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Bridging the clean energy investment gap: Cost of capital in the transition to net-zero emissions

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Abstract

The rapid and deep emissions reductions needed to keep global warming to 1.5°C rely critically on an immense scaling-up of investment in clean energy technologies. The cost of capital plays a key role in determining investment decisions and, when elevated, can pose a significant barrier to accelerated climate action. The high capital expenditure needs of clean energy technologies make them more vulnerable to changes in the cost of capital than fossil fuel alternatives. This paper provides an overview of the cost of capital as a barrier to clean energy investment and depicts the key risk factors that determine the cost of capital for specific investments. It shows how, particularly in developing countries and for new and emerging technologies, a high cost of capital can significantly stifle investment, and calls on governments to implement better risk sharing mechanisms to overcome this barrier.

Résumé

Les réductions rapides et profondes des émissions nécessaires pour maintenir le réchauffement climatique à 1,5 °C dépendent essentiellement d'une immense augmentation des investissements dans les technologies d'énergie propre. Le coût du capital joue un rôle clé dans la détermination des décisions d'investissement et, lorsqu'il est élevé, peut constituer un obstacle important à l'accélération de l'action climatique. Les besoins élevés en investissements des technologies d'énergie propre les rendent plus vulnérables aux variations du coût du capital que les alternatives aux combustibles fossiles. Ce document de travail donne un aperçu du coût du capital en tant qu'obstacle à l'investissement dans les énergies propres et décrit les principaux facteurs de risque qui déterminent le coût du capital pour des investissements spécifiques. Il montre comment, en particulier dans les pays en développement et pour les technologies nouvelles et émergentes, un coût élevé du capital peut étouffer considérablement l'investissement, et appelle les gouvernements à mettre en œuvre de meilleurs mécanismes de partage des risques pour surmonter cet obstacle.

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Executive Summary

Achieving net-zero greenhouse gas emissions in the energy sector by mid-century will require total global clean energy investment of USD 4.5 trillion by the early 2030s.[1] Yet, despite significant increases in recent years, clean energy investment currently stands at an estimated USD 1.8 trillion globally (IEA, 2023[1]). Efforts to decarbonise the energy sector hinge on closing this major investment gap over the next six years.

The cost of capital is a crucial element in evaluating the cost and net present value of any investment, as it determines the rate at which future cash flows are discounted. It has a strong influence over final investment decisions and, by extension, overall investment levels. The cost of capital is composed of a base rate, affected primarily by interest rates, and a risk premium. The latter is influenced by a wide variety of risk factors linked to macroeconomic, country, sector, technology, and project conditions.

For clean energy, these factors include risks related to the country of investment; foreign exchange; political and regulatory changes; design, construction, and completion of projects; technological performance; supply of inputs and equipment; certification; and offtake. Higher perceived risks in any of these categories will lead to a higher cost of capital for clean energy projects, potentially deterring investment.

The significance of risk in assessing the cost of capital is important for climate policy. The required speed and scale of the net-zero transition mean that clean energy investment cannot be limited to lower-risk projects. Meeting the Paris Agreement objectives will inevitably require investment in higher-risk projects, notably in emerging clean energy technologies and in developing countries.

In addition, as they require significant upfront capital expenditure, clean energy projects are generally more sensitive to the cost of capital than fossil fuel equivalents whose lifetime costs rest more heavily on operation and maintenance. As such, as the cost of capital rises, the levelised cost of electricity (LCOE) for clean energy projects tends to increase faster than the LCOE for fossil fuel projects.

Surging inflation rates coupled with monetary tightening measures have contributed to driving up the cost of capital in many economies. This has brought increasing attention to the cost of capital and its role as a potential barrier to scaling up clean energy investment worldwide when elevated.

Despite the challenging investment conditions of recent years, well-established clean energy technologies such as solar PV and onshore wind remain attractive to investors and continue to perform well in advanced economies. This can be attributed to the cost competitiveness of renewable power technologies compared to their fossil fuel counterparts (in part due to high fuel prices), energy security concerns around oil and gas supply, and continued strong political support for clean energy and climate action among governments. For many investors, solar PV and onshore wind projects in advanced economies no longer represent high levels of risk.

[1] Clean energy technologies are defined in this paper as non-fossil fuel technologies across the whole energy system that contribute to achieving the goal of net-zero emissions, including renewable power, nuclear, grids, storage, low-emission fuels, efficiency improvements and end-use renewables and electrification.

However, there are two contexts in which investments remain particularly risky and where high cost of capital has historically posed a barrier to investment:

1. **Developing countries often present challenging investment conditions for clean energy**, as they do for all investments. Complex political, economic, and institutional factors significantly raise the perception of risk among investors, leading to costs of capital that are generally at least two times higher in developing countries (excluding China) than in Europe or the United States (IEA, 2023[2]). Consequently, a significant regional gap has opened in clean energy investment levels. While emerging and developing economies (excluding China) comprise two-thirds of the global population, they represent less than one-fifth of global clean energy investment (IEA, 2021[3]).
2. **Investments in nascent clean energy technologies tend to be perceived as higher risk than well-established technologies** such as solar PV and onshore wind. This stems from factors including uncertain market demand; a shortage of credible offtakers; price uncertainty; lack of trading markets; political risk; insufficient infrastructure; lack of transactional experience; and an absence of historical evidence of technological performance at the commercial level. Again, this higher perceived risk translates to a higher cost of capital, which can prevent these technologies from being rapidly deployed at scale. The example of green hydrogen reflects these challenges: despite a large pipeline of projects, very few have reached final investment decision. Of the 1 046 large-scale green hydrogen projects announced as of January 2023, less than 10% of the USD 320 billion investment through 2030 are real committed capital (Hydrogen Council, McKinsey & Company, 2023[4]).

Several policy options are available to governments to help clean energy investment overcome high cost of capital barriers. It is essential that countries put in place supportive overarching frameworks that enable access to capital at low cost. This includes implementing political commitments to climate action and climate policy packages; putting in place structures that support predictable, efficient, and transparent governance; and developing and strengthening financial markets.

Targeted solutions can be implemented to overcome investment barriers in developing countries and nascent technologies. In developing countries, these include strategic use of public-private partnerships; strengthening the approach of multilateral development banks and of blended finance; development of de-risking instruments; and addressing data and information gaps. For emerging technologies, these include policies to support innovation (such as research grants and R&D-specific tax credits); careful design of feed-in tariffs and contracts for difference in support of newer technologies; and efforts to harmonise international standards on emerging technologies.

This paper provides an exploration of the cost of capital as a significant factor in efforts to reach a net-zero energy sector, keeping in mind that the context-specific nature of risk and overall cost of capital implies more tailored technology- or region-specific research. What follows is an introduction to the topic and a potential starting point for further work in this area.

1 Introduction

Clean energy investment is booming globally, with rapid and consistent falls in the costs of key technologies over the past decades. For instance, from 2010 to 2022, the global weighted average levelised cost of electricity (LCOE)[2] dropped 89% for utility-scale solar photovoltaic (PV) projects and 69% for onshore wind projects (IRENA, 2023[5]). In 2023, global annual clean energy investment exceeded USD 1.8 trillion, a significant increase from the USD 1.1 trillion invested in 2015. Clean energy is estimated to account for almost three-quarters of overall energy investment growth in 2023, with renewable power representing the largest share of total clean energy investment, reaching approximately USD 700 billion in 2023 (IEA, 2023[1]).

Despite these trends, clean energy investment levels remain below what is needed to reach net-zero greenhouse gas emissions in the energy sector, an important part of reaching net zero economy-wide. According to the International Energy Agency (IEA) (2023[1]), global annual investment needs to reach approximately USD 4.5 trillion per year by the early 2030s to be consistent with a pathway to a net-zero energy sector by 2050, i.e. a two- to threefold increase over current levels. While clean energy investment has been growing quickly, few technologies, aside from solar PV and electric vehicles, are experiencing growth rapidly enough to put them on track for net zero by 2050 (IEA, 2023[6]) (IEA, 2023[7]).

Moreover, investment remains unevenly distributed across the globe. While emerging and developing economies (excluding China) comprise two-thirds of the global population, they represent less than one-fifth of global clean energy investment (IEA, 2021[3]). For instance, Africa constitutes approximately 18% of the global population but presently attracts a mere 2% of clean energy investment worldwide (IEA, 2023[6]). To align with a pathway to net zero by 2050, clean energy investment in developing countries (excluding China) needs to increase almost sevenfold, to between USD 1.4–1.9 trillion per year by 2030 (IEA, 2023[8]).

Meeting these targets will require enormous policy effort to reduce barriers to clean energy investments and ensure the best possible conditions for the development and deployment of clean energy technologies. A key determinant of whether projects attract investment is the cost of capital, or the "expected rate of return that market participants require to attract funds to a particular investment" (Pratt and Grabowski, 2010[9]).

The cost of capital is a particularly important factor in mobilising clean energy investment, as it affects renewable power projects more significantly than fossil fuel power projects. The higher upfront capital investment required for renewable power projects makes them more sensitive to a rising cost of capital, and their LCOE tends to rise more rapidly as the cost of capital increases. This underscores the need for policy makers in all regions to carefully account for the cost of capital as part of efforts to advance clean energy transitions.

While long recognised as an important factor in mobilising investment in developing countries, the cost of capital has been relatively neglected in clean energy projections and associated policy discussions in

[2] Per the IEA definition, the levelised cost of electricity (LCOE) combines into a single metric all the cost elements directly associated with a given power technology, including construction, financing, fuel, maintenance and costs associated with a carbon price (2023[83]). It does not include network integration or other indirect costs.

developed countries, at least until recently. This can be partially explained by the favourable investment climate of the past decades. Rapid development of renewable energy has taken place at a time of historically low interest rates, one of several factors that has contributed to a low cost of capital. Along with increasingly strong political commitment to climate action, significant public subsidies (primarily in developed economies and China) and technology learning effects, this low cost of capital has been an important factor in spurring investment and lowering costs for renewable energy.

