio (Table 5). Additionally, global unlisted renewables are not highly correlated to fixed income or commodity benchmarks, highlighting further diversification benefits. Portfolio diversification helps investors minimize the overall impact of market volatility on their overall assets.

4.3. Macro Analysis

This section analyzes the impact of changing credit conditions, macro environments, and commodity prices on global unlisted infrastructure and renewable indices. In this section, we use EDHECinfra's monthly total return index instead of quarterly to capture the impact of changing macro conditions at a greater frequency. For the global unlisted infrastructure index, we used the same index, Infra300, as both quarterly and monthly data were available. For the global unlisted renewables index, we used the closest proxy, InfraGreen, which is a subset of the global unlisted renewable index. InfraGreen includes solar and wind power generation assets only while the global unlisted renewable index covers the broader renewable power generation assets including tidal and hydroelectric assets.

4.3.1. Credit Conditions

Figure 14. 10-Year Monthly Returns with US and Euro High Yield Index Option-Adjusted Spreads (OAS)



Sources: The authors, data from EDHECinfra, Bloomberg, and Federal Reserve Economic Data.

In our previous report, we observed the US investment-grade Corporate Index Option- Adjusted-Spread (OAS) to highlight stressed market conditions. The global renewable listed power portfolio retracted during the Eurozone crisis. However, during periods of market volatility in 2016 and the Covid-19 pandemic, the global renewable power portfolio outperformed the fossil fuels portfolio. This is partly influenced by the revenue buffer that solar and wind projects with long-term power purchase agreements benefit from. However, the renewables portfolio did not fully insulate investors from credit shocks and the fossil fuel portfolio was significantly affected by deteriorating credit conditions.

Figure 14 highlights the returns for the unlisted indices, compared against the MSCI ACWI, the global listed portfolios from the previous report, the ICE BofA US High Yield Index OAS, and the ICE BofA Euro High Yield Index to highlight deteriorating credit conditions during the period. Like in the previous report, the figure highlights three periods in red where market volatility and widening credit spreads impacted global financial markets. These include the European sovereign debt crisis, caused by rising government debts and deteriorating credit profiles that resulted in rising default risks and yield spreads, as well as global economic shocks in 2016 and the Covid-19 pandemic.

Both unlisted indices fared well during the European sovereign debt crisis and the economic shocks in 2016, attesting the resilience of unlisted infrastructure assets to deteriorating credit conditions. This could be due to the contracted and regulated nature of unlisted infrastructures. Most constituents in the unlisted indices are either contracted or regulated and insulated from credit volatilities as they generate secure, long-term cash flow based on long-term contracts and power-purchase agreements (PPAs). Conversely, the unlisted indices offered a relatively weak financial return during the recent Covid-19 crisis, underperforming the listed market benchmarks.

Their response to credit conditions is also different from the listed market benchmarks. Axelson et al. (2013)[35] suggested that a large proportion of leveraged buyout debt is secured bank debt, generally financed at lower rates than high-yield (HY) bonds. Demiroglu and James (2010)[36] found that over the period 1997 to 2007, PE firms incurred a spread over the London Inter-Bank Offered Rate (LIBOR) that averaged around 70% of the HY OAS and was less sensitive to credit conditions than HY spreads. Our use of a constant proportion of the HY OAS may thus overstate the PE cost of debt when HY spreads spike, as in 2008–09.

4.3.2. Commodity Prices

The volatility in commodity prices affects investors through their direct exposures to commodities and through the impact of commodity price volatility on other assets. Figure 15 shows the monthly prices of selected commodities over the past ten years. During this period, there have been significant fluctuations in commodity prices. Market dynamics have shifted over the past 12 months, with prices increasing not only for core commodities required in the energy transition but also for commodities that should be phased out.

Figure 15. Monthly price indicators for selected commodities, 2011–2021

Notes: All commodity index is based on future price. This graph captures monthly volatility, which is smoother than the daily or weekly volatility.

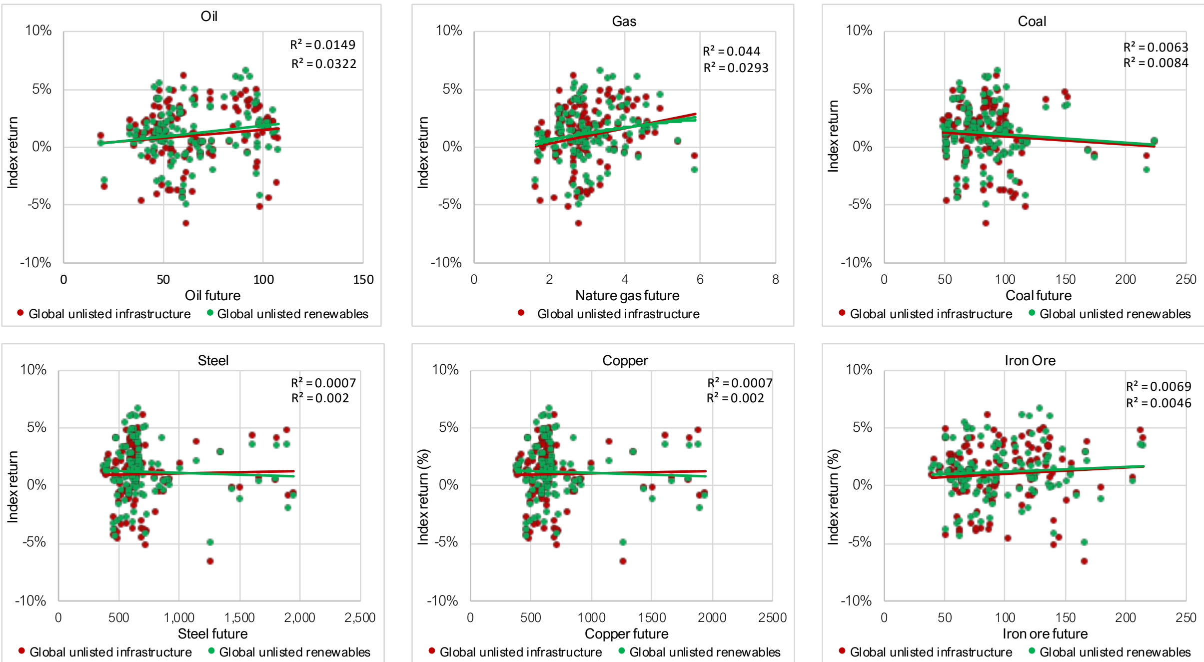
Source: The authors, based on data from Bloomberg (2022) and Investing.com (2022).

