Why Private Markets are the Best Capital Allocators for Energy Transition Investments

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By

Owen Grigsby
Department of Agriculture and Resource Economics, & Department of Economics

Dr. Dana Hoag, Department of Agriculture and Resource Economics

Dr. Andrew Seidl, Department of Agriculture and Resource Economics

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Introduction

According to the International Energy Agency (IEA), global investment in renewable energy (RE) and related infrastructure must reach $4.5 trillion per year by the year 2030, in order to achieve goals that aim to limit global warming to 1.5º Celsius (IEA, 2023). To be clear, this is not money that must be spent on energy consumption, but rather, money that must be used in the development of alternative energy generation, storage, and distribution. This enormous amount of capital flow is already starting to take shape; in 2024, total investment in renewable energy worldwide was about $2 trillion (IEA, 2024a). For comparison, U.S Federal Government expenditures in 2024 totaled $6.75 trillion (U.S Treasury, 2025).

Distilling the issue of solving global climate change into an annual renewable energy investment figure may seem like an oversimplification. However, focusing on the development of clean energy allows the study of the transition to be viewed from a global finance perspective. Because solutions to the issue can build off the ability to produce low-carbon energy, it can be argued that total investment in renewable energy is of principal concern when considering climate change mitigation.

To consider how capital flows to renewables must grow, it's important to examine how investment in the sector has occurred up to now. Of the $2 trillion invested globally in so-called "Energy Transition" development in 2024, about $800 billion was allocated to actual energy production and storage (BloombergNEF, 2025, 2). The rest was invested in related transitional technology, such as power grid development and electrified transportation. The IEA outlines in general terms how the $4.5 trillion per year must be allocated, but we can infer that the market will dictate how much infrastructure is needed to support new renewable investment, and this figure is thus an overarching estimate.

Highly relevant to the goal of growing the overall investment figure is the methods in which the capital allocation has taken place. In 2021, equity financing accounted for roughly 14% of all energy transition investment. In 2024, with overall equity markets slowing in issuance due to broader economic conditions, this proportion fell to only 2% of the total figure. Smaller still is the amount of equity financing that is made up of actual Initial Public Offerings (IPOs), or companies selling shares to the public market for the first time (BloombergNEF, 2025, 4). Other public markets activity, such as mergers and acquisitions, make up a large component of overall equity financing. Most interesting, however, is how private market players have an impact. Although equity financing in renewables fell by some $40 billion from 2021 to 2022, total private market investment actually rose (BloombergNEF, 2025, 4). Thus, as equity finance has pulled back for renewables in more recent years, this form of investment has remained more robust, and accounted for the majority of equity funding in 2024.

Also important to the development of renewables and related technology is government interventions. These can occur through actions such as tax credits, subsidies, and direct government development of infrastructure. According to the IEA, some 25% of total energy finance from 2018-2023 came from governments (IEA, 2024b). This large proportion brings up the debate around the role that governments should play in otherwise free markets. Energy is already a unique sector to public interests, with natural monopolies occurring in distribution markets and the national security importance of power generation. However, the addition of climate change as a concern has led governments around the world to intervene in markets to support renewables. The effectiveness and worthiness of these actions are of high importance to the renewable energy finance situation.

There is no doubt that an economic transition is already underway towards low-carbon energy. Despite the remarkable move by capital markets in recent years to support such a development, much more investment is needed to make a renewable energy future a reality. The trillions of dollars that must begin flowing into the sector, and continue flowing for years to come, are now the subject of great focus worldwide. This work seeks to examine the ways that capital may continue to flow into the effort, and examine how private markets can best support the transition in the future. This paper argues that private market investors, as opposed to public markets or direct government involvement, serve as the best capital allocators when it comes to energy transition investments, and that the strategic involvement of these investment funds will be critical to the future of energy transition finance.

Government Intervention in Energy

The most apparent solution to the growing need for investment in renewable energy is government intervention. With or without a transition, government influence has and will continue to play a role in energy generation and distribution markets around the world. Energy has several attributes that ensure this, and the greatest of these is infrastructure needs. Even on a small scale, the cost associated with distributing energy in a utilities context is relatively high. This high upfront cost means that it's not economically efficient for there to be many utility providers in each regional market. A natural monopoly describes this situation, where the presence of very high fixed costs in an industry creates a barrier to entry to firms, and thus results in declining average costs for a firm that is able to dominate (Greer, 2022, 1). This ultimately means that the most efficient market solution is to allow one firm to take advantage of these declining average costs, otherwise the good would be very expensive for consumers. For a good that is necessary for daily life, such as electricity, governments can allow and effectively

facilitate this at times. In the United States, the Federal Government actively monitors energy markets and engages in the regulation of distribution in accordance with this model (FERC, 2024).

Beyond the intervention of governments in utilities, there has also been a long history of public expenditures in large-scale power generation. In the U.S, historical efforts have aimed at bolstering national energy production, resilience, and independence. In recent years, however, there has been significant intervention to support renewable energy development. Much of this has occurred in the form of tax credits, and the most recent example of this comes from the Inflation Reduction Act (IRA). Within the act, there are two forms of tax credits that apply to renewable energy. The Investment Tax Credit (ITC) grants developers up to 30% of their cost of investment as a credit that can reduce their federal tax liability. Simultaneously, the Production Tax Credit (PTC), grants a credit of $0.0275/kWh of energy produced through a variety of renewable energy technologies (EPA, 2025).

These provisions represent a great opportunity for developers to take advantage of reduced tax liability both in the investment and production phases of a renewable energy project. This has been the case even before the IRA extended the credits, and has been especially true for emerging technologies such as geothermal energy. Geothermal project developers and investors have taken advantage of these credits, particularly the ITC, to make more of their ventures financially viable (Moore, 2016, 520). Geothermal energy differs from other renewables, such as wind and solar, in that it is useful as a base load power source for an electrical grid. That is to say, the heat from the Earth that geothermal infrastructure seeks to harness, is far more consistent than the blowing of wind or availability of sunshine. This means it can play a key role in the renewable energy transition by providing a minimum power supply in an electrical grid

regardless of storage availability or environmental factors (Moore, 2016, 1). As tax credits have supported new projects in this area, they have no doubt helped to establish the viability of a lower-carbon energy future.