Favourable macroeconomic conditions and a low cost of capital cannot be taken for granted, however, as recent years have clearly demonstrated. Russia's ongoing war of aggression against Ukraine has had dramatic impacts on global energy and food supply, and global supply chains are still experiencing pressures as a result of the COVID-19 pandemic. These crises have contributed to high inflation around the world since 2021. The monetary tightening undertaken by central banks in response has had implications for the cost of capital overall, and therefore also potential knock-on effects for clean energy investment and the net-zero transition.

Against this background, growing attention is being paid to the role of the cost of capital in clean energy transitions. Recent reports from the IEA (IEA, 2023[10]), the Oxford Sustainable Finance Group (Zhou et al., 2023[11]) and the Independent High-Level Expert Group on Climate Finance (Songwe, Stern and Bhattacharya, 2022[12]) have highlighted the issue as a potential barrier for investment in developing countries and in nascent energy technologies less established than solar PV and onshore wind. These contexts present a particular challenge, as higher perceived risks lead to a typically higher cost of capital in these countries and for these technologies. The IEA also launched its Cost of Capital Observatory in 2022, with the aim of increasing transparency on financing costs in the energy sector (IEA, 2023[13]). The International Renewable Energy Agency (IRENA) has recently stressed the importance of the cost of capital as a major determinant of the cost of renewable power generation (IRENA, 2023[14]). Lee and Saygin (2023[15]) have examined in depth the risk factors influencing the cost of capital for green hydrogen in developing countries, and the impacts that the cost of capital has on cost competitiveness of green hydrogen projects. Most recently, in early 2024, the IEA released a report on the role of the cost of capital in clean energy projects in emerging and developing countries (IEA, 2024[16]).

The role of risk in cost of capital determinations has important implications for the urgent transition to net-zero greenhouse gas emissions. The required speed and scale of the transition means that clean energy investment cannot be limited to lower-risk projects if the world is to meet the objectives of the Paris Agreement. There will inevitably be a need to invest in projects assessed as higher risk, notably in developing countries and in emerging clean energy technologies. Given that developing countries (including China) already represent almost two-thirds of global carbon emissions, and that their energy demand is expected to continue to grow significantly in the coming decades, these countries will have a central role in driving the global transition to net-zero emissions. As for emerging clean energy technologies, the IEA (2023[1]) estimates that 35% of emissions reductions needed in 2050 to reach net zero will come from technologies not yet available on the market. The higher risk involved in projects in developing countries and in nascent clean energy technologies means they will tend to be subject to a higher cost of capital, presenting a potential barrier to the transition.

This paper provides an overview of the cost of capital as a key barrier to scaling up clean energy investments. While the paper explores some potential policy responses available to governments, it emphasises that the context-specific nature of risk and of overall cost of capital mean that more detailed technology- or region-specific policy recommendations remain outside this paper's scope. Rather, this paper aims to serve as an introduction to the topic and calls for further research and analysis to better advise policy makers on specific solutions.

The paper is structured as follows:

- Section 2 outlines the concept of the cost of capital and its components, along with various risk factors that may affect it.
- Section 3 examines the role that the cost of capital has as a determinant of the cost of energy generation, illustrating key differences in its impact on renewable electricity as compared to fossil fuels.
- Section 4 outlines evidence of the impacts of an elevated cost of capital on clean energy investment in practice. It briefly explores recent trends in clean energy investment and in the cost of capital before outlining the threat that an elevated cost of capital may pose in certain contexts, particularly in developing countries and for nascent technologies.
- Lastly, Section 5 presents policy options that could be considered in order to tackle high cost of capital and support increased investment in clean energy, aiming to highlight these options as fertile ground for further research.

2 Drivers of the cost of capital

According to (Pratt and Grabowski, 2010[9]), the cost of capital is defined as “the expected rate of return that market participants require to attract funds to a particular investment”. To facilitate measurement and comparison, the cost of capital is most often expressed as the weighted average cost of capital (WACC). As a proxy for the “discount rate”, the WACC is a crucial element in evaluating the cost and net present value of any investment, including those in energy, as it determines the rate at which future cash flows are discounted. As such, the WACC has a strong influence over final investment decisions and is thereby a key determinant of investment trends.

The cost of capital is linked to project capital structure, i.e. the balance between debt and equity in a project’s financing. The WACC is weighted between the cost of equity and cost of debt, where the former is the financial return expected by shareholders on equity and the latter is the interest rate secured from lenders by the company. The WACC is calculated using the following equation:[3]

$$WACC = \frac{E}{E+D} * R_E + \frac{D}{E+D} * R_D * (1 - T)$$

Note: E = Equity Market Value, RE = Required rate of return on equity D = Debt Market Value, RD = Cost of Debt, T = applicable tax (or tax shield).

As illustrated in Figure 2.1, the WACC is composed of a base rate, or risk-free rate, and a risk premium. The risk-free rate indicates the return rate achievable by investors for a hypothetical risk-free asset.[4] The risk premium, in turn, reflects the extra compensation required by investors to accept uncertainty in achieving expected returns. It is associated with country- (e.g. country credit rating), sector- (e.g. electricity market regulation) and project- (e.g. technology maturity) specific risks. In addition, risk mitigation options such as price guarantees or technology performance insurance also impact overall risk premium. These risk factors are elaborated upon in the next sub-section.

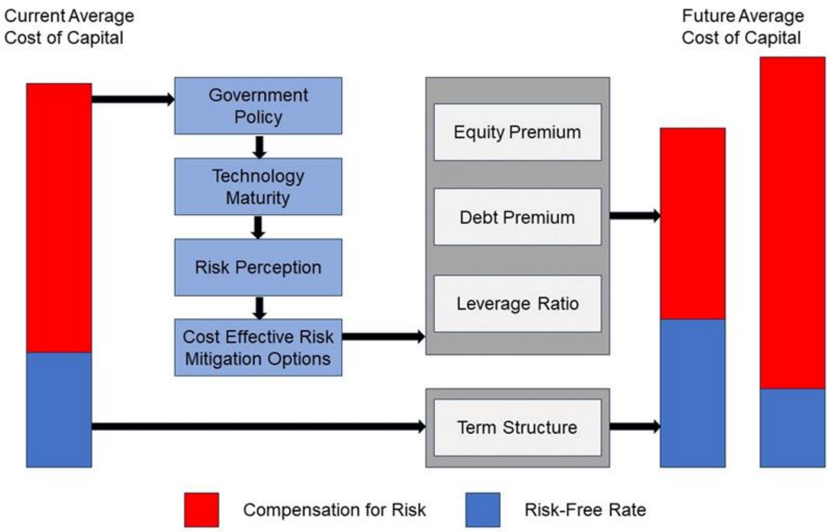
The cost of capital is highly susceptible to macroeconomic factors such as interest rates. In terms of the cost of debt this connection is evident, as central banks hiking interest rates will result in companies paying more for debt financing. Higher interest rates also tend to increase the cost of equity, as shareholders or outside investors will expect a higher rate of return in order to make a project worthwhile. As such, higher

3 In practice, calculating the WACC is often difficult, as companies or projects may have many different sources of debt, with different interest rates, and may be subject to different tax regimes where they operate across borders. In addition, information on the cost of capital is often scarce, owing to the confidential nature of financing structures and absence of disclosed financial particulars. These information and measurement gaps present a challenge to both companies and policy makers.

4 Though no asset is truly risk-free, long-term sovereign bonds such as those issued by the United States Treasury are often employed as a substitute in asset pricing models.

interest rates tend to raise base rates, and therefore the overall cost of capital, through debt and equity channels.[5]

Figure 2.1. Drivers of the cost of capital



Source: (Coleman, 2021[17]).

The cost of capital for clean energy projects is affected by their capital structure. In general, emerging technology projects will have a higher equity share, as access to low-cost debt requires historical transaction records and a certain level of market maturation. As the cost of equity tends to be higher than the cost of debt, and interest payments on debt are generally tax-deductible, this higher equity share means that these nascent technology projects will typically face a higher cost of capital (European Investment Bank, 2018[18]). As technologies reach maturity and are assessed as lower risk, there is typically, although not always, a move towards a higher debt share (or leverage) in their financing. Although both debt and equity are affected by interest rates, the impact on the former is more direct and powerful. As such, while nascent technologies may face generally a higher cost of capital, more mature projects with a typically high level of debt financing are often more exposed to fluctuations in interest rates.

5 At the same time, it is useful to distinguish between nominal and real interest rates, where the latter account for the impact of inflation. In times of high inflation, the real interest rates will give a more accurate representation of increases in the cost of capital. The real interest rate is adjusted for inflation, which erodes the purchasing power of a deposit or loan over time.

Box 2.1. Project financing structure

The first decision companies must make for a new project is whether it will be financed through their own balance sheet (corporate finance) or to open a separate balance sheet drawing on project finance.

- **Corporate finance** involves the company obtaining capital by leveraging its own balance sheet. In this case, the company's debt capacity and borrowing costs are determined based on its overall profile, and its assets serve as collateral in the event of default.
- **Project finance** involves the arrangement of funds through a special purpose vehicle (SPV), an independent legal entity established for each specific project. In this case, security is primarily provided through the project's own assets and cash flows.

Project finance is generally considered to be lower-risk for companies compared to balance sheet financing, as liability is limited to the SPV. As such, project finance is more suitable for financing large, long-term clean energy projects. However, due to procedural or financial issues, such as significantly higher transaction costs, it may not always be feasible for companies to set up SPVs. This can act as a barrier to large-scale clean energy deployment (Steffen, 2018[19]).

Whether a project is financed through a corporate balance sheet or project finance will have implications for the calculation of the cost of capital. In corporate finance, investors and lenders consider the company's overall assets and cash flows, while in project finance, they focus solely on the cash flows of the new asset, which vary by project according to the project development stage, project size, and details of the project finance structure (loan tenors, guarantees, etc.).

