Reducing the Cost of Capital

Strategies to unlock clean energy investment in emerging and developing economies

International Energy Agency

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World Energy Investment Special Report

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Clean energy investment in most emerging and developing economies has yet to take off: A high cost of capital is a major reason why

How emerging market and developing economies (EMDE[1]) meet their rising energy needs is a pivotal question both for their citizens and for the world. Cost-competitive clean energy technologies open the possibility to chart a new, lower-emissions pathway to growth and prosperity, but capital flows to clean energy projects in many EMDE remain worryingly low. Global clean energy investment has risen by 40% since 2020, reaching USD 1.8 trillion in 2023, but almost all the recent growth has been in advanced economies and in China. EMDE account for around 15% of the total, despite accounting for about a third of global gross domestic product and two-thirds of the world's population. India and Brazil are by a distance the largest EMDE clean energy markets.

All pathways to successful global energy transitions depend on expanding capital flows to clean energy in fast-growing EMDE. With growing international attention to this issue, the International Energy Agency (IEA) was tasked by the Paris Summit on a New Global Financing Pact in June 2023 to make recommendations on how to bring down the cost of capital for clean energy investment in EMDE. This report answers that request, building on previous IEA analysis and on new survey data collected for the IEA's Cost of Capital Observatory project.

Our survey of leading financiers and investors confirms that the cost of capital for utility-scale solar photovoltaic (PV) projects in EMDE is well over twice as high as it is in advanced economies. This reflects higher real and perceived risks in EMDE at the country, sectoral and project levels. An elevated cost of capital pushes up financing costs and makes it much more difficult to generate attractive risk-adjusted returns, especially for relatively capital-intensive clean technologies. As a result, EMDE can end up paying more for clean energy projects or they can miss out altogether. Solar PV plants and other clean energy projects tend to involve a relatively higher share of upfront expenditure and a lower share of operating expenses in total project costs. If countries cannot afford high upfront costs, they can be locked into polluting technologies that might initially be less expensive but require persistent spending on – and combustion of – fossil fuels for their operation.

Country and macro factors are a major contributor to the high cost of capital for clean energy projects, but so too are risks specific to the energy sector

Broad country-related risks and macroeconomic factors typically explain a large share of country-by-country variations in the cost of capital. These include the rule of law and sanctity of contracts, as well as concerns about currency fluctuations and convertibility. As the balance of capital spending on energy in EMDE shifts away from dollarised, globally traded commodities, such as oil, towards clean energy projects that rely on domestically generated revenues, the overall quality and predictability of the domestic business environment become even more important for investors. Mechanisms that mitigate these risks include guarantees against expropriation and facilities to reduce the cost of currency

[1] References to EMDE in this report exclude the People's Republic of China (hereafter, "China").

hedging. However, over the longer term there is no substitute for efforts to tackle the underlying issues by strengthening national institutions, reducing inflation, and deepening local capital markets and financial systems. EMDE that have successfully scaled up clean energy investment, including India, Brazil and South Africa, have all relied heavily on domestic sources of capital.

There are also project- and sector-specific risks that can be addressed directly by energy policy makers and regulators; these are the focus of this report. In the case of clean energy generation projects in the power sector, key issues highlighted by survey respondents relate to sector regulations, the reliability of revenues – dependent mainly on the off-taker's ability to pay on time – and the availability of transmission infrastructure or land, and how all these issues are defined in contracts. Such project- and sector-specific elements can account for 20-30% of the higher cost of capital in EMDE. This report provides detailed insights into these factors, how they vary across parts of the energy sector, and what can be done to address them. There are plenty of positive examples in EMDE where clear regulation, a vision and intent to move ahead with clean energy transitions, and a readiness to work with the private sector have yielded impressive results.

The required increase in EMDE clean energy investment is huge, but almost all of it involves mature technologies supported by tried and tested policies

From USD 270 billion today, annual capital investment in clean energy in EMDE needs to rise to USD 870 billion by the early 2030s to get on track to meet national climate and energy pledges, and to USD 1.6 trillion in a 1.5-degree pathway. The increases are needed across a range of technologies and sectors, but three areas stand out: almost a quarter of the total clean energy investment over the next ten years goes to utility-scale solar and wind projects, and another quarter is made up of investment in electricity networks and in efficiency improvements in buildings together. A small fraction of the total investment spend – less than USD 50 billion per year – would be sufficient to ensure universal access to electricity and to clean cooking fuels.

The increase in spending is steep but almost all the required EMDE investment is in mature technologies and in sectors where there are tried and tested policy formulas for success. This would give EMDE a firm foothold in the new clean energy economy, with major benefits for energy access and security, sustainable growth, and employment, as well as for emissions and air quality. Only about 5% of the cumulative EMDE clean energy investment needs to 2035 are in sectors that depend on nascent technologies such as low-emissions hydrogen, hydrogen-based fuels, or carbon capture, utilisation and storage.

Key roles for enhanced international support and concessional finance

Investment on this scale will mean scaling up all sources of finance, with a vitally important role for well-coordinated, enhanced international financial and technical support. As part of the global push to expand and improve finance for sustainable development, we estimate that a tripling of concessional funding for EMDE energy transitions will be required to get EMDE on track for their energy and climate goals. Not all projects or countries require this kind of support, and it cannot replace needed policy actions or institutional reforms. But, used strategically, it can help countries remove barriers that are slowing clean energy investment – including weaknesses in project preparation, data quality, and energy sector policies and regulation that push up the cost of capital – and bring in much larger volumes of private capital. Targeted concessional support is particularly important for the least developed countries that will otherwise struggle to mobilise capital. Stronger coordination among governments, development finance institutions, private financiers and philanthropies will be essential to help EMDE navigate and understand the different financing instruments, risk-mitigation and credit enhancement tools that can help projects get off the ground.