[35] Axelson, U. et al. (2013). Borrow Cheap, Buy High? The Determinants of Leverage and Pricing in Buyouts. The Journal of Finance. 68 (6), 2223 - 2267. DOI: 10.1111/jofi.12082

[36] Demiroglu, C., & James, C. (2010). The role of private equity group reputation in LBO financing. Journal of Financial Economics. 96 (2), 306 - 330. DOI: 10.1016/j.fineco.2010.02.001

Figure 16 shows the correlation between unlisted global indices and the selected commodity prices, including oil, natural gas, coal, steel, copper, and iron ore, based on monthly data. The selected commodities are closely linked to the inflation rates, which are addressed in the macro-environment section below. The data suggest there is no strong correlation between unlisted assets and commodity prices over the past ten years. The regulated and contracted nature of infrastructure assets could provide a financial buffer to volatility in commodity prices, although some merchant infrastructure assets may benefit from increased cash flow from rising commodity prices and inflation rates over time.

Figure 16. Correlation between unlisted infrastructure indices and selected commodity prices



Source: The authors, based on Bloomberg (2022) and IHS Markit (2022) data.

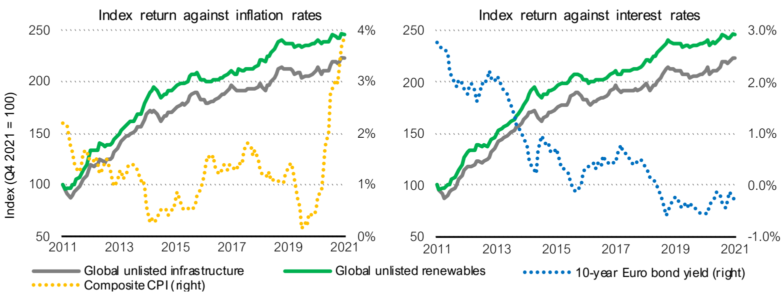
Based on our longer horizon analysis, there seems to be some resilience of unlisted renewable assets to commodity prices. However, we are using Pearson correlations, and we want to flag that this method may not fully capture the full extent of this relationship. For practitioners who want to investigate this relationship further, we would recommend using robust correlation coefficients, such as Bent correlations or Winsorized correlations. Isolating discreet periods of significant commodity price volatility may show different results.

As industry economics adapt to climate change and decarbonization objectives, traditional sources of supply and demand for commodities will change. This will likely cause periods of sustained supply and demand driven imbalances that could exacerbate future periods of commodity price volatility. We are also facing significant geopolitical risks, and commodity market fundamentals are changing. Therefore, investors should carefully manage commodity price related risks.

4.3.3. Interest Rates and Inflation

The academic literature shows that the cost of capital is linked to certain macro variables, such as interest rates and inflation. Especially in the context of infrastructure investments, this highly relevant relationship was also observed in our data set.

Figure 17. Historical performance of global unlisted assets versus inflation and interest rates



Note: Composite CPI is an average of the US CPI, the Euro CPI, and the Australian CPI.

Sources: The authors, based on data from EDHECinfra, Bloomberg, and European Central Bank.

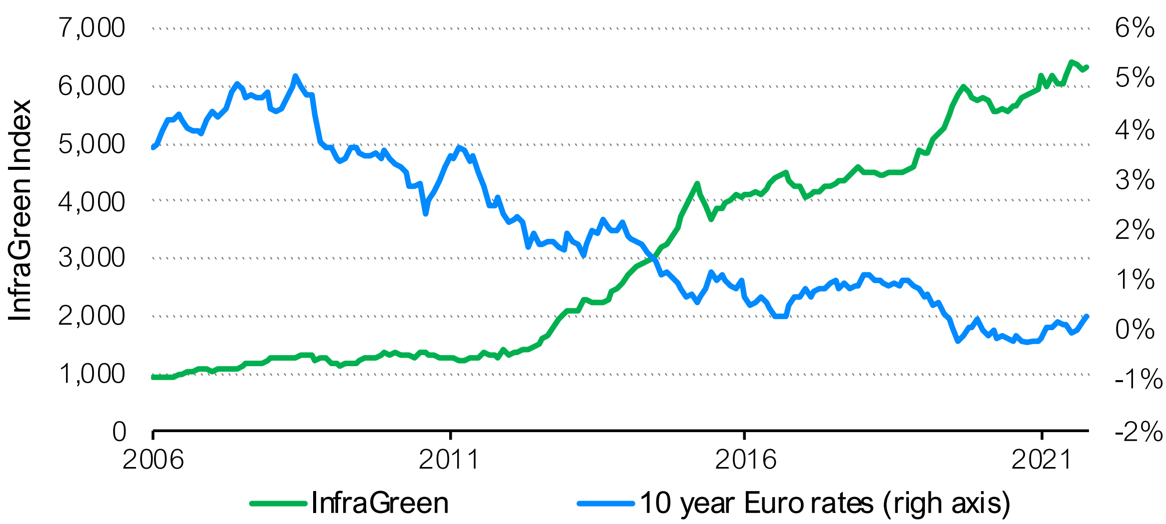
Figure 18. Correlation of the unlisted renewable index proxy and macro indicators, 2012–21.

	10 year Euro rates	InfraGreen Index	Composite CPI
10 year Euro rates	1.00	-0.95	0.55
InfraGreen Index	-0.95	1.00	-0.53
Composite CPI	0.55	-0.53	1.00

Source: EDHECinfra (2022).