As explained above, the risk premium that, along with the base rate, determines the WACC, is affected by a wide variety of country-, sector-, technology-, and/or project-specific risks that can influence perceptions of the stability of project cashflows (Table 1). The context-specific nature of these diffuse risk drivers can lead to a high variation in WACCs for the same technology in the same market, or even for different projects by a single developer (IRENA, 2023[14]). The following paragraphs outline several of the risk drivers at play.

Table 2.1. Drivers of investor risk perception informing the cost of capital

Macroeconomic, country- and sector-specific risk	Macroeconomic and country level	Sovereign risk
		Impact of economic crises, credit crunches and monetary policy
	Sector level	Structure of electricity markets/generators' exposure to price risk
		Design of renewable energy support policies (e.g. feed-in tariffs, premia, quotas, carbon pricing)
		Credibility/expected stability of policies and regulations
	Financial sector	Financial sector maturity and competitiveness level
		Financing/investment experience for clean energy technologies
		Availability of concessional finance or de-risking mechanisms

Technology- and project-specific risk	Technology level	Portfolio of generation technologies and fuels and their emissions intensity
		Maturity of technology (commercial readiness)
	Company level (in case of corporate finance)	Company track-record and local experience
		Firm's financial characteristics
		ESG characteristics
	Project/asset level (in case of project finance)	Project characteristics (e.g. size, resource risk, operational risk)
		Project finance structure (e.g. financing of construction period, loan tenors, guarantees)

Source: Authors adapted from (Steffen and Waidelich, 2022[20]), (Lee and Saygin, 2023[15]), (IEA, 2023[8]).

Macroeconomic, country- and sector-specific risk

Country risk (i.e. exposure to loss caused by events associated with a specific country) such as transfer and convertibility risk and *force majeure*, can lead to considerable differences in the cost of capital. Country risk can be likened to sovereign borrowing rates: in many cases, the sovereign entity serves as the financial guarantor for contractual obligations associated with these projects. There is a well-established correlation between lower country credit rating and higher risk premium, which leads to high financing costs (Table 2). Country risk is a particularly significant factor in developing countries, which, due to a variety of factors, are typically assessed to be of higher risk than developed countries.

Table 2.2. Cost of capital for solar projects across countries

Country	S&P rating	Cost of debt	Required rate of equity return
Germany	AAA	2.8%	8.3%
Australia	AAA	5.4%	8.5%
Sweden	AAA	3.4%	9.3%
USA	AA+	5.3%	10.3%
UAE	AA	4.5%	12.6%
Saudi Arabia	A-	9.3%	14.3%
Chile	A	12.1%	14.4%
Indonesia	BBB	9.1%	14.7%
Morocco	BBB-	12.8%	15.9%
India	BBB-	11.4%	17.2%
Vietnam	BB	14.0%	19.4%
Peru	BBB	11.7%	21.3%
Brazil	BB-	7.8%	22.2%
South Africa	BB-	20.3%	25.8%
Ghana	B-	22.7%	28.3%
Tanzania	B	24.1%	29.6%
Nigeria	B+	25.2%	30.8%
Egypt	B	29.5%	35.1%
Uganda	B+	30.2%	35.8%
Mozambique	CCC+	32.8%	38.3%
Tunisia	CCC+	36.5%	42.1%
Sri Lanka	D	38.1%	43.7%
Zambia	CCC-	45.4%	51.0%
Argentina	CCC+	54.1%	59.7%

Note: Based on data as of January 2023. Source: Authors, adapted from (CPI, 2023[21]).

Foreign exchange risk can arise when project revenue is in a currency different than that of the investment. In jurisdictions marked by underdeveloped capital markets, the predominant avenue for financing projects typically involves hard currency. A currency mismatch exposes projects to the risk of local currency devaluation. To mitigate this risk and encourage investments, currency hedges or swaps with third-party providers, often commercial banks, are utilised. These swaps come at a considerable cost, involving the exchange of principal and interest payments on loans in different currencies, with a third-party provider assuming the currency risk for a fee (Shrimali, 2021[22]).

Political and regulatory risk is the threat to the financial viability of projects arising from legal and political shifts within a country. The severity of this risk can vary, particularly across sectors. In the case of clean energy projects, which often have extended return tenors, investors may encounter uncertainty regarding future government energy policies and tax considerations related to energy investments. It is important for developers to be able to reliably enforce contracts, and projects in countries where strong contract enforcement and other governance arrangements do not exist are likely to be assessed as higher risk.

Technology- and project-specific risk

From a design, construction, and completion perspective, clean energy projects are exposed to several risks. Typically long construction periods often risk projects not meeting their expected budgets and timelines (World Bank and OECD, 2023[23]). Energy projects often involve multiple contractors and stakeholders in a complex supply chain – failure to meet project objectives anywhere along this supply chain can result in delays or poor performance along its length.

Technology risk pertains to the assessment of an energy technology's performance, operational efficiency, durability, and lifespan, which directly influence the revenue stream of a project. The degree of risk associated with technology depends on its maturity and the evidence of its historical performance. Market dynamics and the accumulation of knowledge over time also play crucial roles. Investors commonly rely on past revenue data to inform future projections. Insufficient or unreliable data in this regard tends to heighten perceived risk.

Supply risk relates to the availability of essential inputs and equipment for energy production, which varies by technology. Project developers are often required to secure this supply from utilities or other third parties. This creates risks related to price, volume, and duration of the contracts for this supply (World Bank and OECD, 2023[23]). The relative levels of certainty of supply affect the likelihood of having stable revenue, and therefore the risk premium applied by investors or financiers.

For newer technologies, certification risk can also be a significant factor. As international trade in clean energy continues to accelerate, the ability of project developers to provide proof that their energy is generated through a low-carbon process in line with national and international standards will be crucial. Currently, standards and certifications are not internationally harmonised, which can create difficulties when exporting energy to countries with strict environmental standards or carbon border adjustment mechanisms in place. Again, this risk has implications for the stability of project revenue and creates an element of uncertainty to be considered when obtaining capital for the development of a clean energy project.

Offtake or demand risk is closely linked to a project’s expected cashflow. It is the risk of not having a buyer and not being paid, or not in a timely manner, for the energy to be generated. This also entails risk regarding the future prices of the energy generated, which may fall or fail to keep up with inflation. Without predictable future revenues, it is difficult to forecast the expected cashflow of a project over its lifetime, which can lead to its being perceived as high-risk. Power purchase agreement (PPA) contracts can mitigate this risk, but they typically do not extend far enough into the future to cover the entire lifetime of an energy project with long tenor of return. Offtake risk is particularly significant for emerging energy assets such as green hydrogen, where markets are less mature, and where long-term offtake agreement may not have been established to guarantee future cashflow.

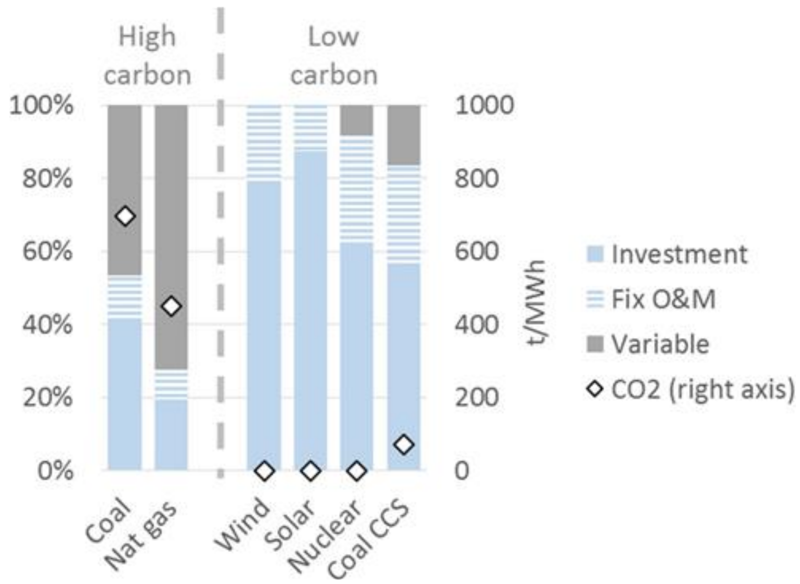
To summarise, many factors affect the assessment of overall project risk, and therefore the associated risk premium. Elevated risks in any of the categories above will lead to a higher cost of capital for clean energy projects, significantly affecting the calculation made by investors considering final investment decision.

3 The role of the cost of capital in the cost of renewable energy projects

As described above, the cost of capital is influenced by a variety of macroeconomic and context-or sector-specific risk factors and has an important impact on investment decisions. The cost of capital affects the cost of all investments economy-wide. Higher WACCs represent a potential obstacle to the net-zero transition insofar as they tend to limit the overall availability of capital for investment of any kind.