While federal efforts such as the ITC and PTC have certainly spurred growth in renewables, the influence of government through these mechanisms may also have a more complicated effect. The convoluted impact of federal tax credits is highlighted by the existence of "Tax Equity Financing." In a Tax Equity investment, a project that qualifies for tax credits is undertaken by a project sponsor, which is to say, an energy company, and financed through external parties, which are usually banks. Because the project sponsor does not have the immediate income for which to claim tax credits, they can effectively sell their credits to a financing party who does have taxable income and can also provide upfront cash to support the project. Of course, in order for the incentive to exist for the financing party to participate in the deal, a renewable energy developer must sell their credits to the financing party at a price that is less than $1 in cash for $1 in tax credit (ACORE, 2023). According to the investment bank, Evercore, ITC transactions can garner anywhere from 75 to 95 cents on the dollar, while PTC deals vary from 89 to around 96 cents on the dollar (Evercore ISI, 2024). Importantly, where a deal lands within these spreads largely depends on the overall size and reliability of the developing party (Evercore ISI, 2024). This also occurs through the formation of a partnership, which allows the financing party to gain "structured equity," giving them a negotiated rate of return over a period of time. This system, with characteristics of both equity and debt financing, has been a major enabler of renewable energy development, and represented a $20 billion market in 2023 (ACORE, 2023). Looking ahead, the total amount of tax credits available for these

transactions rose to $47 billion in 2024, and Evercore's research believes it could top $100 billion by 2030 (Evercore ISI, 2024).

Given the federal incentive landscape for renewable development in the U.S, the need for tax equity financing is apparent. However, the fact that developers must use financial intermediaries, who take a premium in deal structuring, no doubt calls into question the ways in which governments have supported renewable finance thus far. On top of this, critics have identified market distorting effects generated by the need for tax equity that further add to the issue. According to researchers within Yale University's Clean Energy Forum, "Unlike most financial markets, characterized by intense competition with many buyers and sellers, the tax equity market is largely composed of just a few major investors. From 2020 to 2021, over 50% of the $20 billion tax equity market's investment supply came from two large banks: JP Morgan and Bank of America," (D'Alelio & Jiang, 2022). Because of this, the overall ability of developers to take advantage of IRA incentives intended to support renewables is limited. More importantly, however, this environment means that smaller developers are left behind in terms of accessing tax equity financing (D'Alelio & Jiang, 2022). To justify deals that involve claiming tax credits and forming partnerships, overall project size must be large. Given the few tax equity providers, this means that smaller developers lose out in this form of finance, which tips the scale towards large, established energy companies.

To ensure that the renewable industry forms in a robust and sustainable way, competition is necessary to foster innovation and growth. By limiting new market entrants and supporting existing players, the current state of tax equity finance stagnates the renewable energy market even as it supports its growth short-term. While it's not possible to assess the exact impact that this issue has on the emerging sector, it's certainly restrictive in some situations. If the goal is to

bolster clean energy sources and increase their role in the economy, then actions should be taken that promote competition within this industry and thus, promote their competitiveness with traditional energy.

In addition to this market disruption, other research has brought up a different set of concerns associated with public intervention for the energy transition. Because the extent of federal support ebbs and flows with political swings, uncertainty has arisen about whether tax credits and other incentives will remain over the course of any given investment. This uncertainty over public policy has itself presented a risk to private investors, and given a "boom or bust" reputation to certain renewable sources (Barrandale, 2010, 7698). This has caused a unique form of risk to investing in the sector, and some research has argued that the uncertainty over support has had a stronger negative effect than when such support is not made available at all (Barrandale, 2010, 7703). Specifically, uncertainty over the renewal of the Production Tax Credit has driven investment volatility in wind energy, especially as power purchase agreements must be negotiated while developers are unsure of their future returns at the time (Barrandale, 2010, 7703). Another study, titled, "Does climate policy uncertainty predict renewable energy stocks? A quantile-based (a)symmetric causality analysis," and published in *Energy Strategy Reviews*, has found a similar relationship between climate policy uncertainty (CPU) and renewable energy (RE) investments. The article finds that, "An unpredictable policy environment may pose challenges for investors, firms, and policymakers, hamper investment decisions related to RE projects, impede market stability and weaken attempts toward achieving energy transition. Moreover, CPU may exacerbate RE market volatility, increase risk perceptions, and impede capital flows toward green investments," (Alharbey & Ben-Salha, 2024, 1). In other words, the fact that government intervention is subject to a volatile political process

presents a negative aspect to the capital market, even as the forms of subsidies in question are no doubt enacted with good intentions for the sector.

Although these negative consequences of government intervention are certainly real, it's not to say that public expenditures can't contribute to the need for investment capital for renewables in any way. Government has, and should continue to play a significant role in supporting the energy transition. However, more care should be taken to consider these unintended consequences, and future action should focus on mobilizing private investment rather than intervening strongly in markets. One empirical example of this form of success comes from the Climate Investment Funds (CIF) organization. The CIF is a multinational organization that takes funds from governments in developed countries and uses them to invest in renewable energy and climate technology in developing countries (CIF, 2024). Interestingly, however, the greater purpose of the fund is to attract private sector investment in these projects by providing support and long-term capital stability. By investing in projects in emerging sectors and developing countries, the CIF effectively reduces the risk profile of their investments from the perspective of private investors (CIF, 2024). Through this process, government expenditures are used very strategically in order to improve overall investment and sustainability of emerging markets. Notably, the model used by the CIF appears very similar to the model employed by private market investors, such as venture capital and private equity funds. In this system, funds are pooled by partners to form a committed capital base, which is then invested in a certain focus or form of business (KKR, 2025b). While the partners in the CIF are government entities, and the investing committee is multinational, the general format is very similar.