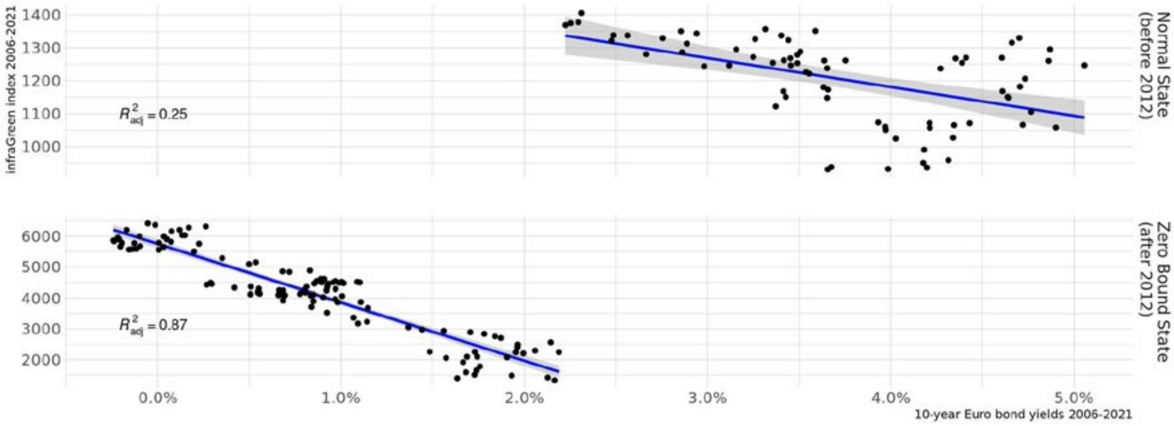
Figure 17 shows the performance of unlisted renewables and broader infrastructure assets versus inflation rates, represented by EDHEC composite CPI and versus bond yields, represented by the 10-year AAA-rated Euro area sovereign bond yields from 2011 through 2021. Composite CPI and Euro bond yields are selected to reflect the geographic decomposition of our indices. We also show a correlation of both macro variables with the unlisted renewable index. Renewable and broader infrastructure indices appear to be negatively correlated to inflation rates and bond yields (Figure 18). Both macro indicators seem to have an impact on unlisted renewable returns, particularly bond yields. To examine the relationship with bond yields further, we go back to 2006 (Figure 19).

Figure 19. InfraGreen Index and 10-year Euro Bond Yields, 2006–2021



Source: EDHECinfra (2022)

Figure 20. Correlation of InfraGreen Index and 10-year Euro Bond Yields, 2006-2021

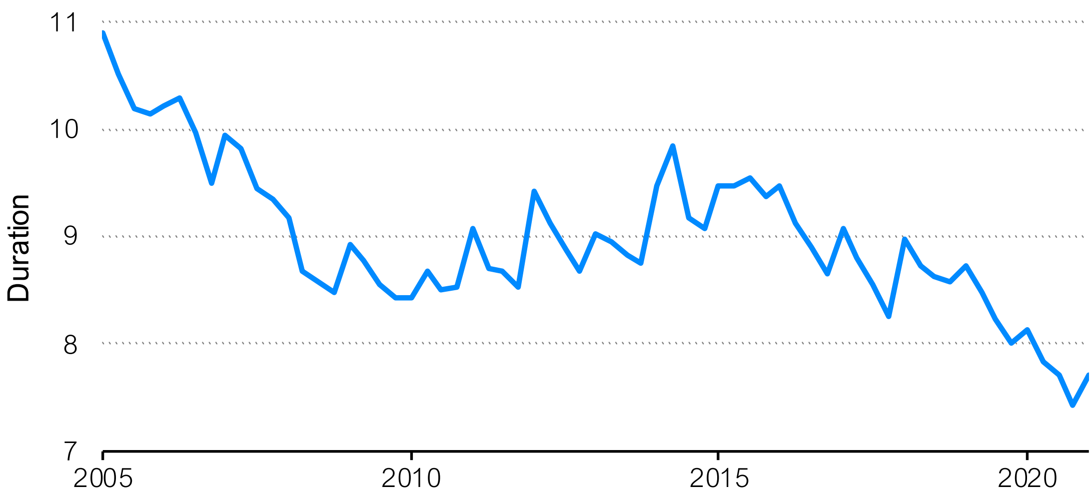


Source: EDHECinfra (2022)

Figure 20 shows a negative correlation between unlisted renewables (represented by InfraGreen) versus 10-year Euro bond yields. We observe two rate regimes – up to 2012, there is some correlation with yields (R^2=25%) when bond yields are higher (normal state). The sensitivity increases after 2012 (R^2=85%), when yields are lower (zero bound state). It is important to note that the correlation dynamic is stronger in a low rate regime and weaker in a higher rate regime- this could mean that unlisted renewables demonstrate an element of resilience in a higher rate environment.

Rate sensitivity is expected as long dated infrastructure investments are more sensitive to changes in discount rates. Figure 21 shows the modified duration of the index. Infrastructure investments have a high duration, and movements in interest rates can impact investment returns.

Figure 21. Weighted average of InfraGreen Asset Duration, 2006–2021



Source: EDHECinfra (2022)

Overall, renewables and broader infrastructure assets performed strongly from 2011 to 2014, with a higher rate of return than the post 2014 period. Until 2014, we saw declining inflation rates and accommodative monetary policy with low interest rates. When bond yields started to increase in 2015 and 2016, indices moved higher, but not as strongly as in the initial period under observation. We observe some negative effects of higher interest rates, but not significant enough to derail the overall positive trajectory of the indices. The negative effects of higher rates on renewable and broader infrastructure were partially muted by strong investment in infrastructure assets and climate-friendly policies. During the Covid-19 pandemic, interest rates once again decreased while renewable and broader infrastructure indices moved higher. In 2021, we saw a sharp spike in inflation, but the indices continued to perform well.

After more than a decade of quantitative easing and low interest rates, we now observe the first period of rising inflation since the inception of the unlisted renewable index. Even though it is not the purpose of this report to forecast the long-run effects of higher rates and inflation, we now enter unfamiliar territory with interesting ground for analysis. While it is too soon to predict the long-term effect of the recent spike in inflation rates on other macro variables and different assets, there could be some resilience in inflationary periods given the heterogeneity of business models in our unlisted global indices. If the current rates continue to rise, regulated and contracted infrastructure assets may lose revenues as construction, operation, and maintenance costs would rise over time while the income remains stable – similar to the correlation of fixed income and inflation rates. In contrast, merchant infrastructure assets may transfer the rising costs to end consumers by adjusting the final prices to inflation rates, less affected by changing inflation.