The cost of capital has a particular effect on clean energy investments. Energy technologies involve different levels of costs at different stages in their project lifetimes. Energy generation cost is a function of several factors, including upfront capital investment; fixed operation and maintenance costs (O&M); variable costs such as fuel, equipment wear and tear and emissions permits; and the cost of capital. In general, investments in renewable energy technologies require a large amount of upfront capital but have relatively low lifetime fixed O&M costs and almost no variable costs (Hirth and Steckel, 2016[24]). On the other hand, O&M and variable costs typically constitute a larger portion of the overall cost of energy generation from fossil fuels, for example due to fuel costs, with relatively less upfront capital required. The cost compositions of these different power generation technologies can be seen in Figure 3.1

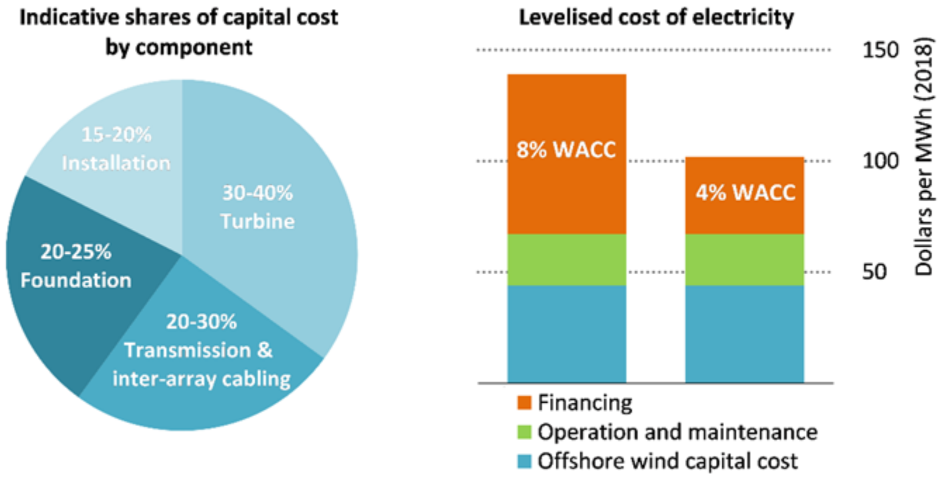
Figure 3.1. Cost composition of different power generation technologies



Note: Cost composition of different power generation technologies. Typical parameters were used: 7% WACC and capacity factors of 60% for fossil fuelled plants, 35% for wind power, 20% for solar power, and 90% for nuclear. A price of USD 30 per tCO_2 was assumed. Under these assumptions, the levelised costs of electricity of all technologies are comparable in level (USD 58-84 per MWh).
Source: (Hirth and Steckel, 2016[24]).

While renewables can often deliver significant savings on operational costs over fossil fuels in the long term, the high upfront capital required for renewable energy projects can present a challenge. For instance, financing costs can account for as much as 50% of the LCOE of offshore wind projects, as seen in Figure 3.2 (IEA, 2019[25]), and around 25-50% of the LCOE of new solar PV plants, depending on the region (IEA, 2022[26]). Recent reporting from IRENA (2023[14]) estimates that increasing the WACC from 2% to 10% raises the LCOE of a representative solar PV or onshore wind project by 80%.[6] Thus, while the costs of all investments increase with higher WACC, they do so at different rates. All other things being equal, the LCOE of renewables will increase more rapidly than fossil fuels as the WACC increases.[7]

Figure 3.2. Offshore wind: indicative shares of capital cost by component and levelised cost of electricity for projects completed in 2018



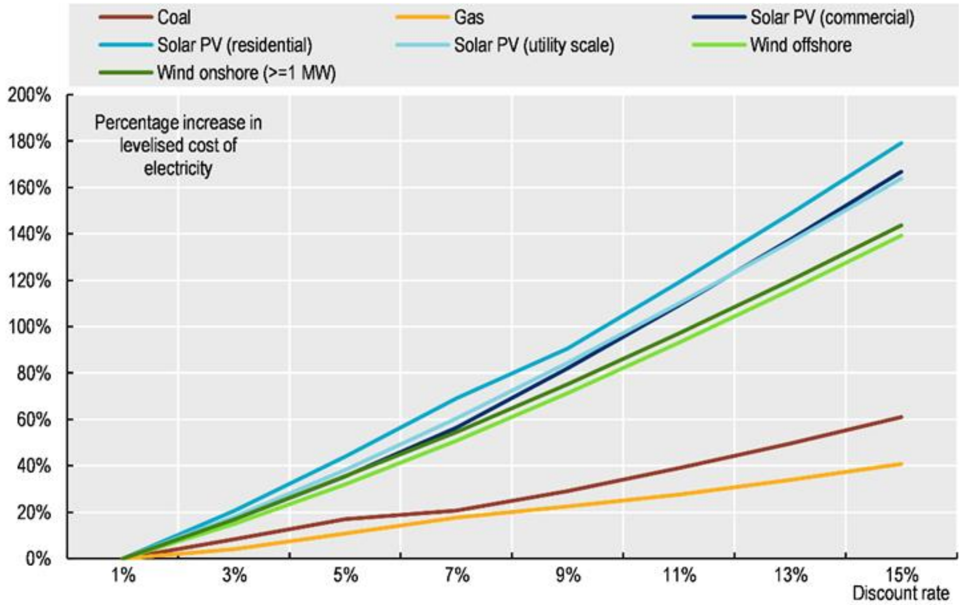
Note: Offshore wind generation costs are heavily influenced by the cost of capital and were about USD 100/MWh for projects completed in 2018 based on low financing costs. WACC = weighted average cost of capital; Transmission includes offshore substations.
Source: (IEA, 2019[25]).

Figure 3.3 illustrates the greater sensitivity of the cost of renewable electricity to the cost of capital compared to electricity generated from coal or gas. It can be observed that while renewables are frequently the lowest-cost options at a low cost of capital, they rapidly lose cost competitiveness as the cost of capital increases. For instance, moving from a WACC of 5% (comparable to the WACC for utility-scale solar PV in advanced economies), to a WACC of 9% (comparable to the WACC for utility-scale solar PV in India, Indonesia, or Senegal) would see an increase of the LCOE by 34% and 29% for utility-scale solar PV and onshore wind respectively, compared to increases of 10% for coal and 11% for gas (IEA, 2023[27]) (IEA, 2020[28]).

6 This assumes an installed cost of USD700/kilowatt (kW) for solar PV, with an 18% capacity factor, and USD 1300/kW for onshore wind, with a 38% capacity factor.

7 For such comparisons, it is important to distinguish between nominal and real rates. In the case of renewable power investments with longer-term offtake agreements, there are typically provisions for adjusting tariffs to inflation. As a result, while cost of capital will tend to increase with inflation, earnings will also do so. In this manner, the rate of return can remain viable for an investor despite the higher cost of capital.

Figure 3.3. Relative increases in levelised cost of electricity from rising cost of capital



Note: The chart shows the increase in levelised cost of electricity (LCOE) across different technologies as the discount rate increases, relative to the LCOE of each technology when the discount rate is 1%. The discount rate corresponds to the cost of capital in the IEA's LCOE methodology. The results assume a carbon price of 30 USD/ton, a heat price of 37.06 USD/MWh and average coal and gas prices from base year.
Source: (IEA, 2020[28]).

The differentiated impact of increases in WACC on the cost of energy generated from low-carbon and fossil fuel sources is supported by past modelling. For instance, Hirth and Steckel (2016[24]) outline how higher levels of carbon pricing become necessary as WACCs increase to keep low-carbon power from losing competitiveness relative to its fossil fuel counterparts. While it is important to note that the context for renewable energy uptake and carbon market maturity has changed significantly since 2016, the underlying link between the WACC and renewable energy competitiveness remains.

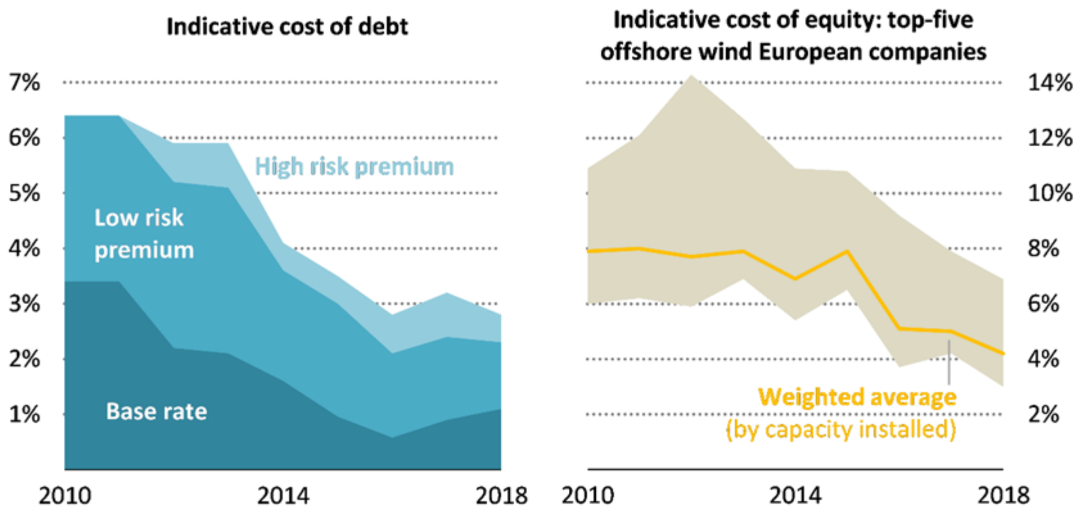
The link between the cost of capital and of renewable electricity generation makes renewable energy technologies more vulnerable to volatile investment climates. For instance, in times of high inflation, as central banks move towards tighter monetary policy, the increased cost of capital will tend to disadvantage renewable energy investment relative to fossil fuels, where all else is equal. At the same time, the cost of capital should not be oversold as the sole determining factor in final investment decisions and ultimate investment levels. In practice, many other factors (e.g. fuel prices, government policies) could mitigate or exacerbate the exposure of renewable energy investments to a rising cost of capital.

4 Impact of the cost of capital on clean energy investment levels

Investment in clean energy has increased dramatically over recent years. In particular, progress in wind and solar PV has far outpaced even the most optimistic projections. Favourable financing conditions were an important factor in the growth of these technologies, with the cost of capital falling significantly for offshore wind from 2010 to 2018 in Europe (Figure 4.1) (IEA, 2019[25]), and financing costs for utility-scale solar PV projects with revenue support falling by 15-30% over 2015-2019 in the leading solar PV markets (Europe, the United States, China, and India) (IEA, 2020[29]).