Lowering the cost of capital by 1 percentage point could reduce financing costs for EMDE net zero transitions by USD 150 billion per year

Our analysis shows that capital costs – e.g. for land, buildings, equipment – are usually the largest single element in total clean energy project costs in advanced economies, whereas in EMDE the largest element is financing costs. Financing costs for utility-scale solar PV projects in EMDE, for example, can constitute around half or more of the levelised cost of electricity. Efforts to decrease the cost of capital in EMDE are not only crucial for investors but also for the overall affordability of energy transitions for consumers. We estimate that narrowing the gap in the cost of capital between EMDE and advanced economies by 1 percentage point (100 basis points) could reduce average clean energy financing costs in EMDE by USD 150 billion every year.

Recommendations on how to bring down the cost of capital for clean energy investment in EMDE

Multiple factors affect the cost of capital and many of the economy-wide risks lie outside the remit of energy decision makers, but the quality of energy institutions, policies and regulations still matters greatly. In this report, we highlight the importance of a clear vision and implementation plan for energy transitions, backed by reliable data and support with project preparation. We underscore the need for enhanced international support and collaboration. Using case studies and EMDE country examples, we also explore in detail some specific risks and applied solutions. Findings are presented here under four headings that reflect recurring themes from our discussions with investors and policy makers: the importance of good policy and regulation, reliable payments, timely permitting and availability of infrastructure, and tailored support for new and emerging technologies.

- **Policy and regulatory requirements** for clean energy projects vary widely across different parts of the energy economy, although a common denominator is the need for regulations to be technically sound, clear and predictable. Regulatory uncertainties in the power sector are a major concern, especially in new areas such as energy storage or privately financed grids. Strong regulatory frameworks for efficiency, including building codes and stringent minimum energy performance standards for appliances as seen in Chile, are a necessary condition to scale up investment in these sectors. South Africa's experience with well-designed, regular procurement programmes for renewables has been very effective to jump-start battery storage investment and deployment.

- **Payment and revenue risks** can be offset by wider availability and use of guarantees, alongside efforts to strengthen the underlying financial health of the entities involved. Delays in payment of power purchased by off-takers, generally state-owned utilities, have been a regular concern for investors and financiers of renewable generation projects in EMDE (except for more mature markets that have already seen considerable deployment of solar PV and wind). Greater availability of guarantees that cover such payment delays, which are being introduced in various African countries for example, can help to reduce risks and unlock more investment in countries that are seeking to scale up renewable power. This implies increasing the capital allocated for guarantees by international financial institutions.
- **Timely permitting and co-ordinated build-out of grids** increases the predictability of project timelines and avoids connection delays, a risk that worries investors more and more, including in EMDE with a good track record of clean power projects. In the case of hydropower for example, identifying viable sites and conducting environmental due diligence can cause significant construction delays. Similar issues are highlighted by investors for grids and utility-scale solar and wind, especially in countries with high shares of variable generation. India's experience with solar parks where tenders were put in place with land provided have reduced risks and enabled lower financing costs. Tenders to allocate transmission around green corridors are also on the rise. As the share of renewables increases, it is easier to earmark transmission lines as "green", given these are needed almost exclusively to evacuate existing or expected solar and wind. Their green characteristics can also help attract high levels of private international capital. Bringing in the private sector to build transmission lines through project finance structures (with contracts like those successfully applied in generation), as seen in Brazil and various other Latin American countries, has a proven track record and could be more widely applied.
- **Some new and emerging technologies and sectors require tailored support** to address specific risks, such as the lack of charging infrastructure for electric vehicles or technological risk associated with first-of-a-kind advanced biofuel projects. These sectors will need tailored solutions such as targeted tax credits or first loss guarantees, alongside complementary measures such as consumer access to low-cost auto loans for electric vehicles and pricing reforms that make electricity competitive with (often subsidised) transport fuels. As with other growth markets, governments should consider renewable fuel standards or biofuel mandates such as those applied in Indonesia to provide stable market conditions for investors.

Unlocking clean energy investment

Why the cost of capital matters

SUMMARY

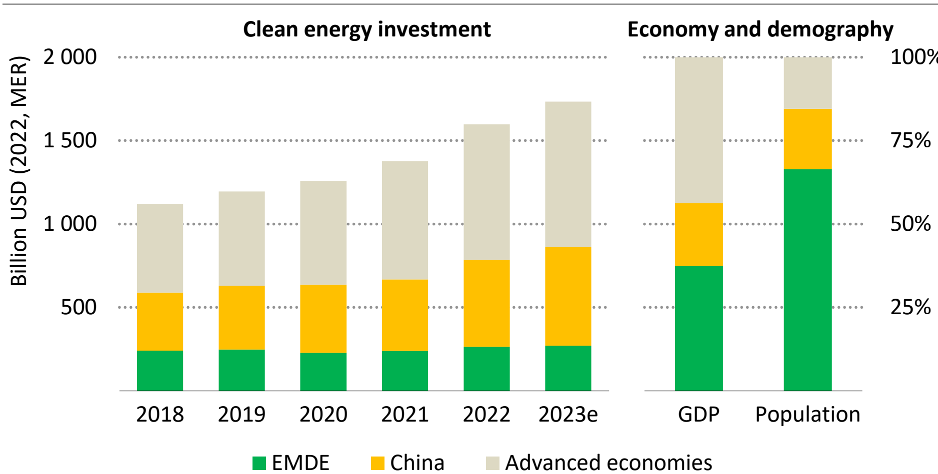
- Meeting national and global climate goals requires a massive scale-up in clean energy investments in emerging market and developing economies (EMDE). Annual clean energy investment to get on track for a 1.5-degree pathway needs to reach USD 1.6 trillion in EMDE (excluding China) by the early 2030s, up from around USD 270 billion today. These sums are way beyond the capabilities of public funding. All sources of finance will need to grow, but the largest growth will need to come from private sources, backed by strategic and judicious use of international public finance.
- A high cost of capital in EMDE makes it much more difficult to generate attractive risk-adjusted returns, especially for relatively capital-intensive clean energy technologies. Survey data collected by the IEA show that the cost of capital is well over twice as high in EMDE as it is in advanced economies.
- Country and macro risks are the largest contributors to this high cost of capital, but there are also energy sector and project-specific risks that are within the remit of energy policy makers to address. These energy-specific elements are the focus of this report, although efforts in parallel to tackle broader risks, such as currency risk, and to further develop domestic financial systems in EMDE are also essential.
- There is a wealth of country examples showing that predictable clean energy policy frameworks, based on a coherent vision for energy transition investments and finance, are prerequisites for scaling up investment. These are areas where national policy makers in EMDE should take the lead. But much greater international financial and technical support is also required, especially for the least developed countries and nascent markets where technology risks are higher.
- Mobilising private finance at the scale needed will require at least a tripling in international concessional funds to help improve the risk return profile of clean energy projects across the electricity, end-use and low-emission-fuel sectors. An estimated USD 90 billion to USD 110 billion per year in concessional funds is needed to get on a 1.5-degree pathway. These funds can help mobilise private capital in countries and sectors that do not have access to commercial finance.
- Lowering the cost of capital can substantially bring down the overall cost of transitions and reduce the costs paid by consumers. A one percentage point reduction in the cost of capital compared with current levels would save around USD 150 billion in annual clean energy financing costs (representing 20% of annual financing costs) for net zero transitions to 2050. Better risk management through strong policy frameworks and regulation as well as enhanced deployment of de-risking instruments are key.