Our analysis provides some key insights into the possible future of renewables and unlisted infrastructure as macroeconomic regimes change (rates and inflation). Furthermore, a low correlation to commodity prices and credit conditions demonstrates a potential diversification benefit of investing in unlisted renewable infrastructures. Nonetheless, in the absence of higher frequency data and sufficient numbers of inflationary environments, we acknowledge that it is difficult to draw conclusions.

4.4. Emerging Markets and Developing Economies

Mobilizing institutional capital into emerging markets and developing economies is critical to delivering the net zero emissions target by 2050[37]. However, institutional investors suffer from the limited number of investable clean energy companies in EMDEs' public equity markets. The lack of financial data on unlisted renewable assets in EMDE is another hurdle. This section aims to shed light on the unlisted renewable risk-adjusted returns relative to the broader unlisted renewable infrastructure assets and the public equity markets. It also provides several real life examples of specific EMDE unlisted renewable investments.

Figure 22. EMDE unlisted assets, 9-year quarterly returns

Table 6. Key results for EMDE unlisted assets

Emerging market and developing economies			
	Unlisted Infrastructure	Unlisted Renewables	MSCI EM
	9 years		
Total Return	223.83%	298.76%	48.88%
Arithmetic return	127.79%	156.76%	53.89%
AAR	13.95%	16.61%	4.52%
Volatility	14.17%	19.70%	17.58%
Sharpe Ratio	0.96	0.85	0.31
	5 Years		
Total Return	76.27%	70.28%	62.83%
Arithmetic return	63.39%	63.16%	59.45%
AAR	12.00%	11.23%	10.24%
Volatility	16.25%	20.52%	20.35%
Sharpe Ratio	0.72	0.57	0.53

Notes: Total return = compounded quarterly returns; Arithmetic return = sum of quarterly returns without compounding effects; AAR = annual average return; AAR = annual average return; Volatility = annualized quarterly volatility; Sharpe ratio = the average excess return over the risk-free rate divided by the standard deviation of the excess return.

Source: The authors, based on data from EDHECinfra and Bloomberg (2022).

The unlisted renewables assets in emerging markets and developing economies outperformed the broader unlisted infrastructure assets and the public equity market benchmark, MSCI Emerging Markets Index (MSCI EM), over 2013–21 (Figure 22). Albeit the analysis suffers from the small sample size, the financial performance of unlisted renewables assets has been robust, especially in 2016 and 2019. Also, the countries covered by the MSCI EM index and the two EMDE's unlisted indices are different[38]. This period coincides with a strong wind capacity and declining interest rates, creating a favorable environment for wind power generation assets.

The unlisted renewables assets exhibit higher volatility than the broader unlisted infrastructure assets in both 9- and 5-year analysis, and this can be explained by the greater resource variability of renewable power assets compared to the broader infrastructures such as road or waste management facilities (Table 6). However, the unlisted renewable assets still offer attractive risk adjusted returns versus MSCI EM, particularly for longer term investors seeking EM exposure.

[37] IEA (2021), Financing Clean Energy Transitions in Emerging and Developing Economies. IEA.

[38] MSCI EM index consists of large and mid-cap companies across 25 emerging market countries including China (>30% of country weighting), Taiwan (>15%), India (>10%), and South Korea. The EMDE unlisted infrastructure assets are located in the Philippines, Brazil, and Malaysia and the EMDE unlisted renewable assets are located in Brazil and Malaysia.

This analysis is limited by the small number of unlisted renewable assets in EMDEs (22 constituents). To complement our analysis, this section includes several case studies, which help to illustrate recent institutional approaches to unlisted investing in emerging and developing economies:

Acquisition of the largest renewable power project developer in Southeast Asia. In 2018, Global Infrastructure Partners, a private equity infrastructure fund manager, acquired 100% of Equis Energy, one of the largest pure-play renewable independent power producers (IPPs) in Southeast Asia. This transaction was executed via its Global Infrastructure Partners III fund launched in 2016. Other co-investors include Canada's Public Sector Pension Investment Board and China's sovereign wealth fund, CIC Capital.

Equis Energy, which is now Vena Energy, manages a portfolio of around 16 GW of solar PV and wind power generation assets in the Philippines, India, Thailand, Indonesia, and other Southeast Asian countries[39]. Vena Energy sells renewable energy to corporate clients by securing a long-term PPA. For example, it invested in a 100 MW solar PV project in India in 2020, securing 80% of debt from local financial institutions and a long-term PPA with a Gujarat state distribution company. Although the company IRR is not disclosed, the investor, Global Infrastructure Partners III fund, targets **12–15% net IRR per annum at a fund-level** (Table 7).

Table 7. Investment Characteristics for Vena Energy

Project name	Geography	Investors	Asset description	Investment metrics
Vena Energy (company)	Headquartered in Singapore with operating assets across the Asia Pacific.	• Global Infrastructure Partners III fund • Canada's Public Sector Pension Investment Board • CIC Capital • Other investors	Vena Energy operates, develops, and constructs renewable power plants across the Asia Pacific region, totaling 16GW of renewable projects. It targets to decarbonize fossil-fuel-dependent energy systems in Southeast Asian markets by developing renewable powers and securing corporate PPAs.	Vena energy was acquired at 5 billion USD in 2017, and valued at 5.8 billion USD in 2021. Approximately, this is **~4% growth per annum** in terms of total capitalisation. The company IRR is not disclosed. As a proxy, the investor, Global Infrastructure Partners III fund, targets **12-15% net IRR at a fund-level.**

Source: The authors, based on the Vena Energy website (2022), IJGlobal (2022), and Preqin (2022).