Figure 4.1. Trends in cost of debt and equity for offshore wind projects

Indicative nominal cost of debt for projects in Europe (left) and LCOE sensitivity analysis to cost component changes (right)

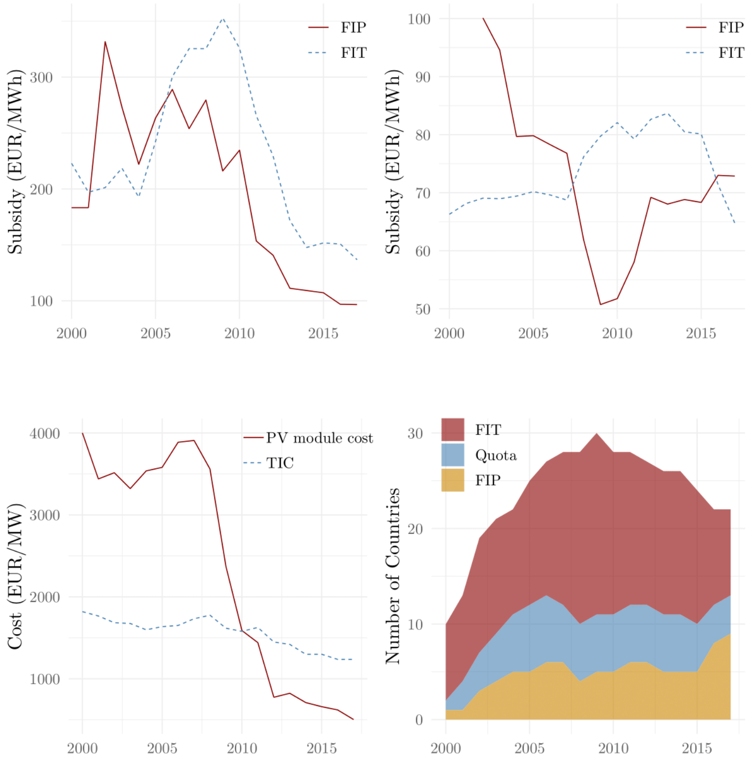


Note: Offshore wind in Europe has benefited from low interest rates and debt risk premiums, allowing developers to decrease project WACCs, the largest component of LCOE. WACC = weighted average cost of capital. LCOE = levelised cost of electricity.
Source: (IEA, 2019[25]).

These decreases reflect the growing maturity of wind and solar technologies, backed by over a decade of government support (Figure 4.2) and a rapid technological learning rate. Wind and solar are increasingly perceived among investors as lower-risk investments, particularly in developed markets. The combination of this low-risk assessment and low interest rates accounted for the notable decline in the cost of capital for these technologies over the period described.

Figure 4.2. Government support for solar and wind led to considerable cost declines

Average feed-in tariff (FIT) and feed-in premium (FIP) levels for solar (top left) and wind (top right); solar PV module costs and total installed costs (TIC) (bottom left) and number of countries implementing FITs, quotas, and FIPs over time (bottom right).



Note: The dataset comprises time-series data from 27 out of the 28 EU member countries spanning the period 2000-2017. Although the proxies presented in the bottom-left graph are not directly comparable, juxtaposing them with the top-left and top-right graphs suggests a positive correlation between lower technology costs and subsidies.
Source: (Sendstad et al., 2022[30]). Under a Creative Commons licence.

The maturity of solar PV and wind has also allowed these technologies to weather worsening investment conditions. In response to high inflation, to which the lingering effects of the COVID-19 pandemic and the impacts of Russia's war of aggression against Ukraine contributed, central banks in many countries began hiking interest rates in late 2021. These increases continued throughout 2022 and into 2023. This monetary tightening raised the base rate component of the cost of capital (as described in Section 2), leading to an increase in the cost of capital overall. Increasing capital expenditure costs and WACCs for clean energy projects contributed to the first increases in a decade in the cost of renewable energy in 2021 and 2022 in most markets.[8]

Emerging evidence suggests that rising costs have not severely impacted the attractiveness of clean energy, however. Clean energy investment levels have remained strong, and the IEA estimates an 8% global increase in 2023 compared to an estimated 5% growth in fossil fuel investment (IEA, 2023[6]).

8 In Europe, between early 2021 and late 2022, the average LCOE increased for solar PV and onshore wind by 30% and 15% respectively (IEA, 2023[6]). In the US in 2021, the average LCOE was USD 38 per megawatt hour for utility-scale solar; in 2023, the cost rose to USD 6. (Lazard, 2023[74]).

Installed renewable capacity is estimated to have increased by nearly 50% globally in 2023 to almost 510 GW, representing the fastest growth rate in the past two decades, and the largest ever annual expansion in absolute terms. Approximately three-quarters of this increase is estimated to be from solar PV capacity additions (IEA, 2024[31]). Not all technologies have fared as well, however, with offshore wind in particular experiencing difficulties in light of recent economic crises (Box 4.1).

Box 4.1. Impacts of the cost of capital on investment in offshore wind

Despite the downward trend in the cost of capital for offshore projects (see Figure 4.2 above), the WACC remains generally higher for these projects than for similar onshore or solar PV projects. Offshore wind is at an earlier stage of development than onshore wind or solar PV and, as such, is subject to several risks associated with newer clean energy technologies. Several factors contribute to these higher levels of risk for offshore projects (Đukan et al., 2023[32]).

- Offshore wind projects typically have long lead times and complex project structures, requiring significant additional investments in technical components such as foundations and grid infrastructure. This complexity contributes to high perceived levels of design, construction and completion risk.
- Project complexity and the large amounts of capital required mean that ownership in offshore wind projects is often concentrated among large-scale utilities and oil and gas companies. Such companies typically have high return expectations both for projects financed through their balance sheets and those financed through SPVs.
- Declining prices for offshore wind auctions and one-sided contracts for differences have incentivised large-scale investors to bid zero or negative, exposing projects to high levels of merchant risk and revenue volatility. This is associated with high levels of price and offtake risk.

Faced with a generally higher cost of capital in many countries in 2022 and 2023, offshore wind has struggled compared to onshore wind and solar PV. In December 2023, 12 GW of offshore wind capacity faced delays or cancellation in the UK and US. Several major industry players were forced to write off against offshore wind projects in the US, including Ørsted (USD 4 billion) and BP and Equinor (USD 800 million) (IEA, 2023[33]).

Several factors may have helped to prevent a severe downturn in clean energy investment. First, despite cost increases, renewables remain the most cost-efficient option for power generation in many countries, even before accounting for soaring coal and gas prices. Indeed, IRENA reported a significant improvement in competitiveness for renewable power generation between 2021 and 2022 (2023[5]).[9] Second, national climate policies and net-zero pledges continue to support and underline the importance of renewable energy investment. Despite the economic shocks related to the COVID-19 pandemic and Russia's war on Ukraine, the message from many governments that climate action remains a strong priority has been unwavering. This message has been reflected in government recovery spending on climate, which, despite failing to live up to promises, has still been significant (Aulie et al., 2023[34]). Third, concerns over energy

9 IRENA reports that in 2021, nine of the 20 countries for which it has detailed data saw the competitiveness of their utility-scale solar PV improve by more than the global weighted average LCOE. Eight of 20 countries saw such an improvement in 2022. Between 2021 and 2022, 15 of 20 countries saw their largest absolute improvement in competitiveness of onshore wind since detailed data became available (IRENA, 2023[5]).

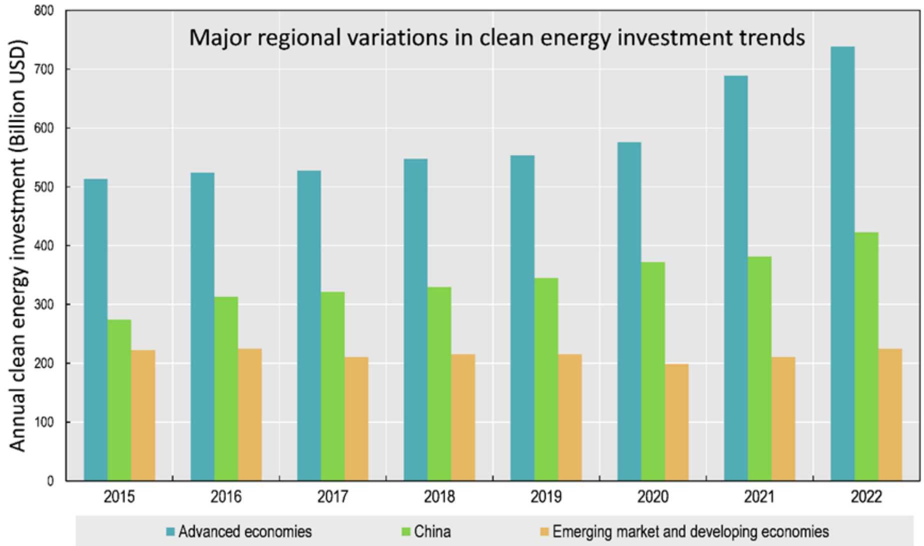
security, stoked by the war in Ukraine and subsequent energy crisis, have driven further interest in renewables, particularly in Europe (IEA, 2022[35]).

While clean energy has performed well overall despite recent challenges, with well-established solar PV and onshore wind leading the way, it is important to note that these trends are driven primarily by investments in established technologies in developed countries. As explained below, investments in emerging technologies and in developing countries continue to face a far higher cost of capital, and this is only being further exacerbated by recent crises. The resulting shortfall in investment could prove detrimental to efforts to accelerate emissions reductions to net zero, and thus pose a key challenge for policy makers.

Impact of high cost of capital on clean energy investment levels in developing countries

Clean energy investment levels in developing countries have consistently fallen below what is needed for the global net-zero transition. While clean energy investment worldwide has risen significantly since the signing of the Paris Agreement, clean energy investment in developing countries (with the exception of China) remains broadly stagnant at 2015 levels ((IEA, 2023[6]). A key reason behind lagging clean energy investment is the high levels of perceived risk in developing countries by investors resulting in higher costs of capital that ultimately prevent sufficient access to finance. This is largely due to the macroeconomic, political and foreign exchange risks outlined in Section 2.

Figure 4.3. Trends in annual clean energy investment by region



Source: Figure based on (IEA, 2023[6]).

Macroeconomic risks, already historically higher in developing countries, have been exacerbated by rising debt levels as a result of the COVID-19 pandemic. In most low and low-middle income countries, sovereign credit ratings are speculative or non-investment grade, implying a significant risk of debt not being repaid (OECD, 2022[36]).