1.1 The clean energy investment gap

Clean energy investments have increased rapidly in recent years, rising by 40% since 2020 to reach an estimated USD 1.8 trillion in 2023. These investments encompass a range of technologies, including low-emissions power and fuels, energy efficiency improvements, electrification of mobility and heat, and grids and storage. Spending in these areas is now significantly higher than the USD 1 trillion going to unabated fossil fuels.

However, patterns of investment reveal a major geographical imbalance. More than 80% of clean energy investments – and the vast majority of the increase in recent years – is concentrated in advanced economies and in the People's Republic of China (hereafter, "China"). There are some bright spots in other emerging market and developing economies (EMDE[1]), but overall capital flows to clean energy in these economies remain flat and far below where they need to be to satisfy rising demand for energy in a sustainable way. These economies are home to two-thirds of the world population, and account for around one-third of global GDP but for only around 15% of clean energy investment (Figure 1.1). This report from the IEA explores the reasons for this imbalance, focusing on the high cost of capital, and what needs to be done to bring down these costs and scale up clean energy investments in the countries that need it most.

Figure 1.1 ▹ Clean energy investment, GDP and population by region



EMDE make up over one-third of global GDP and two-thirds of the global population, but only around 15% of clean energy investment

Notes: MER = market exchange rate. Values for 2023 are estimates.

[1] References to EMDE in this report exclude China, unless otherwise specified, but include Chile, Colombia, Costa Rica and Mexico. The full list of countries included in the EMDE grouping is in Annex A.

This report has been produced in response to a request from the Summit for a new Global Financing Pact in June 2023 (Elysee, 2023), which tasked the IEA by the time of its 50th Anniversary Ministerial Meeting in February 2024 to do as follows:

"Building on the IEA-IFC report to the Summit on "Scaling up Private Finance for Clean Energy in Emerging and Developing Countries", the IEA should make recommendations on how to bring down the cost of capital for clean energy investments in emerging and developing countries, taking into account the transparency and data availability to assess risks".

Since this analysis was asked of the IEA, its focus is on issues and solutions that lie within the remit of energy decision makers. We do so with reference to IEA scenarios that provide detailed insights on technology and deployment trends in net zero transitions (Box 1.1). However, risks that push up the cost of capital extend well beyond the energy sector, highlighting the need for a broad effort to create the conditions that will allow all countries to benefit from participation in the new clean energy economy.

Box 1.1 ▷ IEA scenarios used in this report

IEA analysis is based on scenarios that explore pathways based on various conditions, which in turn lead to differing outcomes. Three scenarios are referenced in this report:

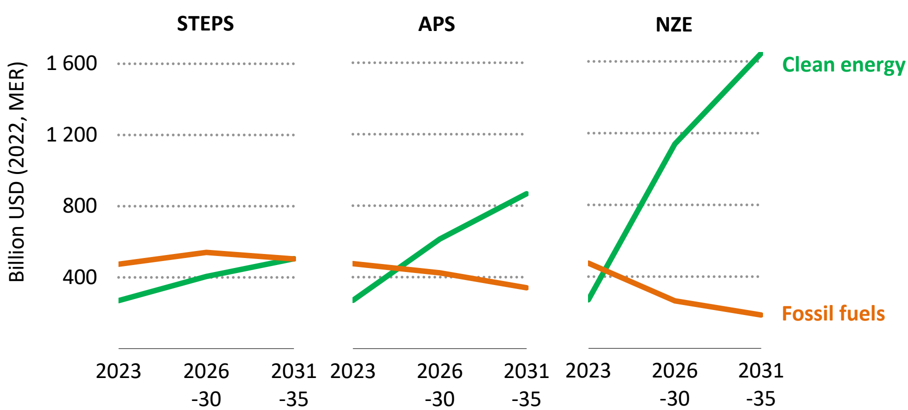
- **The Net Zero Emissions by 2050 (NZE) Scenario** sets out a pathway to the stabilisation of global average temperatures at 1.5° C above pre-industrial levels, showing what is needed for the global energy sector to achieve net zero CO_2 emissions by 2050. It also meets the key United Nations (UN) Sustainable Development Goals (SDGs) related to universal energy access, alongside major improvements in air quality.
- **The Announced Pledges Scenario (APS)** assumes that governments will meet, in full and on time, all of the climate-related commitments that they have announced, including longer-term net zero emissions targets and pledges. The APS is associated with a temperature rise of 1.7° C in 2100.
- **The Stated Policies Scenario (STEPS)** explores the implications of today's policy settings, based on a detailed sector-by-sector assessment of what policies are actually in place or are under development by governments around the world. This scenario does not automatically assume that ambitious net zero or other climate targets are met. Emissions in the STEPS do not reach net zero and the rise in average temperatures associated with the STEPS is around 2.4° C in 2100.