The Clean Technology Fund (CTF), one of CIF's key initiatives, has invested $5.2 billion in different projects around the world, but has attracted over $57 billion in "co-financing," (CIF,

2024). Much of this figure comes from other public funding sources, such as development banks, but it also includes $19 billion of private sector funding. This is critical, because this capital may have never otherwise been directed towards climate initiatives, and the private sector holds an enormous amount of investment funds. Counting only the private co-investments, this means that a dollar invested by the CIF effectively translates to $3.65 once the private investment that follows is included. Including the whole $57 billion, this becomes over $11 for every CIF dollar invested (CIF, 2024). With tax credits, such as those issued under the Inflation Reduction Act, a dollar foregone by the government translates to less than a dollar in renewable energy investment, due to the necessity of tax equity financing. By investing directly, through the same mechanism used by private markets investors, the CIF is not only able to convey its full investment into projects, but it's also able to attract other investors and leverage the broader capital market. As it follows the model of locking in investments into projects for the long-term, the CIF is also able to overcome the issue of climate policy uncertainty, despite representing investments from government sources.

In these examples, it’s clear that governments can have a significant impact in increasing the flow of investment to the energy transition. It’s also apparent that when unintended consequences of policies are not fully understood, these efforts can distort and even damage the markets that support the establishment of lower-carbon energy. More broadly, however, what all government interventions to support this change have in common is the concept of public goods. The benefits of changing our economy to avoid extreme climate change could be enjoyed by any person, regardless of whether they helped pay for the necessary transition, or even wanted it to occur. These benefits are also not rivalrous, meaning one person’s enjoyment of a stable climate doesn’t lessen another’s. If the investment to create this better future were left entirely to the free

market, then it's possible that the aforementioned attributes would prevent the transition from ever being funded. With each individual acting in their own self-interest, there is a natural incentive to free-ride. Since the benefits of changing our economy are not rivalrous or excludable, each person would try to leave it to the others to pay, even if the benefits they would enjoy certainly outweigh the costs. Especially as renewable energy becomes an attractive investment, the outlook for beating this public good issue using the private sector is improving. With that being said, the ability of governments to provide public goods using tax dollars should not be overlooked when considering the energy transition. The objective should be to leverage the ability of governments to correct this market failure, but to do it without damaging the market's incentives and fairness. In addition, as policy uncertainty causes unnecessary damage to the market, government action should avoid easily revocable policies as a general rule. As is the position of this work, more public efforts should follow the CIF's model of acting as a partner, providing some level of investment and lowering the apparent risk to private capital allocators.

Public Markets and Energy Transition Investments

The ultimate goal of starting a business is often viewed as the move from a privately held company to a publicly traded corporation. The selling of shares on a public exchange provides numerous benefits to businesses and founders that can justify the decision to do so. These include accessing new equity capital, improving liquidity for founder and early investor interests, and improving the overall credibility and status of a business (Ritter & Welch, 2002, 1796). Once shares are traded publicly, a business also becomes subject to a host of new regulations and obligations. In the renewable energy space, there are several examples of large developers who have made the decision to go public, and this section explores the effect that public markets can have on energy transition players.

As explored earlier, equity financing for renewables has fallen as a whole in recent years, but public market investment through IPO activity has been the most laggard form of equity from 2021-2024 (BloombergNEF, 2025, 3). According to BloombergNEF, “Capital raised via initial public offerings (IPOs) totaled $6.2 billion in 2024, 85% less than in 2021. Funding for already-listed climate-tech companies fared decently with secondary offerings growing 7% annually,” (BloombergNEF, 2025, 3). Thus, as IPOs have fallen behind in the renewable energy finance space, secondary offerings have grown somewhat in their stead. Secondary offerings are public sales of stock that occur after an IPO. These can be shares that were owned by initial investors or insiders, and can sometimes include new shares from the issuing company to raise additional capital (Geddes, 2005, 211). There are many reasons for secondary offerings, but a rise in the market price of a stock since the time of an IPO is certainly an incentive for original investors to seek liquidity and take profits. Interestingly, this shift in public equity format is in line with the idea that there is a consolidation occurring within the industry towards larger and more established firms. This is no doubt due to many factors, but is likely influenced by the previous assessment that U.S federal incentives may be favoring larger developers.

As IPOs have retreated and secondary offerings have grown, the extent to which the public markets can support renewables has become questionable in recent years. As publicly traded stocks represent highly liquid markets, they can act as a court of public opinion around sectors and companies. An example of this comes from NextEra Energy, one of the largest energy producers in the United States (NextEra, 2025b). NextEra operates a subsidiary called XPLR Infrastructure, which focuses exclusively on renewable energy (XPLR, 2025). Prior to the outcome of the 2024 U.S Presidential election, on November 4th, XPLR’s stock price closed at $20.19 a share (XPLR, 2025). By November 8th, once Donald Trump had won the election and

markets had time to react, the price had fallen to $17.50, dropping over 15% (XPLR, 2025). Likely due to the same exposure, NextEra itself also shed nearly $8 billion in market value, and while it's not possible to say that this was entirely due to the outcome of the election, it was certainly the most significant event of that period (NextEra, 2025a). This came as the broader market, as measured by the S&P 500 index, gained almost 5% over the same 4 days (S&P Global, 2025). All companies can be affected by political outcomes, but the perceived dependence on federal support that energy transition investments have clearly created downward volatility in this instance when the result of the election was determined.

The effect behind NextEra's stock price drop has been measured quantitatively in the study, "Does climate policy uncertainty predict renewable energy stocks? A quantile-based (a)symmetric causality analysis," as referenced earlier. The research uses a nonparametric causality-in-quantile test to measure the effect of climate policy uncertainty on publicly-traded renewable energy stocks from 2010 to 2022 (Alharbey & Ben-Salha, 2024, 2). The study finds that renewable investments are highly impacted by overarching policy through investor protections, funding for research and development, and subsidies. As a result, they concede that there is an important linkage between policy and the energy transition (Alharbey & Ben-Salha, 2024, 2). They also find that climate policy uncertainty has a strong impact on stock market performance of renewable energy firms, unless there is a broader period of extreme growth or contraction occurring (Alharbey & Ben-Salha, 2024, 8). The study concludes that, "The findings indicate an asymmetric causal impact, supported by significant causal relationships stemming from a decrease in CPU rather than an increase," (Alharbey & Ben-Salha, 2024, 11). This is highly concerning, because it effectively means that when the policy picture becomes more clear as it pertains to renewables, it has an outsized effect on stock prices than when it becomes more

uncertain. For example, if a candidate is elected who will have a clear negative impact on climate policy, renewable stock prices are likely to fall in a significant manner as a result.