Political risks in developing countries can include an absence of strong contract enforcement and other arrangements that support predictable revenues. Political instability is often a greater risk in developing countries, which threatens stable project revenues. Policy uncertainty, for instance around carbon pricing and energy subsidies (whether for renewable or fossil fuel energy), makes it difficult for investors to be assured of the long-term economic viability of projects (OECD, 2023[37]). This is in stark contrast to decades of strong support for clean energy in many developed countries (e.g. Germany's Energiewende). Further difficulties in developing countries are presented by institutional capacity and underdeveloped or shallow financial sectors.

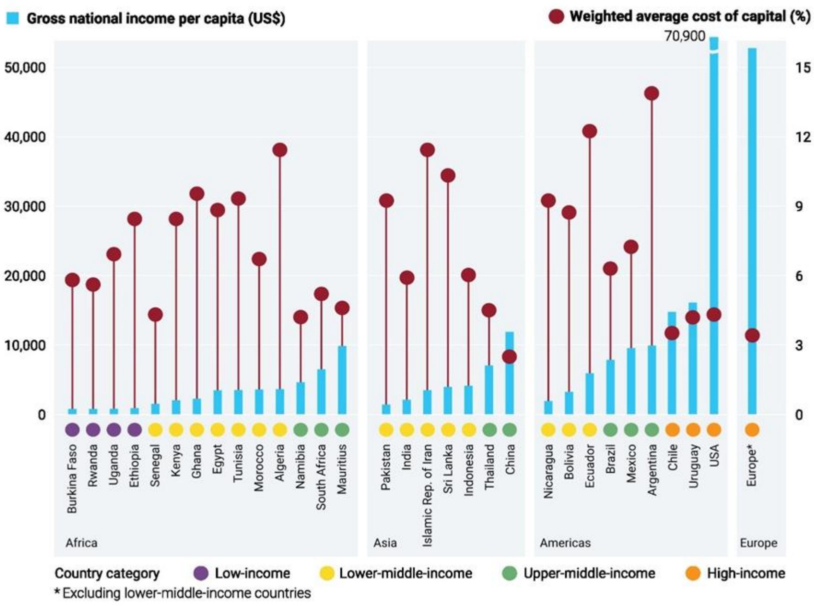
Foreign exchange risk can be substantial in developing countries, where currency fluctuations are influenced by prevailing political and economic conditions. A solar plant in Egypt financed in US dollars with electricity tariffs levied in Egyptian pounds is an example of an asset-liability currency mismatch.

In addition, an overall lack of complete, reliable, and standardised data makes it challenging for investors to assess risk, often leading to overestimations (OECD, 2023[37]). This can be negatively self-reinforcing, as it impedes the development of a steady pipeline of commercially viable projects in developing countries, which in turn discourages global investors from the kind of major, long-term commitments that could help to overcome informational challenges (OECD, 2022[36]) (Songwe, Stern and Bhattacharya, 2022[12]).

Climate risk is increasingly figuring into clean energy investment decisions in developing countries, where physical climate impacts such as heat stress, water stress, and rising water temperature can result in significant generation losses for renewable power plants. While this can occur in many parts of the world, developing countries are often among those most vulnerable to physical climate impacts. High assessed climate risk is thus another factor contributing to the high cost of capital and challenging investment conditions in these countries (Luo et al., 2021[38]).

The IEA estimates that financing costs in developing countries (excluding China) are generally at least two times higher than in Europe or the United States (IEA, 2023[2]). This is particularly significant given the capital intensity of low-carbon investments, as described above. Figure 4.4 shows dramatic differences in the WACC for solar PV projects in a selection of countries.

Figure 4.4. WACC for solar PV projects against per capita gross national income for selected countries in 2021



Source: (United Nations Environment Programme, 2023[39]).

A high WACC is one of the factors that can contribute to what is referred to as the “climate investment trap” in developing countries. A combination of factors may deter investors from investing in low-carbon assets and technologies in these markets, stifling mitigation efforts and implying worse climate impacts and economic consequences. This reinforces the high levels of risk in these countries that hinders the development of financial markets, which feeds back into high WACCs in developing regions (Ameli et al., 2021[40]).

Recent modelling comparing a scenario using global average WACC with one using regionally differentiated WACCs found that accounting for regional differences in WACCs has significant implications for the speed of climate action (Ameli et al., 2021[40]). For example, WACCs in Africa are currently far higher than the global average. Not accounting for this difference (i.e. using a global average WACC) greatly overestimates the speed of progress on climate action, for example with Africa seeing 35% more low-carbon electricity generation by 2050 and reaching net-zero emissions seven years earlier than in the scenario using regionally differentiated WACCs. The results indicate that policy interventions to reduce the WACC for low-carbon investments in developing countries would have a significant impact on clean electricity generation and net-zero trajectories, particularly if implemented quickly.

These results are consistent with other studies that conclude that governments in India, South Africa and elsewhere could save billions of US dollars if renewable energy financing were available at rates similar to those in Europe and the United States (Donovan and Corbishley, 2016[41]). The IEA recently estimated that a 200-basis point reduction in the WACC in all developing economies would reduce cumulative clean energy financing costs to reach net-zero emissions by USD 15 trillion through to 2050 (IEA, 2022[42]).

OECD work on opportunities for green hydrogen development also finds that production costs are significantly higher in many developing countries, particularly in Africa, when accounting for country-level interest rates. This is despite the huge potential in many of these countries for solar energy, a crucial factor in green hydrogen production. Analysis shows that the cost of green hydrogen production decreases dramatically under lower interest rates comparable to those in OECD and EU27 countries (Cordonnier and Saygin, 2022[43]).

Impact of high cost of capital on deployment of emerging technologies

The financing conditions for well-established solar PV and wind technologies are vastly different from those faced by nascent clean energy technologies. Emerging, unproven technologies are perceived as far riskier by investors and habitually face a higher cost of capital. The risk factors associated with such technologies are often highly context-specific, at technological, country, and even project levels. This section demonstrates how such factors can hinder clean energy investment, using green hydrogen, an emerging technology projected to play a crucial role in the net-zero transition over the coming decades, as an example.[10]

Green hydrogen projects rely heavily on regulatory incentives and government support in the early stages of deployment, so are generally exposed to high levels of political and regulatory risk. For example, the permitting process for green hydrogen is typically complex and time-consuming, with permitting rules still in development and subject to considerable flux. Green certification processes are emerging, but to date there is little international harmonisation of standards, implying a high level of certification risk. This is particularly significant, as international trade is anticipated to make up a significant share of total green hydrogen consumption in the coming years.

Country risk can also be particularly significant for green hydrogen projects. Many developing countries have made green hydrogen a cornerstone of their development strategies, and projections of green

[10] A more complete breakdown of these risks can be found in Lee and Saygin (2023[15]).

hydrogen deployment in developing countries are projected to play a key role in global mitigation efforts (Cordonnier and Saygin, 2022[43]).. However, typically high levels of risk in developing countries, combined with those associated with newer technologies, pose a particular challenge for investment in green hydrogen in these countries.

Green hydrogen is still in the early stages of take-up and there are a limited number of experienced buyers and entities with experience implementing these projects. Hydrogen buyers are in general in a different pool of buyers than those in the electricity market – hydrogen is treated as a commodity with spot prices and short-term contracts. This increases offtake and price risk stemming from unpredictable long-term cash flow.

Design, construction and completion risks are often heightened for projects based on new technologies for which various contractors and other stakeholders have limited technical expertise and experience. In the case of green hydrogen this risk is significant, particularly since such projects are typically complex and intricate involving multiple contractors along the supply chain, as well as various technologies including renewable power and electrolysers.

Investors in well-established clean energy technologies are more likely to have evidence of strong historical performance and reliable projections of future revenues. The absence of similarly extensive data for emerging technologies increases uncertainty, which tends to lead to a higher risk premium. In the case of green hydrogen projects, the limited levels of deployment of electrolysers to date means that their performance has yet to be fully tested and many unknowns remain, which investors tend to view as higher risk.

Supply risk is also high for green hydrogen projects, which are highly dependent on a ready supply of water and renewable power. Reliance on utilities or other third parties for this supply can create risks around creditworthiness of electricity providers. To counteract potential power price volatility and to ensure a steady supply of renewable power, it is common for projects to generate their electricity internally to manage this risk, resulting in higher costs. Water stress can create a supply risk for hydrogen projects, as countries where water stress is common tend to be attractive for hydrogen projects due to abundant sources for solar PV electricity generation.

The precise weights of these risks in the risk premium and its effect on the cost of capital is difficult to estimate. However, green hydrogen project developers, financing institutions and other stakeholders recently surveyed by the OECD ranked the following key risk factors in descending order of impact: uncertain market demand, a shortage of credible off-takers, price uncertainty, lack of trading markets, political risks, and insufficient infrastructure (Lee and Saygin, 2023[15]).

Although a lack of detailed and comparable financial data makes calculating the cost of capital for green hydrogen a challenge, recent OECD work analysing financial proxy data for off-balance-sheet Special Purpose Vehicles (SPVs) estimated WACC values as ranging from 6.4% to 24% (Lee and Saygin, 2023[15]). For comparison, country simple averages assessed by IRENA (IRENA, 2023[14]) ranged from 2.2% to 12.2% for utility-scale solar PV, 1.5% to 12.2% for onshore wind, and 2.8% to 8.1% for offshore wind.

Technological challenges are often cited as the most significant barrier for the development of operational green hydrogen markets, but the cost of capital is equally important to cost competitiveness. Green hydrogen production is doubly exposed to cost of capital increases, as a higher WACC will raise not only the cost of electrolysers, but also the LCOE of renewable energy, which constitutes 30-50% of the levelised cost of green hydrogen (LCOH), and which is itself particularly sensitive to the cost of capital, as outlined above. If all other generation cost factors are kept constant, an increase in the cost of capital from 10-20% can lead to an increase of up to 73% of the LCOH (Lee and Saygin, 2023[15]) (Cordonnier and Saygin, 2022[43]).