1.1.1 Today's investment trends and future needs

A growing number of EMDE have announced net zero targets and clean energy goals, but these have yet to be translated in most cases into the policy environment and incentives needed to achieve a rapid acceleration in investments. For the moment, contrary to the situation in advanced economies and in China, the USD 270 billion invested in clean energy in EMDE in 2023 is considerably lower than the USD 475 billion that these countries invest in aggregate in unabated fossil fuels (Figure 1.2).

There are positive examples of the potential to scale up investments in different parts of the clean energy economy. In countries where clean energy investments continue to grow, markets are underpinned by sound and relatively predictable policy frameworks, highlighting the critical role that policy and regulation play in attracting finance and investment. For example, Brazil and India have successfully stimulated significant amounts of investment in renewable power through a variety of policy support schemes. Beyond the electricity sector, improvements in energy efficiency in India have been driven by strong policy signals (building codes, appliance standards, innovative use of public procurement) as well as mechanisms such as the Perform, Achieve and Trade scheme for industry. Some EMDE, including major producers of oil and gas, are leaning into investments in low-emissions fuels, including financial close of the world's largest electrolytic hydrogen plant, a USD 8.4 billion investment in Saudi Arabia.

Figure 1.2 ▷ Annual average clean energy and fossil fuel investment in EMDE by scenario



Clean energy investment in EMDE picks up in all our scenarios but needs to accelerate dramatically to get on track for climate and other sustainable development goals

Notes: Values for 2023 are estimates. Fossil fuels represent unabated fossil fuels.

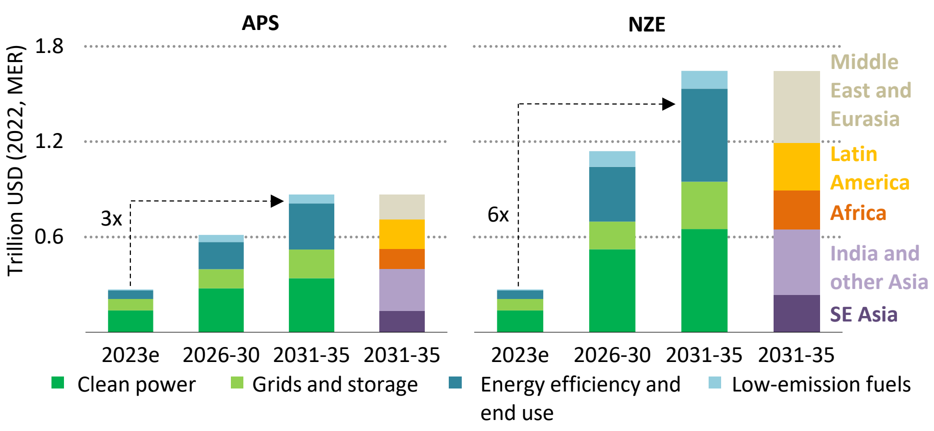
Unfortunately, there are too few of these success stories, especially among the least developed economies. While the underlying cost drivers for projects involving clean energy technologies such as solar photovoltaic (PV) and wind remain strong, the financing environment has become more complex in recent years in a world of higher interest rates. Moreover, investor attention has been drawn to new incentives and subsidy schemes (such as the United States [US] Inflation Reduction Act) put in place by advanced economies that are very difficult for most EMDE to match.

A very rapid scale-up in clean energy investment will be essential if EMDE are to get on track for national energy and climate goals (as modelled in the APS) and an even more precipitous rise is needed to pursue a 1.5-degree pathway (as in the NZE Scenario). From USD 270 billion today, annual clean energy investments in EMDE need to reach USD 865 billion by the early 2030s in the APS, and over USD 1.6 trillion in the NZE Scenario. Such a scale-up would give EMDE a firm foothold in the new clean energy economy, with major benefits for energy access and security, sustainable growth, and employment as well as for a range of indicators for emissions and air quality.

1.1.2 Investment priorities to 2035

The power sector accounts for the largest share of clean energy investment needs over the next ten years in the APS and the NZE Scenario (Figure 1.3). Low-emissions sources of electricity generation alongside investments in grids and storage account for around half of the total. Around another third of the total is required for investments in electrification and efficiency, with the remainder going to low-emissions fuels, including deployment of carbon capture, utilisation and storage (CCUS).

Figure 1.3 ▻ Clean energy investments in EMDE by sector and region in the APS and the NZE Scenario



A dramatic scale-up in all sectors and regions is essential to get on track for national energy and climate pledges and a global 1.5-degree pathway

Notes: SE Asia = Southeast Asia. Middle East and Eurasia includes EMDE countries in Europe.

Box 1.2 ▹ How do IEA clean energy investment numbers compare with other sources?

The rapid increase in clean energy spending in EMDE over the next decade in the NZE Scenario is part of a much broader surge in global clean energy investment that encompasses continued growth in China and in advanced economies.

The IEA investment numbers are consistent with other estimates of the cost of getting the energy system on track for the Paris Agreement and the 1.5° C goal. The recent Synthesis Report of the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report concluded that "average annual modelled investment requirements for 2020 to 2030 in scenarios that limit warming to 2°C or 1.5°C are a factor of three to six greater than current levels, and total mitigation investment (public, private, domestic and international) would need to increase across all sectors and regions".