If political control is seen as a factor that affects the viability of renewables and similar investments, then companies with exposures to the energy transition will absolutely see their valuations affected when certain candidates are elected. This can generate negative outcomes for accessing capital in the public markets, particularly for emerging companies that could raise less from an IPO when an adverse political regime is in control. This does not bode well for a sector that should be seeking to become as robust and sustainable as possible to ensure that the worst effects of climate change are able to be avoided.

In addition to volatility driven by policy, renewable energy investments have other attributes that can make them unsuitable for public markets. Generally, developers require very high upfront capital expenditures for a project, and they also need prolonged periods to pay back this investment (Alharbey & Ben-Salha, 2024, 1). Considering the differences between fossil fuel and renewable power generation, the explanation for this becomes apparent. In a traditional combustion power plant, a developer must pay to build the infrastructure, the technology for which has existed for many years, and then the fuel that is burned can be paid for over time through the plant's cash flows. In a solar or wind development, the variable costs are virtually nonexistent, as solar radiation and wind have no marginal cost associated with attainment. With that being said, the infrastructure that must be purchased upfront represents much more advanced technology, and all of this must all be implemented at the start of a project. As explored in the concept of tax equity financing, this usually means that developers are forced to take advantage of any opportunity to raise cash, and sell their federal incentives for development capital. Despite these headwinds, the cost of electricity produced from renewable sources has recently become

competitive with traditional energy in many markets, in large part due to the public incubation of alternative technologies (Liñeiro & Müsgens, 2025, 2). At the same time, the frontloading of costs in renewable projects means that they will still be less profitable in the near term than traditional energy. This may be overlooked by private investors, who can integrate energy transition goals and longer time horizons into their investment theses, but public markets will be inherently less forgiving.

Research has shown how companies with long term projects, such as those implemented by renewable energy firms, can often clash with the shorter-term focus that many stock market investors have. A study published in the *Journal of Financial Economics*, titled, "The short-termism trap: Catering to informed investors with limited horizons," confirms this disconnect. The study uses an empirical model that examines how "short-termism" by investors can not only impact stock prices of companies, but can actually affect their managerial performance, as well (Dow et al, 2024, 16). The key result of the model indicates that, "...while stock market listings [IPOs and Secondary Offerings] can potentially create substantial value through price informativeness, up to 100% of this value can be dissipated by the short-termism trap when investors have sufficiently short horizons," (Dow et al, 2024, 2). For renewables firms, whose projects require longer payback periods, this presents a major exposure that could even erase the price feedback benefits created by going public.

Stemming from the same issue, when a company goes public, the fiduciary duty they have to shareholders extends to anyone who buys their stock, meaning they lose some control over how their corporate mandate is interpreted. In addition to the short-termism issue, public markets can also push back on less profitable actions when they are done for sustainability reasons. This problem has manifested recently in the issue of Environmental, Social, and

Governance (ESG) initiatives by public companies. Blackrock, the world's largest asset manager, has engaged in these sorts of actions in recent years, and encountered significant opposition on the issue from investors and the general public (Blackrock, 2025a). Blackrock has taken a focus on the energy transition, and had to explain this decision in corporate communications after experiencing pushback. The firm published an article titled, "Energy Investing: Setting the Record Straight," wherein they explained that, "Our focus on climate risk and energy is about driving financial outcomes for clients," (Blackrock, 2025b, 1). This example demonstrates the kind of clashes that firms investing in renewable energy can have with public market investors. As the apparent necessity of an energy transition can sometimes run counter to pure profit motive, operating in public markets will leave developers more vulnerable to this sort of hostility. Given these concerns, the ultimate goal of businesses as being the move to an Initial Public Offering, may not hold true for renewable energy and similar energy transition companies.

Beyond these issues, more important to renewables than the public equity market is the public credit market. With equity investment growth slowing, and the pressures laid out previously from public stock markets, credit necessarily becomes a critical part of the picture. According to BloombergNEF, debt issuance for the energy transition amounted to $1 trillion in 2024 (BloombergNEF, 2025, 4). This means that debt has become the primary form of financing for the energy transition. For this reason, how the issuance process is carried out, and which investors are involved, is of high importance to the need to grow the overall capital flow.

Within the global credit markets, there are many investment vehicles offered by issuers that differ in terms of structure and function. Of these, most relevant to public markets are corporate and government bonds. As part of the efforts to move to a lower carbon economy, a

new form of bond, labeled as “Sustainable,” or “Green,” has emerged. This designation indicates to investors that the security represents debt associated with the energy transition, or similar environmental initiative (ICMA, 2021, 2). According to BloombergNEF, these labeled sustainable bonds accounted for 64% of energy transition debt in 2024 (BloombergNEF, 2025, 4). This large proportion represents the amount of debt issued within the effort that seeks to single out investors who care to invest specifically in the solutions to global climate change.

The Federal Reserve Board of the U.S has published a paper on this topic, titled, “The Green Corporate Bond Issuance Premium,” (Caramichael & Rapp, 2022, 1). This research identifies that labeling a bond as “Green” or “Sustainable” is an attempt by the issuer to lower the necessary interest rate on their bond, by signaling to investors that it supports positive environmental outcomes (Caramichael & Rapp, 2022, 3). This difference in cost of capital is known as the Green premium, or “Greenium.” The extent of this effect is significant; the FRB estimates that the yield spread for Green bonds averages about 8 basis points lower than conventional corporate bonds. Notably, their work finds that, “Relative to the average yield spread of our sample, this reflects a roughly 5% decrease in the borrowing cost to the issuer… This borrowing cost advantage is economically meaningful, but at the same time it is reduced by green bonds’ compliance costs (certification, monitoring, reporting) and a longer issuance process, particularly for complex green projects and small or first-time issuers,” (Caramichael & Rapp, 2022, 14). To summarize, labeling bonds as sustainable investments attracts a type of investor who is willing to earn less from their bond because it supports an environmental goal. At the same time, however, the challenges associated with issuing this form of bond reduce said benefits, and this is especially true for smaller and less established firms. This is effectively the same challenge presented by tax equity financing, as referenced earlier, where emerging firms

are once again placed at a disadvantage in the unique financing options available to energy transition companies.