Public-Private Partnership investing in Africa's first renewable energy yieldco. Macquarie's Green Investment Group (GIG) and the UK Government's Department for Business, Energy and Industrial Strategy (BEIS) invested in Africa's first renewable energy yieldco, Revego Africa Energy, through a joint venture, UK Climate Investments (UKCI). Other co-investors include Investec Bank and Eskom Pension and Provident Fund, a private pension fund based in South Africa.

Revego Africa Energy is structured as a private equity fund managed by Revego Fund Manager based in South Africa. Their target fund size is 5-6 billion ZAR (~ 330 million USD). The fund will only invest in renewable projects in sub-Saharan Africa by holding significant minority stakes in each project. It currently manages 600 MW of renewable energy projects and plans to grow its portfolio with additional funding from UKCI and other co-investors. The fund (yieldco) targets **8%–10% dividend yield per annum** (Table 8).

[39] Vena Energy (2021), Vena Energy 1H2021 Update. Vena Energy.

Table 8. Investment Characteristics for Revego Africa Energy Limited (yieldco)

Project name	Geography	Investors (ownership %)	Asset description	Investment metrics
Revego Africa Energy (fund	Domiciled in South Africa with underlying assets across sub-Saharan Africa	• Investec (43%) • UK Climate Investments (33%) • Eskom Pension and Provident (24%)	Revego Africa Energy invests in renewable power assets in sub-Saharan Africa with significant minority stakes in each asset. The target IRR at a fund level is 12%–14%.	The fund will pay semi-annual dividends to investors, initially targeting an **8-10% yield per annum**, with a goal to reach **around 11%**.

Source: Interview with Macquarie's Green Investment Group (GIG) (2021) and information from Revego.

Derisking Mozambique's renewable project with patient capital from development banks. Norwegian development bank (Norfund) invested in the development phase of Mozambique's first large-scale solar power project – Central Solar de Mocuba (CESOM) in 2016. It invested with two other investors, Scatec, Norwegian renewable power project developer, and Electricidade de Moçambique (EDM), a state-owned utility company in Mozambique. The project secured a syndicated loan of 55 million USD from International Finance Corporation, Climate Investment Funds, and other debt financiers in 2017 (Table 9).

The investment is supported by a 25-year PPA from EDM and aims to provide clean energy to over 170,000 households in Mozambique's northern grid system. The project created over 1,000 jobs during the construction phase and avoids approximately 79,000 tons of CO_2 emissions annually during the operations stage. Also, Norfund and other development finance institutions enhanced the bankability of the project by providing project guarantees to cover any excess construction costs and potential payment defaults by off-takers.

Table 9. Investment Characteristics for Central Solar de Mocuba (unlisted solar PV asset)

Project name	Geography	Investors (ownership %)	Asset description	Investment metrics
Central Solar de Mocuba (project)	Located in Mozambique	• Scatec Solar (52.5%) • Electricidade de Moçambique (25%) • Norfund (22.5%)	Central Solar de Mocuba is a 40 MW solar power generation project located in northern Mozambique. The project secured a 25-year PPA from a state-owned utility company. Several development finance institutions invested in both debt and equity tranche of this asset. It has not disclosed a target IRR. As a proxy, Norfund's average return on investment on clean energy assets is around 6.6% over 1997–2018.	The project secured 14 million in equity and 55 million USD in debt with **a debt to equity ratio of 80:20**. The project level IRR is not disclosed. As a proxy, the interest rate of non-recourse financing was **6.41%** as of 31 December 2019.

Source: Interview with Norfund (2021) and analysis based on publicly disclosed documents on Norfund website (2022).

In addition to the successful delivery of the project, the development process resulted in the adoption of new renewable energy laws, paving the way for future investors to enter the market. A similar approach could help bolster the renewable energy industry in other frontiers markets with inadequate legislation or during times of weakened market fundamentals caused by macroeconomic conditions.

Frontier markets such as Mozambique exhibit a high country risk, which requires an increased internal rate of return at a project level. A high country risk, combined with high foreign exchange and political risks, often creates a major barrier to investing in emerging markets. Therefore, de-risking investments and providing attractive risk-adjusted returns to commercial investors is critical to mobilizing institutional capital at scale into emerging markets.

Fundraising via USD-denominated green note in Pakistan. In 2021, Pakistan Water and Power Development Authority (WAPDA) issued the first corporate green bond denominated in USD, raising 500 million dollars with Standard Chartered as a joint bookrunner. The bond was 4.4 times oversubscribed, which resulted in an increase of 62.5 basis points from the initial price. The financial coupon rate is 7.50% with a tenor of 10 years. The bond is traded at London Stock Exchange's ISM market.

This transaction showcases foreign investors' strong interest in green bond products in emerging markets and developing economies when the currency risks are mitigated. The use of proceed will be restricted to financing or refinancing eligible green projects defined by WAPDA's Green Financing Framework. The independent third party will issue a second party opinion (SPO), which will be available on the company's website. The company plans to expand hydro and renewable power generation with the raised capital

Table 10. Investment Characteristics for Pakistan Water and Power Development Authority's Green Bond

Transaction name	Geography	Investors	Asset description	Investment metrics
500 million green bond issued by Pakistan Water and Power Development Authority (WAPDA)	Pakistan	Various domestic and foreign investors	This is the first green bond issued in USD by a Pakistan company. WAPDA will finance or refinance eligible green projects with the raised capital	• Tranche size: 500 million USD • Coupon: 7.50% • Tenor: 10 years • Credit rating: B3 (Moody's), B- (S&P), B- (Fitch)

Source: The authors, based on data from Standard Chartered (2022) and Bloomberg (2022).

Module 5
Investment risks and potential solutions

We established that investing in renewable infrastructure could be beneficial from a financial perspective and provide portfolio diversification. A key question remains: why are we not seeing more capital allocated to this asset class? Clark, Reed, and Sunderland (2018)[40] provide two key reasons for why the private sector has been slow to step up sustainable and green investing – there are information gaps and short-termism. Institutional investors face a number of challenges related to the availability of transparent and reliable data on unlisted asset valuation, as well as asset-specific and macro-financial risks. Both factors continue to limit allocations to unlisted renewables investments.