There are a few important considerations to have in mind when comparing energy-related investment projections:

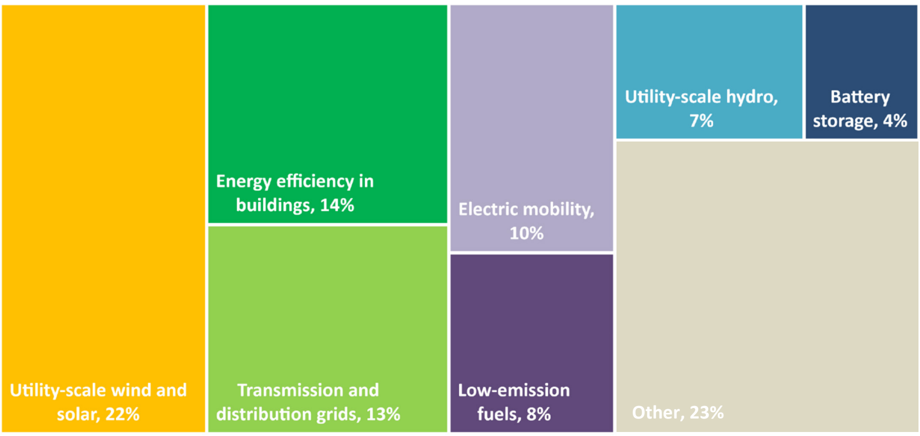
Degree of ambition: Near-term capital expenditure tends to be higher in scenarios with greater ambition; scaling up investment quickly obviously comes with challenges, but these scenarios also deliver higher climate and other benefits, as well as more rapid reductions in spending on fossil fuels. The NZE Scenario is classified as a scenario that stays below 1.5° C with no or limited overshoot, the most ambitious of the categories assessed by the IPCC.

Coverage: The investment projections in this report cover the expenditure associated with the transformation of the energy system, but complete accounting of the investment required to tackle climate change and achieve the SDGs will generate higher figures. For example, the Report of the Independent High-Level Expert Group on Climate Finance (Bhattacharya et al., 2023) concluded that EMDE will need to spend around USD 2.4 trillion per year by 2030 to get on track for these goals, whereas the IEA clean energy investment requirement for EMDE in 2030 is USD 1.4 trillion. However, the higher number also allows for investment in adaptation and resilience (USD 250 billion), mechanisms to deal with loss and damage (USD 300 billion), and investment in sustainable agriculture and restoring the damage human activity has done to natural capital and biodiversity (USD 300 billion). Once adjusted for these categories, the numbers for clean energy are well aligned.

Treatment of demand-side investment: The methodology for supply-side and infrastructure investment is generally similar across different models. However, there is a much wider variation in the way that investment in efficiency and end-use sectors is defined. The largest variations in investment requirements are typically due to methodological differences on the demand side, for example how efficiency investment is calculated in different sectors or how investment in electrified end uses such as electric vehicles is included.

This report narrows its focus to specific high-priority sectors — **utility-scale solar PV** and **wind**, **grid infrastructure**, and **energy efficiency in buildings** — where reductions in the cost of capital can make a major difference. These three sectors collectively account for around half of the EMDE investment requirement between today and 2035 (Figure 1.4). In the NZE Scenario, almost a quarter of total clean energy investment to 2035 goes to utility-scale solar and wind projects, and another quarter to electricity networks and efficiency improvements in buildings combined. These sectors are therefore a natural focus for policy makers and for the analysis in this report.

Figure 1.4 ▷ Cumulative clean energy investment needs in EMDE in the NZE Scenario, 2024-2035



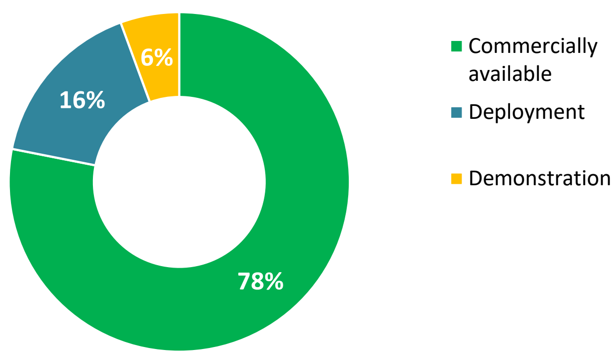
Utility-scale solar PV and wind make up about a quarter of the cumulative investments to 2035 in the NZE Scenario, with an additional quarter in grids and efficiency in buildings

In addition to these three areas, we look in detail at some sectors that present strategic value for secure, affordable energy transitions and for sustainable development. **Electric mobility** has yet to take off in most EMDE except for two- and three-wheelers in India and a handful of other countries. **Low-emissions fuels** also deserve attention, as electricity cannot provide for all the needs of rapidly growing and industrialising economies that need to build out their national infrastructure: we take advanced-fuels as illustrative of investment issues in this sector. Finally, we explore two areas that are critical alongside modernised grids for the **flexibility and security of power systems: utility-scale hydro and battery storage**. Overall, these sectors account for almost 80% of the total EMDE clean energy investment to 2035.[2]

[2] This report does not focus on specific plans to phase out unabated fossil fuel power, which is covered in other recent IEA work, notably 'Phasing Out Unabated Coal: Current Status and Three Case Studies' (IEA, 2021a) and the 'World Energy Outlook Special Report on Coal in Net Zero Transitions' (IEA, 2022).

Sectors present different degrees and types of risks to investors, and every country has its own context and circumstances. There are different issues and business models in play for a large solar PV project with a long-term contract, transmission lines that are financed on balance sheet by a state-owned utility, and an electric car that is paid by a household with consumer finance. Risks can vary substantially for different projects within a single sector, depending on the financial situation of the entities involved (especially the creditworthiness and reliability of off-takers for renewable power) and the maturity of the market. We explore these elements in detail in Chapter 2.

Figure 1.5 ▷ Investment in EMDE by sector's commercial and technological readiness, cumulative 2024-2035



Three-quarters of clean energy investment needs are in commercially proven technologies

Notes: "Demonstration" category includes hydrogen, hydrogen-based fuels, direct air capture, CCUS, ammonia, and marine power. "Deployment" includes large-scale heat pumps, concentrating solar power and investment in high-efficiency building envelope measures (excluding energy-efficient appliances that are commercially available in EMDE).

The increase in investment in clean energy in EMDE to get on track with national energy and climate pledges and global goals is extremely steep. But most of these investments are in mature technologies and in sectors where there are tried and tested formulas for success, both in advanced economies and in many EMDE (Figure 1.5). Only about 5% are in sectors that depend on nascent technologies such as hydrogen, hydrogen-based fuels or CCUS. Viable business models exist, and significant expertise has been developed globally that can be adapted to specific EMDE contexts.