In addition to this, the compliance costs that reduce the benefits of a "Greenium" are concerning for other reasons. According to the FRB, "Green bonds currently lack a universal global regulatory framework. Instead, green bonds are customarily structured to align with the Green Bond Principles published by the International Capital Markets Association (ICMA)," (Caramichael & Rapp, 2022, 5). The need for a form of verification for Green bonds is apparent; any corporation, "Green" or not, could try to label their debt as "Sustainable." This would be especially attractive if doing so could result in a 5% reduction in the cost of raising that capital, as the FRB has found. The validity of the environmental benefit aspect of Green labeled bonds is therefore generally upheld by the ICMA. However, the ICMA's framework for what constitutes a Green Bond is not a binding set of rules. Instead, the organization's Sustainability Bond Guidelines are, "...a collection of voluntary frameworks with the stated mission and vision of promoting the role that global debt capital markets can play in financing progress towards environmental and social sustainability," (ICMA, 2021, 2). As such, even the underlying rules for labeling as a Green Bond rely on some form of self-compliance by issuers. The FRB's work highlights that the voluntary nature of these rules may result in "greenwashing," where firms deceitfully try to appear environmentally responsible despite having little to no real impact (Caramichael & Rapp, 2022, 5). Recall that the costs associated with this process may even negate the benefits of labeling a bond as Green in the first place. Even still, the designation does not guarantee that money loaned for environmental impact actually gets used for such initiatives. For a renewable energy developer, this means that they have little advantage in public credit

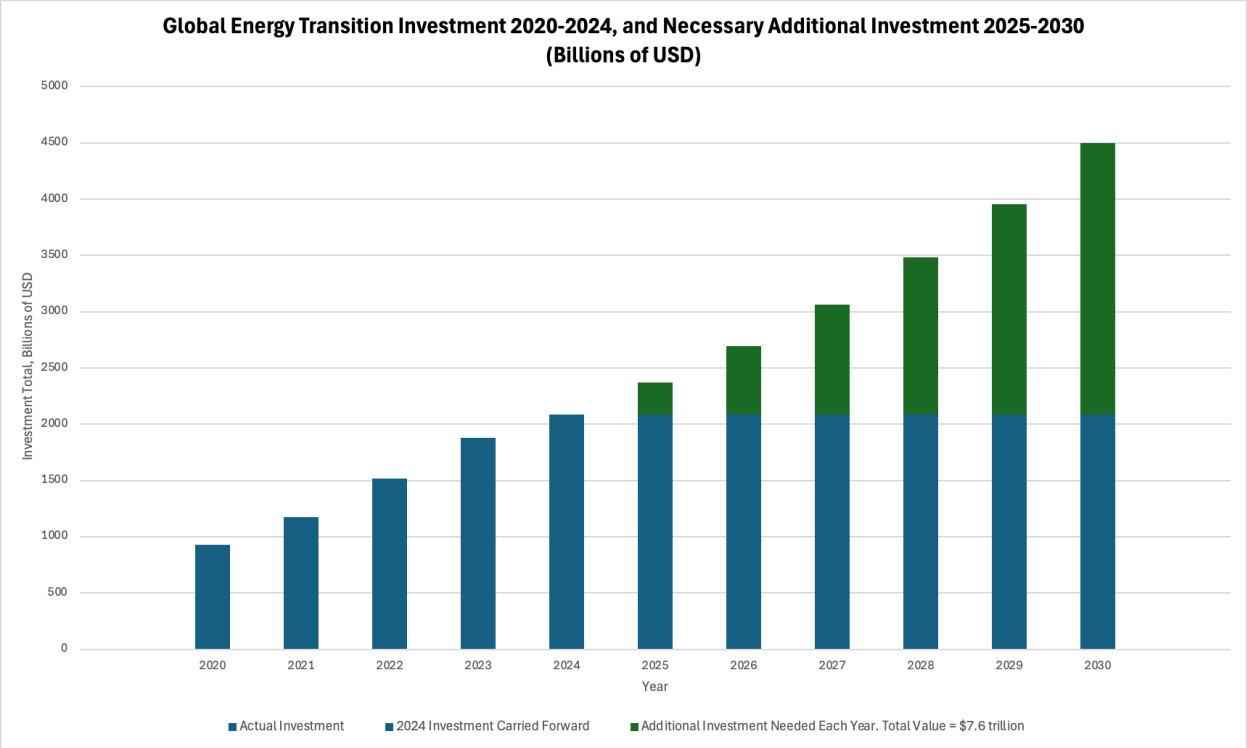
markets for investing in socially necessary change, and the market structure that forms around them can still be taken advantage of by firms that "greenwash."

Due to these disconnects, it's clear that renewable energy transition firms and public markets do not represent an ideal partnership. High liquidity of stock markets means that capital flight from energy transition equities can easily occur during times of policy uncertainty, even if the firms involved maintain strong performance over time. In addition, the fundamental motivations of public markets investors don't align best with the investment structures and goals of the companies in question. Even as some investors certainly do appreciate the public good aspect of investing in the transition, the situation regarding bond issuance does not support the realization of these benefits as of now.

Private Markets and Energy Transition Investments

Despite efforts by governments and investors around the world, total investment in renewable energy and supporting technologies still falls short of what is needed. Even if the current level of capital flow continues, the IEA's target of net zero emissions by 2050 requires more investment in coming years beyond this amount (IEA, 2024b). Figure 1 shows empirical values of total investment from 2020-2024, as well as what's needed each year from 2025-2030 in order to achieve $4.5 trillion in global investment by 2030. Critically, the need for additional investment totals $7.6 trillion between 2025 and 2030 (BloombergNEF, 2025, 2; IEA, 2024a).

Figure 1



Note. Additional investment needed each year assumes constant growth from 2025-2030. Investment Total Data from BloombergNEF (2025). Target figure from IEA (2024a).

In confronting this issue, what both governments and public markets fail to provide is stability of funding. Swings in support render governments and public markets unreliable for funding the transition, and this means that a more dependable form of investment is needed. As of 2025, global assets under management (AUM) in private markets topped $13 trillion (Blackrock, 2025d, 2). This sector of the global capital market represents some of the fastest growing asset classes, and AUM within private markets is expected to exceed $20 trillion by 2030 (Blackrock, 2025d 2). Notably, this growth of over $7 trillion is very close to the $7.6 trillion in additional energy transition capital required above 2024 levels over the same time span, as shown in Figure 1. In addition to this enormous opportunity for allocation alignment,

private markets fundamentally serve the needs of the energy transition best, due to the investors they access and the structures they use.