A major barrier to accelerating green hydrogen deployment is that current LCOH is not cost competitive. The higher cost of capital significantly increases the cost of generation, adds complexity to investment decisions, and is a significant factor in disincentivising investment in green hydrogen. This is reflected in investment decisions on the ground. At first glance, there has been healthy recent growth in the global pipeline of green hydrogen projects, with the collective value of large-scale projects having increased by 35% from May 2022 to January 2023. However, despite this pipeline growth, the vast majority of projects have not reached final investment decision. Of the 1 046 large-scale projects announced as of January 2023, only less than 10% of the USD 320 billion investments through 2030 are real committed capital (Hydrogen Council, McKinsey & Company, 2023[4]). Only about 20 clean hydrogen projects in developing countries, excluding China, have reached final investment decision (World Bank and OECD, 2023[23]). Tackling the high cost of capital for green hydrogen projects is critical to reduce the LCOH and increase deployment of green hydrogen.

As this example of green hydrogen has illustrated, the challenges faced by emerging clean energy technologies are significant. The large amounts of upfront capital investment involved makes them sensitive to high cost of capital, while the various risks associated with newer, relatively untested technologies result in projects involving such technologies routinely being subject to a higher cost of capital.

Green hydrogen is not the only emerging clean energy technology facing these challenges. The same can be observed for other technologies including for carbon capture, utilisation and storage (CCUS), concentrated solar power (CSP), and others. In general, accelerating action to meet the level of ambition needed to reach net-zero emissions by mid-century will require significant investment in projects that investors currently view as high-risk. This is the case even for investment in some technologies that are not necessarily new. For instance, a rapid and large-scale expansion of electricity grids will necessarily entail directing investment capital towards some higher-risk grid infrastructure projects, where a higher cost of capital can be expected (The Economist, 2024[44]).

5 Tackling high cost of capital: options for policy makers

Clean energy investment growth must accelerate rapidly across all regions. The required scale and speed of the transition means that investment cannot be limited to low-risk projects only, meaning that a greater number of clean energy investments will be exposed to a higher cost of capital. Governments must take action to tackle the high cost of capital for emerging technologies and in developing countries to ensure the proportional deployment of low-carbon technologies. Scaling up investment to the levels needed will depend on policy makers recognising high cost of capital as a significant potential barrier and enacting policies to tackle it.

The following section explores a number of options for the consideration of policy makers, noting that the context-dependent nature of clean energy investments necessitates deeper analysis of country- and technology-specific solutions.

Creating enabling conditions for clean energy investment: overarching policy approaches

The overarching investment climate naturally plays a crucial role in determining levels of investor confidence and the risk-return profile of investments. Creating the right enabling conditions can help to significantly scale up investment levels, as evidenced by the rapid development and deployment of now well-established clean energy technologies in advanced economies. This includes strong political commitments to climate action backed up by credible and ambitious policy frameworks, putting in place governance structures to implement these policy frameworks, and strengthening financial markets to facilitate investment in clean energy technologies.

Some of these factors may be more or less significant depending on regional and technological contexts (e.g. some regions may already have strong governance structures in place for certain technologies while others do not). Simply addressing one factor but not the rest is unlikely to significantly affect investment levels and that a more systemic approach is needed. Finally, considerable barriers remain to establishing these enabling conditions, particularly in developing countries. What can be done to address these countries specifically is discussed in the subsequent sub-section.

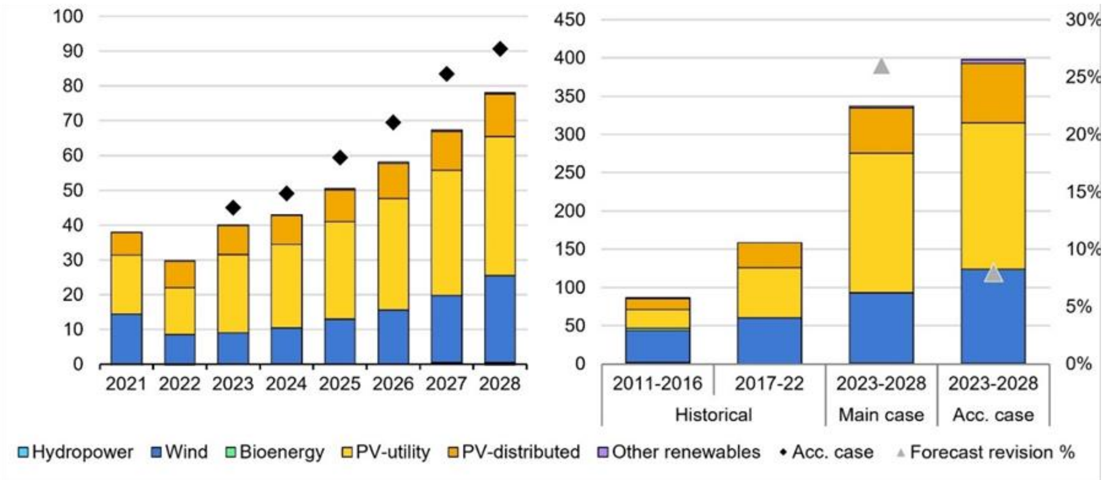
Political commitments and climate policy packages

Governments can shield low-carbon technologies from the risks associated with high cost of capital by demonstrating strong political commitment to the net-zero transition and maintaining and increasing the stringency of core climate policies. Political support at the highest level sends a strong signal to investors and financial institutions about the future role of clean energy technologies. It is important that governments establish credible emissions reductions pathways and sectoral decarbonisation plans with well-defined long-term and intermediate targets.

To back up strong political commitments, governments need to develop and implement suitable climate policy packages. For example, the large industrial policy packages recently announced by several major economies have had a powerful effect in stimulating growth in low-carbon investments. The support and long-term policy visibility provided by the US Inflation Reduction Act (IRA) is expected to have a sizeable positive impact on investment in renewables, with the IEA revising upwards its forecast for capacity growth to 2027 by more than 25% in 2022 compared to 2021, before the IRA was approved (IEA, 2022[45]). Historical and projected growth in renewables capacity in the US is illustrated in Figure 5.1. Similarly, the revision of Germany's Renewable Energy Sources Act in July 2022 introduced ambitious new targets for renewables, along with support policies including regulations to reduce permitting times. As in the US, the impact of these policies on renewable energy is expected to be significant, with the IEA revising its five-year forecast for capacity growth in Germany upwards by 52% in 2022 compared to 2021 (IEA, 2022[45]). Other major economies have launched similar large-scale packages, such as the EU's REPowerEU plan and Green Deal Investment Plan, and Japan's Green Transformation (GX) initiative. These long-term commitments to clean energy, as well as the sizeable fiscal support provided, are key enabling factors for investment.

Figure 5.1. Growth in renewables capacity, United States

Annual renewables capacity additions by technology 2021-2028 (left) and total renewables capacity growth 2011-2028 (right)



Source: (IEA, 2024[31]).

Subsidies still have a role to play in the deployment of key low-carbon technologies. This is particularly important in the case of emerging technologies such as offshore wind, concentrated solar power (CSP) and green hydrogen, given the implications of a rising cost of capital and the risks of exposing these technologies to the open market. Fiscal support from governments will be important to bridge the green premium (i.e. the difference in cost between low-carbon technologies and their traditional, carbon-intensive equivalents) and ensure the continued economic viability of these technologies in the face of challenging investment conditions. Political and financial support by governments can also mitigate perceived investor risk, thereby keeping financing costs in check (Pahle et al., 2022[46]).

It is important to note that large-scale subsidy programmes such as those in the US and EU have global trade implications. There is potential for these green industrial packages to stimulate innovation and deployment of clean energy technologies, but at an elevated cost. While government support can play a valuable role, it is important to gradually reduce public capital support and encourage a gradual shift to market-driven initiatives. Over-reliance on public support in clean energy projects could potentially see the misallocation of scarce public resources. To be most effective, these types of incentives must be well-designed, well-targeted, and time-bound.

As subsidies represent a significant cost to a country's economy, their expected benefits need to be carefully assessed. The world's economies are not on equal footing in their ability to fund green subsidy programmes, and for many developing countries, the type of large-scale programme described is unfeasible. Consequently, there is a risk of widening the gap between developed and developing countries, leaving the latter energy poorer and more reliant on high-emitting energy sources. Trade distortions could see low-carbon investment move away from developing countries towards developed countries with major subsidies in place. The benefits of subsidies may be more evenly spread where they encourage market creation and demand in developed economies and provide opportunities for supply from developing economies.

Governance structures

To reduce political and regulatory risk, which is often elevated in developing countries, regulation to ensure high-quality and predictable governance in clean energy-related sectors is crucial. Governments should avoid retroactive policy changes and carefully assess any potential unintended effects of non-climate related financial regulations that could undermine policy efforts elsewhere. Ensuring transparency and non-discrimination, including between domestic and foreign investors, is essential. Policy to ensure the protection of intellectual property rights, including by facilitating patenting of clean energy innovations, and robust contract enforcement can help to mitigate political and regulatory risk for investors in a similar manner (OECD, 2015[47]).

Governments in all countries can act to reduce the permitting barriers that add costs to renewables projects in particular (IEA, 2022[45]) (OECD, 2023[48]). Green public procurement and policies that support R&D are among the tools that can help to expedite market creation and development for nascent clean energy technologies, thereby mitigating offtake and price risk. Public procurement and R&D support must be implemented in a fair and transparent manner to ensure predictability for investors (OECD, 2015[49]). Governments should endeavour to provide legal certainty on certification definitions, and international harmonisation of standards on emerging technologies, as far as possible. This can reduce certification risk, which is a particular issue for emerging technologies, as well as transaction costs for clean energy projects.