1.1.3 Sources of finance

For the moment, around half of the financing for clean energy projects in EMDE comes from public finance, including development finance institutions (DFIs). The share of public financing is much lower in advanced economies, at around 20%. Funding from all sources needs to grow, but many EMDE have limited space to expand public support. Fiscal positions were weakened in many cases by the Covid pandemic and more recently by rising interest rates and concerns around debt sustainability.

Meeting sustainable development goals and climate pledges in EMDE will require a much greater effort to scale-up financing from private sources. Public and DFI funding needs to work more effectively to mobilise private capital from both international and domestic sources. Thus far, the record has been poor. For example, multilateral development banks mobilised only USD 18.6 billion in private finance compared with USD 60.9 billion in their own lending for climate action in EMDE in 2022 (EIB, 2023). In EMDE such as India where clean energy markets have grown, domestic sources of finance have accounted for most of the capital.

Mobilising more private capital will require an improvement in the risk-return profile of the sector with governments playing an active role in reducing real and perceived risks through strengthening domestic policies and regulation. While most EMDE are not able to replicate the strong incentives provided by some advanced economies, their markets represent much higher growth potential for investors. EMDE will need to reduce macroeconomic risks through the adoption of stable monetary and fiscal policies as well as investments in capacity building.

Financing for low-emissions power (renewable generation, electricity grids and energy storage) is predominantly debt financed, with public utilities dominating markets in the transmission and distribution sector in most EMDE. High debt levels and poor revenue sustainability of some of these public utilities make it particularly challenging to raise adequate and affordable capital for grid expansion that is critical to meet rising electricity needs while decarbonising the sector. Greater international support will be vital to ensure adequate access to capital. Measures to reduce financing costs and expand concessional funding will be key to ensure a just and affordable clean energy transition.

1.2 The cost of capital

1.2.1 What is the cost of capital?

The cost of capital is the minimum return that a company requires to justify a decision to invest (Box 1.3). As such, it is also a measure of real and perceived risk: the riskier the project, the higher the rate of return that would be required to justify investing. For the moment, the cost of capital is considerably higher in EMDE than in advanced economies and in China. This explains to a significant degree the variations in capital flows to clean energy seen across these regions. Mobilising much more capital to clean energy projects in EMDE will depend largely on reducing risks that push up the cost of capital.

The cost of capital is especially important for clean energy projects because of their capital intensity: they involve a relatively high share of upfront expenditure and a correspondingly low share of operating expenses in total project costs. Utility-scale solar PV and wind projects are a good example: they require significant initial spending but are then very cheap to run. Thermal power plants operating on coal or natural gas have a very different cost profile because of the continued expenditure over their operating lifetimes on sometimes volatile fuel inputs. A higher cost of capital can tip the economic calculation away from more sustainable choices. Other assets that are essential for clean energy transitions, such as grids, have higher operating costs but also require investing large amounts of money up front.

The cost of capital largely depends on the assessment of two sets of risks: country and macroeconomic risks, and risks specific to the project, or sector, or company(ies) involved. The portion of the cost of capital that relate to country and macroeconomic risks apply to any investment in a jurisdiction. Project- and sector-specific risks result in an additional premium. The focus of this report is on this second category, as these generally fall within the scope of actions by energy ministries, regulators and other energy-related policy makers. However, a comprehensive approach to bringing down the cost of capital requires attention to a broad range of factors.

Box 1.3 ▷ How to estimate the cost of capital

The **cost of capital** represents the expected financial return, or the minimum required rate of return, to justify an investment in a company or a project.[3] It plays a vital role in the financial decision-making processes of investors. The cost of capital serves as a benchmark to assess the risk and return preferences of investors and is also referred to as the **hurdle rate**. "Cost of capital" is also used interchangeably with "**financing cost**".

In the context of this report, the cost of capital is defined as the weighted average of costs associated with raising funds for investments. These funds can come from debt or equity. Unlike interest on debt, there is no commitment from a company or a project to repay equity to shareholders, who accept to take on higher risks in exchange for higher rewards in the form of dividends and capital appreciation. Debt providers have primary claim on assets in the case of solvency issues, while equity shareholders have a residual claim (IEA, 2021b). The weighted average cost of capital (WACC) factors in their respective contributions based on predetermined weights:

***WACC* = (*cost of debt* x *share of debt*) + (*cost of equity* x *share of equity*)**

- The **cost of debt** is estimated as the after-tax interest rate that a company or project must pay on its debt. It comprises two components: a benchmark minimum cost of borrowing (like a 10-year EMDE government bond rate, when financing in local currency) and a premium that reflects the credit and other risks associated with the borrowing company or project cash flows.
- The **cost of equity** represents the financial return expected by shareholders as compensation for their capital investment and is commonly referred to as the expected return on equity.

[3] Note, however, that "capital cost" is a different concept, referring to the expenses incurred on the purchase of land, equipment and other assets that are needed for a productive asset.

Estimating the cost of equity is generally more challenging than the debt component, primarily because the factors influencing it are not explicitly defined, and there is confidentiality around returns. For instance, when a company issues debt, the cost is relatively straightforward to find out, while determining the cost for the same company offering equity is more challenging. Estimating the cost of equity for projects in EMDE can be even more challenging, as capital markets are less developed, and there are fewer projects and a lack of transparency around risks.

This prompted the IEA and other partners to establish the Cost of Capital Observatory,[4] an initiative aimed at gaining a better understanding of and tracking the cost of equity and, consequently, the cost of capital, by surveying investors and financiers. Based on surveys and interviews with leading practitioners in EMDE, the Observatory not only provides investors with WACC values but also offers insights into the key underlying risks perceived by investors and financiers in each country.