A private market investment is any investment that is not listed publicly on an exchange. Primary forms of private markets include Venture Capital, Private Equity, Private Credit, and Real Estate (Blackrock, 2025d, 2-22). In the U.S, the only investors that can participate in organized private markets (such as private equity and venture capital funds) are "accredited investors," meaning they have significant financial assets. To be an accredited individual requires having a net worth over $1 million, and income of over $200,000 a year (SEC, 2024a). Additionally, for an institution to participate, they must own investments totaling over $5 million (SEC, 2024b). This restriction, for which various iterations exist around the world, means that the money supporting private markets is inherently more stable. This is because it comes only from affluent sources, where those directing the funds are aware and engaged in the risks associated with their investments.

On top of this restriction, private markets investments are characterized by significantly less liquidity than those listed on an exchange. This is due to the structure of funds operating within private markets; instead of using stocks or bonds that trade in highly active markets, private market funds generally use a partnership model. This means that investors lock up their money as "Limited Partners," allowing their funds to be invested over a period of time by "General Partners," also known as fund managers (SEC, 2024b). This structure has significant implications for how private investments are allocated, as well as how they impact the firms that receive their capital. Fundamentally, the individuals and institutions who choose private markets for investing understand that longer time horizons are part of the asset classes that they've chosen. In addition, this partnership means that fund managers can raise funds designated for a

specific purpose, and only include investors who are onboard with their thesis. These features provide the basis for why private markets must play a critical role in funding the remainder of the transition's capital flow requirements.

Fundamentally, one recurring issue within the examination of government and public markets investment for renewable energy has been the favoring of investment towards larger firms. As discussed, this could have market distorting effects that are inhibiting to both growth and competition, and could ultimately hold back the establishment of low carbon energy within the economy. For these reasons, a goal of energy transition investment for investors and policymakers going forward should be to properly fund new market entrants, as well as companies that represent emerging technologies. This is one area in which investment from private markets can naturally excel. Venture Capital (VC) funds are private investors that identify start-up enterprises, aiming to provide capital early in the development process (Zider, 1998). Venture Capital funds exist to fit a niche within the economy that is essential for driving growth. Due to the extremely high risk profiles of start-ups, founders of these companies face an uphill battle in securing financing. Importantly, public banks are often not willing or not able to lend at large scale to these emerging companies (Zider, 1998). In addition to this, public markets face constraints and regulations that are meant to protect investors from the high risks associated with emerging companies, and this situation creates a need for VC (Zider, 1998). By stepping in and providing capital to new companies, VC plays an integral role in helping spur new growth and ensuring that smaller firms are funded.

While VC funds aim to generate returns through the eventual sale of equity in the companies they invest in, research has shown their effect to be positive in several key regards. In 2021, a multi-country study across several industries found that firms who obtained VC funding

have been shown to display more innovation as a result of these investments (Khan et al., 2021, 5). Notably, using data from markets in 41 countries, their study points to the amount raised from VC as an explanatory variable for innovation indicators such as number of patents issued by the emerging firm (Khan et al., 2021, 7). As the energy transition will no doubt rely on the emergence of new technologies and firms that create better solutions, this attribute is especially important within the role of VC.

More specific to the energy transition, additional research has found that VC investments can have a positive impact on the ability of companies to create growth that promotes environmental sustainability. A study published in *Energy Economics,* titled, "How does venture capital spur the innovation of environmentally friendly firms? Evidence from China," provides quantitative evidence that supports VC in this regard (Dong et al., 2021). The study considers patents related to environmental initiatives, earned by Chinese companies that fall into either the environmental protection industry, or the so called "New Energy Industry," (Dong et al., 2021, 4). According to the researchers, "The new energy industry includes solar energy, lithium batteries, water utilities, power utilities, photovoltaic, new energy vehicles, biomass energy, and their corresponding equipment manufacturing sectors," (Dong et al., 2021, 4). Their results show that of the companies operating in these areas, those backed by VC are more successful in applying for patents, and their patents have a greater impact when compared to companies that are not VC funded (Dong et al., 2021, 7). In other words, when a company in the energy transition space is backed by a VC, they are more effective both in how much innovation they can create, and the efficacy of this innovation towards a lower carbon economy.

In considering the role that VC investors have in emerging markets, these findings are intuitive. VC fund managers have a natural incentive to try to fund the best firms, representing

the best new technologies. In addition, because of their private partnership model, VCs have the ability to designate the purpose of their fund as to promote the energy transition. This means that investors can be entirely supportive of their initiatives, providing fund managers with confidence for investing in innovation that carries greater risks. During the course of a VC investment, uncertainty in climate policy or lack of public support for the transition could still arise. However, due to the sophistication and selection of investors involved, and the lack of liquidity within the fund structure, portfolio companies for VC funds will remain funded and effectively weather the storm. Even as total investment for renewable energy has lagged behind necessary figures, Venture Capital has displayed these beneficial attributes for the sectors it invests in.

One example of a VC fund that has had success investing in the energy transition and related technologies is Energy Impact Partners (EIP). With over $4 billion in assets under management (AUM), EIP is able to invest broadly across both renewable developers and energy-transition related companies (EIP, 2025a). Portfolio companies for the fund include mainstream renewable power companies, but also software and technology companies associated with decarbonization (EIP, 2025b). Similarly, Lowercarbon Capital is a fund of over $2 billion in AUM, investing in the same sectors and initiatives (Lowercarbon, 2025). The fund has backed startups focused on “Fully electric passenger planes,” and “Zero-carbon cement,” in their expansive portfolio (Lowercarbon, 2025). With multiple funds of over $1 billion investing solely in the energy transition and similar environmental initiatives, Venture Capital has already established a key presence in startups involved in climate change mitigation.