Strengthening financial markets

Developing and strengthening financing markets for low-carbon technologies is important to put downward pressure on financing costs through competition (Egli, Steffen and Schmidt, 2018[50]). As discussed above, strong political commitment to climate action, with clearly defined policy packages and pathways and the necessary governance structures in place, are essential for strengthening financial markets. (OECD, 2015[49]) Beyond this, governments can facilitate the creation of markets for clean energy technologies and financing instruments (e.g. green bonds) tailored to investor risk profiles for clean energy technologies (OECD, 2015[49]).

Many financial institutions have made commitments to various climate targets, through which they can make important contributions to mitigating the negative effects of a high cost of capital, provided they receive the right support and incentives. To ensure that capital continues to go where it is needed, governments also have an important role in supporting the evolution of market products and measurement methodologies to allow investors to better align portfolios with climate objectives. (OECD, 2015[49]) Data and other informational gaps pose serious challenges to financial institutions attempting to follow through on their climate targets, so government regulation to support standardised and transparent measurement, accounting and disclosure will be valuable here. The development of sustainable finance taxonomies can be useful in guiding the financial sector.

At the same time, these approaches must be carefully designed, particularly considering the potential risk of redirecting investment away from developing countries. While environmental, social and governance (ESG) criteria can encourage alignment of investment with climate goals, these criteria are generally more difficult to assess and apply in developing countries, where transparency of information is most likely to be an issue. This does not mean that these countries should be passed over for investment (OECD, 2023[51]).

Lastly, in addition to ensuring that financial sector initiatives and investment criteria do not act as barriers to low-carbon investments, policy makers should steer away from approaches purely focused on financial risk, as these may see developing countries passed over due to their typically higher climate risks, thereby impeding capital from flowing where it is needed (Ameli et al., 2021[40]). Instead, more focus should be put on due diligence procedures aligned with OECD recommendations (OECD, 2018[52]), which can support both financial institutions and business in responsibly engaging in higher-risk sectors and regions.

Addressing barriers to lowering the cost of capital in developing countries

In many developing countries, establishing the enabling conditions described above is challenging. Developing country governments may not have the technical capacity to develop clear and credible sectoral decarbonisation pathways or clean energy technology roadmaps. As such, external technical assistance, for example from multilateral development organisations, is important to support governments in designing credible clean energy technology strategies (Rickman et al., 2023[53]).

Investments are often path-dependent – i.e. requiring a track record of previous investments and indicating financial learning as a key component to scaling-up investment (Rickman et al., 2023[53]). Effective use of (often-scarce) public finance is essential to ensure that the necessary infrastructure is in place to attract private investments in clean energy projects. Public-private partnerships can be a useful way to develop projects, acting as enablers or catalysts for final investment decisions and project implementation. Various models are possible whereby state-owned entities and public institutions participate in private sector-led initiatives, often backed by public funds (Lee and Saygin, 2023[15]). This can be important for developing a pipeline of high-quality largescale projects.

Developing countries cannot normally borrow at the same low rates as developed countries, limiting the ability for low-cost public finance to catalyse private investment. This provides an opportunity for multilateral development banks (MDBs) to step in. Given their development mandates and range of instruments at their disposal, MDBs will have a key role to play going forward to support developing countries in meeting their concurrent climate and development goals. MDBs and governments can support and incentivise accessibility, transparency and standardisation of practices.

Some institutional rethinking will be necessary for MDBs to function as effectively as possible.[11] Expanding the volume of MDBs' financing for clean energy projects can improve developing countries' access to capital at low cost, providing a way to overcome cost barriers to infrastructure development discussed above (Bhattacharya et al., 2023[54]; IEA, 2023[55]). It is important to note, however, that an overreliance on concessional finance can be harmful if it crowds out commercial lending. (IEA, 2023[8]).

[11] Several options exist to enable reform of multilateral development banks. For instance, shareholder governments can support stronger mandates for mobilisation and capacity development activities, along with a shift in corporate and staff performance indicators away from financial indicators, such as financial resources committed or disbursed, towards those that focus on mobilisation and impact.

Arguably more important than MDBs' financing volumes is their scope. While direct development finance from MDBs and countries in the form of official development finance (ODF) is important, private capital flows are far greater in volume than ODF in developing countries. This suggests that MDBs could provide greater support not as sole financiers of individual projects, but by catalysing additional commercial finance and channelling existing capital flows towards low-carbon assets and technologies (OECD, 2023[37]). All of this will require the targeted use of grants or concessional resources to bridge viability gaps in developing countries with challenging investment conditions.

This shift in emphasis should serve to highlight the importance of blended finance in mobilising capital for low-carbon investment. Blended finance is defined by the OECD Blended Finance Principles as the strategic use of development finance for the mobilisation of additional finance towards sustainable development in developing countries. Additional finance refers to commercial finance that does not have an explicit development purpose and that has not primarily targeted development outcomes in developing countries (OECD, 2022[36]). Through blended finance, relatively small volumes of development finance can be used to mitigate specific risks, such as those related to costs of capital and generally tight financing conditions, which may otherwise render investments unviable for commercial investors. Risk reduction instruments can be tailored to the context, through guarantees and insurance, and the provision of cost-effective currency hedging. Further development of these instruments at scale is needed, in order to more effectively address risks (Bhattacharya et al., 2023[54]). Pilot projects can help to serve as technological, business model, and financial proof-of-concept, thereby contributing to lowering perceived risks and improving investor confidence.

Other financing instruments can incorporate de-risking elements with the aim of assuring investors and lowering WACCs. Finance for utility-scale renewables can be tailored to address specific risks, for instance by incorporating political risk insurance for uncertainty around project development, partial risk guarantees for revenue risk, or guarantees for non-payment due to delays related to necessary infrastructure (OECD, 2022[36]). Export credit agencies can be mobilised for these guarantees. Loan tenor extensions, and other de-risking facilities such as subordinated debt and first-loss structures can also be useful (OECD, 2022[36]). Governments can encourage the development and use of contracts such as power purchase agreements (PPAs) to support stable revenue, thereby reducing offtake risk (OECD, 2015[49]).

In addition, efforts to address informational and data gaps regarding clean energy investments are of particular importance in developing countries. More transparent and reliable data can help to overcome the uncertainty and frequent lack of familiarity among investors with developing country contexts. There is evidence that this unfamiliarity can manifest itself in investment risks, while nonetheless real, being overstated in developing countries. For instance, infrastructure default rates in Africa are amongst the lowest in the world but such investments are still perceived as high-risk, and investment levels remain low (Moody's Analytics, 2021[56]) (OECD, 2023[37]). Addressing information asymmetries can contribute to reducing this gap between perceptions and reality.

Addressing barriers to lowering the cost of capital for emerging technologies

The high-risk nature of emerging technologies means that specific efforts beyond establishing sound overarching enabling conditions for clean energy investment may be needed to overcome the high cost of capital. For example, climate policy packages will need to emphasise innovation in order to ensure the necessary support for emerging technologies. Recent work has shown that governments' science, technology and innovation policies are often skewed towards supporting the deployment of established technologies rather than the development of nascent ones (OECD, 2023[57]). Overcoming this requires targeted support for research and development, rather than horizontal support that favours technologies that are already close to market. Research grants, R&D-specific tax credits, and public finance for demonstration projects are all areas where government efforts could be increased (OECD, 2023[57]).

Beyond strengthening policies in support of innovation, governments also need to design deployment support carefully to ensure that public resources are used effectively. For example, feed-in tariffs should be designed to adjust to changes in technological maturity, phasing out as technologies become commercially viable without government support. Contracts for difference offer another policy option, whereby governments can assure investors of long-term price stability but do not risk over-spending if market prices increase. Finally, government spending may be most needed to ensure the necessary infrastructure is in place to enable new technologies to be deployed at scale. For example, regarding green hydrogen, infrastructure needs to be in place to transport hydrogen once it has been produced. For offshore wind, ensuring grid connection is similarly critical.

In addition, certification and standardisation is key for emerging technologies, with uncertainty often leading to higher perceived risk among investors. Here governments can play a crucial role in regularly updating taxonomies and taking early efforts to discuss appropriate standards and certification structures for new technologies.

6 Conclusion

A major surge in clean energy investment between now and 2030 is crucial to keep the objective of net-zero emissions by mid-century within reach. The cost of capital is a key factor influencing clean energy investment levels.

The cost of capital is determined to a high degree by levels of investment risk. The scale and speed of the transition required to achieve net-zero emissions by mid-century mean that investment capital cannot exclusively target clean energy projects in low-risk environments. Investment must increase significantly in two areas typically seen as higher risk: in developing countries and in nascent clean energy technologies. In addition, it is noteworthy that highly capital-intensive clean energy investments tend to be more affected by rises in the cost of capital than their fossil fuel counterparts. As such, all else being equal, a rising cost of capital (as has been observed in recent years) will tend to undermine investor incentives to invest in important assets for climate goals.

In advanced economies, clean energy investments in established technologies such as solar PV and onshore wind have proved remarkably resilient to deteriorating macroeconomic conditions in recent years. Decades of significant government support and technology learning effects have ensured that these technologies are perceived as low-risk, and the incentives to invest in them are well established. The same cannot be said for such investments in developing countries, or in nascent technologies. As such, strong and systematic action by governments is needed to help bring down the cost of capital and provide a valuable boost to such investments.

As well as advocating for greater awareness of the role of the cost of capital in clean energy investment in general, this paper provides an exploratory discussion of actions that governments could take to enable a lower cost of capital for clean energy investments. These potential solutions are grouped into three categories: political commitments and climate policy strategies; governance structures; and strengthening financial markets. In addition, the paper recognises the particular barriers facing investments in developing countries and in newer technologies, and outlines some of the approaches that can be taken in these challenging contexts.

This paper has presented an overview of the importance of the cost of capital in scaling up clean energy investment. As always, the devil lies in the details. The interactions between risks at systemic and project level create particular challenges that need to be addressed on a case-by-case basis. More specific research needed to untangle these issues, and to develop improved and targeted policy advice to enable a lower cost of capital. This can provide a valuable step towards closing the investment gap between advanced and developing economies and ensuring that nascent technologies are developed and deployed in time to reach net zero emissions by mid-century.

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