An additional layer of complexity occurs because project financing – the provision of debt and the expected return on equity – in EMDE can be priced in domestic or foreign currency. Though many energy investment decisions in EMDE are still priced and evaluated in foreign currency (generally US dollars), domestic financing is important and has been increasing over the last decades as many EMDE have grown considerably and become more stable. Domestic financing is also set to increase in the energy transition, particularly in some countries. For instance, producer economies in EMDE will move from fossil fuels for export, denominated in foreign currency, to electricity-related investments largely based on domestic consumption and revenues in local currency. Power generation contracts in large EMDE for example tend to be denominated in domestic currency, with the financing done in the same currency. There are exceptions though, as in Argentina, where renewable power purchase agreements (PPAs) were defined in US dollars given high actual and perceived currency and other macroeconomic-related risks. In the next section, we will focus on country and macro risks.

Country and macro risks

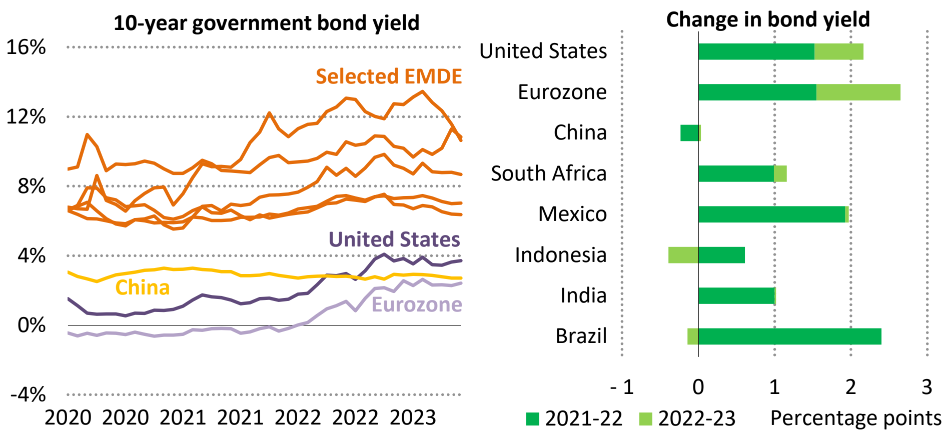
The cost of borrowing in domestic terms depends on the macroeconomic policies of a country. In fact, a key issue in many EMDE is high domestic interest rates – stemming from high inflation – which set a high bar for investment and make it difficult to obtain financing. The cost of borrowing in hard currency is typically defined as the US borrowing rate plus the country risk premium for the country where the project is taking place.

Interest rates of long-term government bonds – a benchmark indicator used to estimate borrowing rates – rose considerably in many countries in both 2022 and 2023, with the notable exception of China (Figure 1.6). The ten-year yield of bonds issued by India and South Africa increased by about 1 percentage point since early 2021 and by at least twice

[4] For more information on the Observatory, see iea.org/reports/cost-of-capital-observatory.

that in Brazil and Mexico. Yields of bonds issued by the US and European governments also rose by 2 percentage points or more since early 2021, affecting the cost of borrowing in external currency.

Figure 1.6 ▷ Indicators of economy-wide cost of debt (ten-year government bond yield), 2020-H1 2023



Bond yields in emerging market and developing economies are significantly higher than those in advanced economies and China; in recent years, they have risen significantly

Notes: H12023 = first half of 2023. 2023 data include first semester only. "Selected EMDE" includes South Africa, Brazil, Mexico, India and Indonesia, listed from highest to lowest bond yields as on 30 June 2023.

A way to reduce the cost of capital in EMDE is by addressing country-level macroeconomic and political risks. This typically means bringing inflation down to low and predictable levels, improving the rule of law and strengthening institutions and governance. Efforts to develop domestic capital markets and the banking sector also help. By doing so, lending costs should reduce in both domestic currency (as countries no longer need to sustain high interest rates to face domestic inflation) and foreign currency (as country risk ratings improve). However, this is a long-term task for governments and would help attract investments across the economy.

There are instruments available to help mitigate these broad categories of risk: the World Bank's Multilateral Investment Guarantee Agency (MIGA), for example, provides insurance for projects against losses relating to breach of contract, expropriation, war or civil disturbance. Regional institutions, such as the African Development Bank, also offer alternatives to cover these risks, such as Partial Risk Guarantees. Another crucial element of macro risk for projects financed in foreign currencies relates to fluctuations in exchange rates. Improving the availability and affordability of hedging instruments – such as those offered by MIGA or The Currency Exchange Fund (TCX) – is not straightforward but can be crucial in attracting investment (Box 1.4).

Box 1.4 ⊳ Tackling currency risks

Lending in local currency can be limited due to financial providers' concerns around capital controls – such as restrictions on currency repatriation – or due to local currency volatility. A strong track record of limited foreign exchange controls can help reduce perceived risk, but finance providers may also choose to adopt some form of currency hedging to reduce their exposure to currency volatility in projects that earn revenue in a different currency to the lending currency. Many hedging approaches and instruments exist, but those used most widely in EMDE are:

- **Natural hedging via portfolio diversification:** Investors with exposure to multiple currencies effectively create a natural hedge within their portfolio, with currency devaluations in one country mitigated by appreciations elsewhere.
- **Currency swap:** Under a currency swap, two parties agree to exchange the equivalent amount of a loan in one currency (in this context, the foreign currency) for a loan in another (the domestic currency). They will later re-exchange these equivalent loans at a predetermined rate and time.
- **Forward contracts:** Forward contracts are a one-payment swap via an agreement to buy one currency (in this context, the domestic currency) by selling another (the foreign currency) at a specified future date and rate.

Currency hedging instruments are not widely used in poorer EMDE and are generally limited to middle-income countries where the currencies are more liquid. These larger markets also tend to be the only ones where commercial swap or other hedging product providers operate, or where export credit agencies are financially strong enough to provide currency guarantees. Beyond these market limitations, currency hedging products are also complex to structure and add to the cost of projects, which can affect the level of interest in adopting such approaches.