While VC is pivotal in incubating and funding early stage companies, returning capital to investors necessarily entails exiting a fund’s holdings in portfolio companies by selling equity stakes. Generally, buyers for this process can be larger corporations through mergers and

acquisitions (M&A), or public market investors through an IPO (Zider, 1998). For VC funds in the energy transition space, M&A can be a valuable option, as the industries involved are growing and larger companies are looking to increase their market share. However, as explored earlier, public markets leave companies involved in the energy transition vulnerable to issues endemic to the market, meaning a different exit opportunity is necessary. To remain insulated from volatility, companies that grow beyond the scope of what VC can support must remain in private markets ownership. This gap can be filled by private equity fund investors.

Private equity (PE) is the largest asset class within private markets, representing more than $10 trillion in AUM as of 2023 (Blackrock, 2025d, 8). In comparison to Venture Capital, which aims to support early-stage companies through their initial development, Private Equity is much more versatile. While the fund structure is largely the same as VC, PE investors focus on buying established companies and improving them through operational changes (KKR, 2025b). PE funds still pursue companies with the goal of growing and eventually selling them, but they aim to buy companies that have surpassed the earliest stages and have proven to be successful enterprises. As such, this process effectively picks up where Venture Capital seeks to leave off. Private Equity can therefore be a solution to companies hoping to grow beyond their initial stage, but also seeking to avoid public markets.

In conventional industries, this move from Venture Capital to Private Equity has already become a frequent occurrence. As it serves the needs of the renewable energy transition best, it is beneficial that this process becomes established within capital markets as overall investment into the effort grows. The boutique investment bank, Clipperton, has published industry research on this trend, focusing on how it has become a common form of deal within technology transactions (Valorge et al., 2023). The research confirms the historical necessity of VC backed companies to

transition either into public markets, or into a larger firm through M&A. Importantly, however, they find, "...the exit landscape for VC-backed startups has undergone a substantial transformation over the past decade; notably thanks to the emerging trend of what we like to call 'VC-to-PE deals.' While exits to PE funds made up just 8% of total exits for VC-funded companies between 2006 and 2010, that figure has surged to a whopping 24% for the years 2021 to 2023," (Valorge et al., 2023). As this form of deal already represents about a quarter of exits for VC portfolio companies, a greater possibility forms for emergent companies within climate change technology to remain in private markets control.

With VC-to-PE transactions already growing within capital markets, the groundwork has been laid for further dealmaking between these asset classes. A renewable energy or climate change technology firm that grew initially through VC investment should therefore aim to grow into private equity ownership once past the early stages. A key benefit of what PE can provide in these instances is the patience of capital stemming from longer term investment horizons. One issue identified within public markets was "short-termism," and choosing to remain in private ownership can help avoid this exposure. Traditional PE funds raise capital from investors with the goal of locking it up within portfolio companies for significant time, sometimes over 10 years (KKR, 2025b). As such, investors do not expect the ability to divest at any time, giving the objective of the fund a much more long-term focus. This attribute is important to the renewable energy transition for several reasons. Similar to VC, the underlying partnership in this case ensures that capital flight does not occur when the political or social situation around renewable energy deteriorates. Portfolio companies remain in the ownership of private investors who made the decision to invest for multiple years, and possibly even to tailor their fund to focus on climate change mitigation. Secondly, the longer-term investments from private equity align well with the

necessary profitability horizons of renewable energy projects. Recall that renewables require much longer periods of payback on initial capital invested. This means that their business models require an equity investor seeking a stable return over a long period of time. Lacking this, developers must leverage their tax credits, resulting in an inability to fully realize federal support for renewable energy. As PE funds can provide capital for projects that require significant time commitment on payback, they can serve as a critical catalyst for further investment in the energy transition.

With the move to a lower carbon economy requiring mobilization from around the world, the role of PE must expand accordingly. Research has found this to be the case in India, with an article published in *Heliyon*, titled, "Private equity renewable energy investments in India," (Gandhi et al., 2025). The research emphasizes the fact that India represents one of the fastest urbanizing economies in the world. As India adds millions of people to its urban population and electrical grid, the country is expected to have the highest growth in energy consumption and carbon dioxide emissions in the world over the next 20 years (Gandhi et al., 2025, 2). India has set goals on the amount of renewable energy it seeks to add, and due to the sheer size exposure, the country's ability to achieve these goals is of great concern to the global energy transition. The financing need is enormous, however: India's solar goals alone would effectively entail tripling the amount of capital that flows into the country's renewable energy sector (Gandhi et al., 2025, 2). The naturally high risk profiles of these new projects, combined with India's status as an emerging economy, means that developers will struggle to raise this capital in conventional markets (Gandhi et al., 2025, 2). However, private equity investors from around the world have already begun stepping in, as the long-term cash flows and opportunistic niche of India's need aligns well with many fund strategies (Gandhi et al., 2025, 2). The research finds that PE is the

best form of capital allocation for this rapid scale, partially due to the same impact created by the Climate Investment Funds group, which the researchers refer to as "basis arbitrage," (Gandhi et al., 2025, 12) . By acting as a respected and known backer to Indian RE projects, PE funds can lower the apparent risk profile to other investors, particularly those offering credit financing (Gandhi et al., 2025, 12). According to the research, "Domestic and foreign lenders are more comfortable lending to companies backed by reputable investors, particularly long-term institutional investors[1]. For example, prominent Indian developers backed by foreign pension funds and sovereign wealth funds, Azure Power and ReNew Power, have raised foreign bonds at a significantly lower cost than domestic debt," (Gandhi et al., 2025, 12). Specifically, the study finds that every $1 of PE project financing can generate $4 of debt financing, which occurs at a lower interest cost to the developer when a project is PE-backed (Gandhi et al., 2025, 2). Thus, on top of the significant capital provided by PE, these funds can also help lower cost of capital from other sources. In addition, as foreign fund managers must be wary of risks of the emerging market, their natural incentive is to conduct careful due diligence that ensures that the best and most efficient developers receive funding. This research shows some of the benefits of private equity for renewable finance, manifesting in a critical emerging market.