Below we discuss a set of asset specific and macro-financial risks and limitations associated with renewable infrastructure investing in general. Some of these are more pronounced in the unlisted market:

- Lack of flexibility: The initial investment in any infrastructure asset is effectively a sunk cost due to its capex heavy capital structure – high upfront capex and low operating costs. Once an investment is made, it cannot be easily recovered or re-directed for other purposes because these assets have limited operational flexibility.

- Credit risk: Even though many projects are underpinned by contracts that provide income streams, their highly leveraged capital structures create an element of credit risk that must be carefully managed. If off-takers are unable to consistently meet their payment obligations or unable to refinance maturing debt, cash flows become insufficient to cover debt and equity obligations. In extreme cases, this can even lead to project bankruptcies. Credit risk matters to lenders but also to investors, who can lose the value of their investment.

- Regulatory risk: Regulatory risk, or the risk that policies/schemes can undermine a project contract, are unpredictable and can lead to losses or bankruptcies. There are many examples of retroactive action being enforced on project owners in both advanced economies and emerging and developing markets. For instance, a regulatory change in a capacity payment or a long-term power purchase agreement could result in a significant revenue loss and eventually lead to project bankruptcy.

- Currency risk: Some currencies are difficult to hedge, and it is challenging to protect investors from foreign currency fluctuations. For investors that require access to hard, more stable currency returns, hedging project cash flows is a necessity but is not always available in certain countries due to the lack of liquidity of long-term currency swaps from local to hard currency. This inability to hedge can result in shorter debt tenors and lower debt-to-equity ratios for projects, consequently lowering returns.

- Lack of data and transparency: The heterogeneous nature of unlisted infrastructure assets and lack of good quality data on financial and non-financial asset performance act as major barriers to increased infrastructure investment. This barrier is even higher in emerging and developing economies.

- Illiquidity risk: Unlisted assets are more illiquid than listed assets, and financial institutions have liquidity constraints and thresholds.

[40] Clark, R., Reed, J., & Sunderland, T. (2018). Bridging funding gaps for climate and sustainable development: Pitfalls, progress, and potential of private finance. Land Use Policy, 71, 335-346. DOI: 10.1016/j.landusepol.2017.12.013

While we cannot eliminate all risks, there are nonetheless various avenues to mitigate and distribute certain risks across the system. In developed and particularly developing countries, investors are hesitant to take merchant or construction risks without a higher risk premium, making the financing of infrastructure projects more expensive. Some of these risks could be partially mitigated. For instance, financial institutions, sovereigns, and multilateral balance sheets could be used to provide credit enhancement and risk mitigation mechanisms

- Credit enhancements: credit enhancement can be particularly effective in lowering the risk of expected loss related to investing in emerging economies, making renewable energy projects more attractive to the private sector. A deployment example of such a risk mitigation instrument is the World Bank's provision of 500 million USD as a partial guarantee to Argentina's RenovAr program. The program focuses on the development of Argentina's renewables sector. While this instrument cannot turn a non-bankable project into bankable, it demonstrates that multilaterals could become an important source of support for the financing global renewable infrastructure[41].

- Sovereign guarantee: in some countries, a sovereign guarantee for infrastructure projects can significantly reduce targeted risk factors such as regulatory, political and currency risk. However, the quality of such a targeted guarantee is dependent on the respective government's credit quality. In some rare cases, a sovereign can provide a full credit guarantee for the project.

- Power-Purchase-Agreements: currency and other macro-economic risks like interest rates and curtailments can be mitigated by negotiating a favorable power-purchase agreement.

- Targeted Insurance/Guarantee: a variety of risks factors can also be reduced by purchasing some form of targeted insurance or guarantee. For example, the World Bank's Multilateral Investment Guarantee Agency (MIGA) supplied political risk insurance for a small hydro project in Indonesia, thereby reducing the risk for the private sector.

- Investment Treaties: a renewables project may rely on a bilateral investment treaty between the project and the developer's home country. Where there is no such treaty, investors may sign a host government agreement. However, this is only worth as much as the sovereign's incentive not to retroactively change legislation.

- Pre-determined FX rate: Currency risk can furthermore be mitigated by prior agreement between an energy off-taker (i.e. local utility) and the power producer by paying in local currency alongside a prevailing exchange rate to hard currency with appropriate credit support regarding currency convertibility. The degree of support the off-taker is able to extend is likely dependent upon its external credit rating, the support of its ministries to extend additional credit support and the availability of foreign currency reserves within those ministries to service these payments over the life of the asset, which could be 20 years or more.

- Geographical diversification: finally, as applicable to most investment portfolios, a well geographically diversified portfolio can further have an overall risk mitigating effect.

As the risks can be region and asset-specific, investors should also tailor their risk management approach. However, it is important to note that some of these methods come at a price. This needs to be factored in by the project sponsors as it could have an impact on the project's IRR and make it less competitive.

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[41] Bariletti, M. (2019), Credit enhancement: a boost to private capital in infrastructure? World Bank Blogs.

Conclusion

In order for clean energy transitions to be successful, the amount of capital allocated to clean energy transitions needs to increase significantly – especially in emerging markets and developing economies (EMDEs), and across listed and unlisted markets. These markets are often characterized by limited data availability and inherent risk factors that require tailored risk management. This report aimed to establish greater transparency by analyzing the financial performance of unlisted renewables and infrastructure assets globally, including emerging economies.

Our main findings are:

- Overall, the unlisted renewables assets outperformed the broader unlisted infrastructure assets, as well as the listed market benchmark, MSCI ACWI, over the past 10 years at a diversified index level.
- The unlisted renewables exhibited lower volatility than unlisted infrastructure and the listed market benchmark over the past 10 years at a diversified index level.
- The unlisted renewables provided high and stable cash yields.
- Both renewables and broader infrastructure unlisted assets provided diversification benefits during credit events and against cyclical changes in some macroeconomic conditions, such as commodity prices and credit regimes.
- Inflation and interest rates do have an impact on renewables returns. However, lower correlation in a higher rate environment could potentially point to an element of diversification when interest rates are higher (normal state).
- Correlation analysis shows there are diversification benefits if unlisted renewables are added to the market portfolio.

Despite the comprehensive analysis, our study is restricted by several limitations:

- The indices used to proxy returns for global unlisted infrastructure and renewables assets are heavily tilted towards Europe, which accounts for well over 70% of the underlying investments. This geographical bias is not representative of global renewables investment, where Europe accounts for a lower share (20%). It also does not account for sub-region dynamics, notably policy frameworks, which can vary from country to country.
- The renewables index is also strongly weighted towards wind assets, which account for more than half of the portfolio. This means that returns for unlisted renewables depend, in particular, on the evolution of utilization rates (which stem from wind resource availability and technology performance) and capacity additions for wind generation in Europe.
- Although our use of a quarterly index (and its subcomponent, InfraGreen, which is monthly) helps address some of the common shortcomings of unlisted infrastructure valuation, in terms of artificially smoothing returns, it does not fully capture the volatility associated with underlying investments.
- The unlisted indices have limited data points from emerging and developing economies and rely on risk factor estimations that may be more challenging to verify in such markets.
- As in our listed renewables report, currency fluctuations do not impact unlisted infrastructure and renewables portfolio returns. Investors, however, would be impacted by currency fluctuations and/or hedging costs.

Despite risks and limitations outlined in this report, our analysis makes it evident that institutional investors, corporates, and governments need to fund renewable infrastructures globally – particularly in emerging and developing economies. The opportunity exists for investors and governments to partner and de-risk early-stage financing for renewable infrastructure, which is needed to build momentum. Climate finance frameworks need to evolve to support channeling clean energy investments in emerging and developing economies, addressing barriers to foreign direct investment and adopting bolder government policies in order to boost both clean energy supply and demand[42].

The banking sector needs to further evolve in order to enable the clean energy transitions. Banks can use their balance sheets to fund renewable infrastructure, specifically in lower-income countries. Financial sector development could be a determinant of renewable energy expansion in some regions[43]. One of the main hurdles preventing banks to invest at scale is that renewable energy projects have high start-up costs relative to the expected financial returns and long payback periods. As a result, renewable energy projects in less developed countries are at a disadvantage to fossil fuels projects, which have a longer track record and lower up-front costs. Consequently, local banks are hesitant and international banks will demand full foreign currency exchange protection.

Multilateral banks should take a bigger role in de-risking projects in emerging markets by ensuring that projects meet high climate and compliance standards and provide leverage in setting up viable contractual and financing frameworks for renewable energy projects.

Our discussions with institutional investors and analysis of successful case studies suggest a strong appetite and benefits to investing in unlisted renewable assets. The quantitative analysis presented here suggests that unlisted renewables investments could improve the overall performance of investment portfolios. However, unlisted infrastructure assets often have long lives, so it is important that the longer-term risks associated with investing are adequately managed.

Investors today face a multitude of risks when it comes to increasing asset allocations towards unlisted clean energy, ranging from illiquidity to currency and regulatory risks that constrain their ability to increase investments, particularly in emerging and developing economies. In order to tap into the large potential pools of capital that investors can provide, concerted efforts are required by policymakers and the financial community to better address these risks in the markets and technologies where they are present. However, investors and policymakers require better data on financial performance and its interaction with underlying risks to better mitigate them. We hope this report addressed challenges related to data and transparency. With analysis on listed and unlisted renewable assets, we aim to deliver the fourth joint report on the strategic asset allocation of clean energy assets and transition enablers to optimize the risk-adjusted returns at the broader portfolio level and achieve the clean energy transitions targets.

[42] Raghutla, C., Shahbaz M., Chittedi, K., & Jiao, Z. (2021). Financing clean energy projects: New empirical evidence from major investment countries, Renewable Energy, 169, 231-241. DOI: 10.1016/i.renene.2021.01.019

[43] Le, T-H., Nguyen, C.P., & Park, D. (2020). Financing renewable energy development: Insights from 55 countries. Energy Research & Social Science, 68, 101537. DOI: 10.1016/j.erss.2020.101537

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The International Energy Agency

The IEA examines the full spectrum of energy issues, including oil, gas, and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand-side management, and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability, and sustainability of energy in its 30 member countries, 8 association countries, and beyond.

The Centre for Climate Finance & Investment

The Centre for Climate Finance & Investment (CCFI)'s purpose is to unlock solutions within mainstream capital markets to address the challenges posed by global climate change. It aims to make a material impact on increasing the flow of capital to climate change mitigating investments.

The CCFI investigates how financial markets and organizations are affected by climate change; defining and quantifying the risk associated with climate change and undertaking research on how capital markets are responding. Its work is generating a new understanding of the multi-trillion dollar investment opportunity encompassing renewable energy, clean technologies, and climate-resilient infrastructure.

Combining interdisciplinary research with real-world experience, the CCFI is creating a point of interface between academics and practitioners. Researchers working with the CCFI bridge the academic and business worlds and undertake research and industry collaborations geared towards answering the questions that the investment community is asking.

Annex A – Definition of Key Terms

Arithmetic Return (Additive Return)

Arithmetic return is equivalent to rebalancing the portfolio to a constant notional exposure without compounding effects. It is a sum of the returns for all sub-periods. In the figures, we show the arithmetic return, as this is visually comparable across different time periods.

Average Annual Returns

Average annual returns (AAR) represent the implied yield over a specified period. Following academic convention, these are calculated as geometric mean returns.

Annualized Volatility

Volatility is a range of prices for a security or portfolio of securities. We have adopted here a definition of volatility as the standard deviation over the stated period. Given monthly data observations, an appropriate adjustment has been made to arrive at annualized figures.

Capital Call

When limited partners/institutional investors commit to providing funds to private equity firms, they usually maintain control of the funds until such funds need to be deployed towards particular investments. Therefore, a Capital Call refers to the act of private equity general partners collecting the funds already committed by limited partners.

Carried Interest

Refers to the share of profits that general partners of private equity funds receive as compensation if a fund/investment performs above a certain threshold. This is typically paid over and above management fees, which are paid irrespective of investment performance.