Highly relevant to the situation in India, U.S empirical examples of PE funds operating in climate change mitigation comprise even more significant investment than what is shown in VC. Blackstone Energy Transition Partners, a fund within the PE Giant, Blackstone, has invested $23.5 billion across many sectors related to renewable energy (Blackstone, 2025c). Additionally, KKR, another significant PE investor based in the United States, has invested over $45 billion in "Sustainability Focused Investments," since 2010 (KKR, 2025c). In fact, KKR is listed in the

[1]Private equity funds are a form of "long term institutional investor."

previously discussed research as an investor of over $360 million in India's growing RE infrastructure (Gandhi et al., 2025, 2). As private equity already shows billions of dollars in investments that fit into these initiatives, the investment sector is primed for further growth that supports the transition.

Aside from VC and PE, which make equity investments in companies, private markets can support credit needs, as well. As debt has become the largest form of financing for the energy transition, private markets need to grow to support this need in order to achieve the necessary investment into the effort. Interestingly, private credit has already grown in recent years to around $1.5 trillion in global AUM, and is expected to be the fastest growing asset class within private markets in years to come (Blackrock, 2025d, 14). Private credit funds, leveraging the limited partnership model, focus on making unique and tailored debt investments that are typically more versatile than traditional banks (KKR, 2025a). This allows the fund to lend to unique situations, and structure debt to meet specific needs. As accessing public markets for debt financing can be difficult for renewable energy and related firms, private credit can bridge this gap going forward.

Although private credit has not yet established a strong force within the transition, industry players project the role of private lending solutions to expand rapidly in years to come, especially within renewable energy. Investment bank Goldman Sachs cites the need for credit financing within the transition, combined with the sustainability focus that Limited Partners are increasingly developing, as evidence for the coming growth (McDuffy et al., 2024). The bank's research emphasizes that, "Private equity catalyzed this industry, but private debt is needed to scale it," (McDuffy et al., 2024). Additionally, solar energy investing has begun to make its way into private credit, with Blackrock's Private Markets Outlook identifying the assets as a

significant portion of private credit AUM in 2024 (Blackrock, 2025d 8). As such, while renewables and related technologies have only begun to access private credit's capabilities, the relationship is very likely to grow significantly in years to come.

Fundamentally, private markets can serve as the best capital allocators for further financing of the energy transition. Due to their ability to provide long-term capital and select investments that represent the highest potential, the role of these investors should not be overlooked. On top of this, the volatility and pressures that come from government and public market investments can be avoided through private capital, both through the illiquidity of fund structures and the priorities of limited partners. Going forward, policymakers and investors should bear this in mind, and adapt priorities to favor growth in this form of energy transition investment.

Recommendations and Conclusion

An assessment of the state of energy transition finance in recent years shows several recurring themes. First, public opinion around addressing climate change, manifesting in policy development and investor sentiment, is fundamentally volatile. According to Yale University's Program on Climate Change Communication, only a slight majority of Americans believed that global warming was caused mostly by human activities in 2024 (Marlon et al., 2025). Research has shown that the climate change policy uncertainty generated by this indecision in public sentiments has had a major impact on renewable energy investment (Barrandale, 2010, 7703). In addition, the same effects have been shown to impact stock prices of publicly traded renewable energy firms (Alharbey & Ben-Salha, 2024). As government investments and public markets are easily subject to this volatility, they leave firms involved in the energy transition vulnerable to negative effects.

Secondly, the efficacy of investment from governments, which comprises an enormous portion of the total energy transition financing, shows flaws in comparison to private forms of investment. Tax incentive structures from governments are less efficient than private mechanisms, and can favor larger firms due to the necessity of financial intermediaries. However, direct government investments, such as those made by the CIF, can prove more efficient than tax credit programs. This occurs by combining the long-term investment horizon of a private markets fund structure with the reliable nature of committed capital from governments, thus lowering the risk profiles of invested initiatives.

The headwinds that threaten to stall further renewable energy investment can be addressed by further private markets involvement. As private markets are projected to grow by roughly the same amount of additional capital needed by the energy transition from 2025-2030, the opportunity already exists for growth. As such, the goal of policymakers going forward should be to ensure that growth in private markets equates to capital flows towards the energy transition, and this can be done through a variety of incentives. Tax incentives, similar to the IRA's Investment Tax Credits, should arise for private markets funds that invest in energy transition companies. Implicit in this action is the need for a more robust framework for what defines a firm operating in the energy transition, as the initiative covers far more than renewable energy alone. Because enacting tax incentives for private investors promotes long term investments, this credit program could avoid the negative effects created by the ITC and PTC.

In addition, when the political and fiscal situation allows, governments should participate directly in transition investment through methods such as the CIF. By lowering the risk profile of emerging projects and firms, governments can help attract private capital that is necessary to fund the transition. Governments could also intervene to reduce risk in energy transition

investments by engaging in underwriting actions. By offering to insure an investor against a certain amount of their invested principal in a qualified energy transition initiative, governments could improve the risk-adjusted returns of such investments. As all of these actions leverage stable funding mechanisms, they could improve capital flow while ensuring investment protection from uncertainty and volatility.

For renewable energy and related companies, these findings indicate that remaining in private ownership, and avoiding reliance on government support, are essential for raising further investment. Whenever possible, startup companies should pursue venture capital, followed by private equity investment. As the size and ability of private credit grows, companies may consider pursuing debt financing in this format rather than issuing “Green Bonds” in public markets. While these solutions may not make sense for every energy transition company, they should certainly inform financing decisions for business leaders going forward.

For investors, this situation represents an opportunity to participate in a reallocation of capital and new adaptation of the global economy to prevent further climate change. As accredited investors seek new opportunities in private markets, they should display a strong preference towards energy transition investments to fund managers. Demonstrated success in these investments, especially from large and established funds, could unleash a movement within private markets towards the energy transition that moves global investment towards the critical amount of $4.5 trillion per year by 2030. With funds already emerging that focus solely on this initiative, the outlook is strong that private markets will continue to grow and support this growing need.

With a total investment of over $2 trillion in 2024, the move towards a lower-carbon economy has shown impressive results in raising funds. Even still, the necessity of significant

growth in the capital invested presents a great and essential challenge to the entire world. Unfortunately, the companies involved have unique needs, and political attitudes towards renewable energy routinely shift entirely. As a result, the conventional financing methods that have led investment thus far, may not properly support the initiative going forward. However, by unleashing private markets, we can achieve the necessary funding without drastic interventions, and in doing so, avoid the mounting effects of climate change that threaten our future.

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