Correlation

Correlation is the strength of a relationship between two variables, such as a stock or portfolio. It's a statistical figure that measures how two securities move relative to each other. The range for correlation coefficients is -1.0 to 1.0. The higher the value is, the stronger the relationship between the two variables. A strong negative correlation of -1.0 means that variables move in the opposite directions, zero means there is no relationship, and 1.0 indicates that variables move in the same direction.

Credit Crisis

A credit crisis is caused by deterioration in market liquidity and the credit quality of market participants, resulting in a slowdown in lending activity due to rising levels of credit risk. This can cause a breakdown in the financial system and result in a credit crisis.

Credit Regime

A credit regime represents a period of rising credit risk and financial market deterioration. The credit regime analysis highlights three periods in the past ten years. The three periods coincide with the European sovereign debt crisis, global economic shocks experienced in 2016, and the Covid-19 pandemic. A credit regime was determined by a 350 bps increase in the average option-adjusted spread (OAS) to capture rising credit risk, with periods extended based on subjective analysis to include pre-and post-market deterioration before the OAS spread spike. The credit regimes cover the following periods: October 31, 2010, to December 31, 2012; July 1, 2015, to July 31, 2016; and March 1, 2020, to July 31, 2020.

Commodity Regime

The included commodity regime depicts changes in historical market prices for oil, natural gas, and coal, the largest sources of primary energy production. We selected the most widely traded energy commodities for the analysis at the global portfolio levels: Europe Brent Spot Price FOB for oil, Henry Hub Natural Gas Spot Price for natural gas, and Northwest Europe ARA 6,000 kc NAR for coal.

Enterprise Value

The enterprise value represents the total value of an asset or a company, which is the sum of the market value of equity and the market value of debt minus cash and cash equivalents.

IRR (Internal Rate of Return)

The IRR is a metric that is commonly used to evaluate the profitability of an investment(s). It refers to the discount rate that equates the Net Present Value of an investment to zero. The higher the internal rate of return, the more profitable an investment is likely to be.

Multiple on Invested Capital (MOIC)

Multiple on invested capital (MOIC) is a ratio of the realized and unrealized value of an investment to the total amount initially invested.

Option-Adjusted Spread

The option-adjusted spread is a measure of credit risk and takes into account embedded options. The credit risk is reflected by the yield-spread differential on a fixed-income security to that of the risk-free rate.

Sharpe Ratio

The Sharpe Ratio measures the risk-adjusted average excess return over the risk-free rate and is a useful return indicator for performance comparison. The ratio is calculated by dividing the average excess return over the risk-free rate by the standard deviation of the excess return.

Total Return (Geometric Return)

Total return is equivalent to rebalancing the portfolio, reinvesting gains, and realizing losses with the effects of compounding.

Weighted Average Cost of Capital (WACC)

The weighted average cost of capital refers to the cost of capital from all sources at an asset or a company level. This is often used as a hurdle rate for a project or a company or a discount rate to calculate the present value of future cash flow. WACC = (Market Value of Equity * Cost of Equity) + (Market Value of Debt * Cost of Debt * (1 – Tax Rate)).

Annex B – Risk factors to calculate the equity risk premium

1. Size (Total Assets): Larger infrastructure assets and companies are more illiquid; therefore, an increase in size contributes to the increase in risk premia.
2. Profit (Return on Assets before Tax): More profitable assets present less of a risk, therefore the factor premia is negative as profits increase. The opposite is true during the development phase when cash flows are negative.
3. Investment (Capex over Total Assets): Capital expenditures are typically incurred during the development/greenfield phase of infrastructure projects (growth capex), followed by ongoing capital expenditures over the life of the asset (maintenance capex). More capital intensive projects with higher capital expenditures relative to assets during the development/greenfield phase would demand higher returns and contribute positively to the risk premia, whereas assets with higher maintenance capex would reduce the cash flows available to investors.
4. Leverage (Total Senior Liabilities over Total Assets): As the share of project debt increases, project risk increases and contributes positively to the risk premia.
5. Term (20-year public bond yield minus 3-month public bond yield): Higher term spreads contribute positively to the risk premia.

Annex C – IEA Scenarios

The Stated Policies Scenario (STEPS) is designed to give feedback to decision-makers about the course that they are on today, based on stated policy ambitions. This scenario incorporates our assessment of stated policy ambitions, including the energy components of announced stimulus or recovery packages (as of mid-2020) and the Nationally Determined Contributions under the Paris Agreement. Broad energy and environmental objectives (including country net-zero targets) are not automatically assumed to be met. They are implemented in this scenario to the extent that they are backed up by specific policies, funding, and measures. The STEPS also reflects progress with the implementation of corporate sustainability commitments. It assumes that the pandemic will be brought under control over the course of 2021.

The Sustainable Development Scenario (SDS) is designed to meet the energy-related United Nations Sustainable Development Goals to achieve: universal access to affordable, reliable, and modern energy services by 2030, a substantial reduction in air pollution, and effective action to combat climate change. The SDS is fully aligned with the Paris Agreement to hold the rise in global average temperature to "well below 2 °C ... and pursuing efforts to limit [it] to 1.5 °C". The SDS assesses what combination of actions would be required to achieve these objectives. In this Outlook, investments in the 2021–23 period are fully aligned with those in Sustainable Recovery: World Energy Outlook Special Report (IEA, 2020). In the SDS, many of the world's advanced economies reach net-zero emissions by 2050, or earlier in some cases, and global carbon dioxide (CO_2) emissions are on course to fall to net-zero by 2070.

The Net Zero Emissions by 2050 Scenario (NZE) is a normative IEA scenario that shows a narrow but achievable pathway for the global energy sector to achieve net-zero CO_2 emissions by 2050, with advanced economies reaching net-zero emissions in advance of others. This scenario also reaches key energy-related United Nations Sustainable Development Goals (SDGs), including universal energy access by 2030 and major improvements in air quality. The NZE does not rely on emissions reductions from outside the energy sector to achieve its goals, but with corresponding reductions in emissions from outside the energy sector, it is consistent with limiting the global temperature rise to 1.5 °C without a temperature overshoot (with a 50% probability).

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