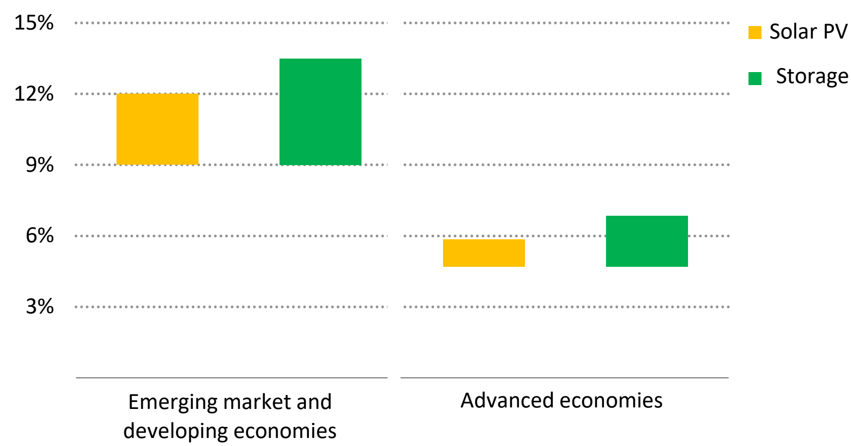
Some international funders have sought to support hedging options to facilitate greater levels of local currency lending, for example the DFI and global currency hedging facility TCX. TCX offers a range of currency hedging products in more than 100 economies, which it can do by pooling currency risk within their own portfolio (i.e. via natural hedging). While TCX has been able to catalyse private currency markets, its products are still primarily used by other DFIs due, in part, to the additional costs hedging can add to a project and unfamiliarity of other lenders with the product offering. Blended finance can be utilised as a tool to expand currency hedging options, including reducing the costs.

Expanding the use of currency hedging products remains challenging. Alongside currency risk mitigation instruments, the durable solution is to build up domestic financial markets and support their capacity to finance infrastructure assets directly, via partnerships between international and domestic financial institutions and targeted products such as guarantees. There is approximately USD 17 trillion of domestic financial capital in EMDE, made up of household savings, pension capital, and corporate and local bank finance. Channelling this capital into clean energy projects and infrastructure is a major and, for the moment, largely untapped opportunity.

Project- and sector-specific risks

Variations in the base rate (long-term, locally denominated bond yields for borrowing in domestic currency or US risk-free rates plus country risk premium for borrowing in foreign currency) are typically the largest reason for differences in the cost of capital among EMDE. However, the premium associated with project- or sector-specific risks is the component that can be most readily reduced via targeted interventions from national policy makers, supported by international technical and financial assistance.

Figure 1.7 ▹ Cost of capital ranges for solar PV and storage projects taking final investment decision in 2022



The cost of capital for solar PV and storage projects in EMDE is at least twice the value in advanced economies, despite relatively larger interest rate hikes in advanced economies

Notes: Values are expressed in nominal, post-tax and local currency. WACCs for solar PV projects represent responses for a 100 megawatt (MW) project and for utility-scale batteries a 40 MW project. Values represent average medians across countries. Advanced economies represent values in the United States and Europe.

Project- and sector-specific risks can vary widely across projects in different parts of the energy economy. On average, the premium on top of the base rate is around 20-30% of the overall cost of capital for power projects in EMDE. For a project in electricity generation, for example, the premium incorporates risk perceptions related to the sector regulations, the ability to collect revenues – generally set up by a contract and dependent on the creditworthiness of the off-taker (will it be able to pay, will it pay on time) – as well as risks around the availability of transmission infrastructure or land, and how all of these are defined in the PPA. The next section explores the reasons for a high cost of capital for such projects in EMDE and quantifies the benefits of action.

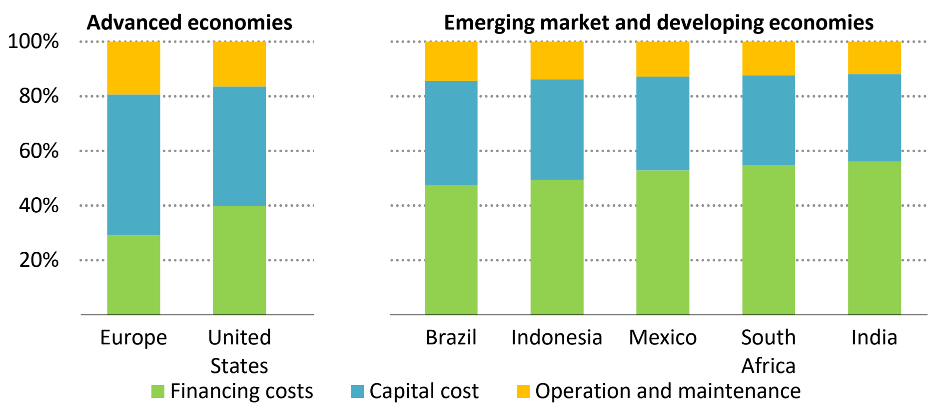
1

1.2.2 Why does the cost of capital matter for EMDE energy transitions?

The IEA collects data on the cost of capital in EMDE as part of its Cost of Capital Observatory initiative. The latest release of data shows that the cost of capital for utility-scale solar PV projects taking final investment decision in 2022 in major EMDE (average of Brazil, India, Indonesia, Mexico and South Africa) was at least twice as high as that in advanced economies (United States and various European countries, Figure 1.7). This year's survey also shows that nine out ten respondents expect increases in the cost of capital in EMDE in 2023 (IEA, 2023a).

Our findings also show that in almost two-thirds of cases, the WACC for utility-scale solar power projects was either the same as or lower than those for gas-fired projects. This means utility-scale gas-power projects are perceived to be at least as risky as utility-scale solar PV projects. This can be the result of greater uncertainty over fuel prices, transition-related risks for gas projects and their emissions, and more policy support for renewables and for solar PV. Project WACC for utility-scale batteries were also above or equal to those for solar PV projects, although stand-alone battery storage projects are relatively rare as solar and storage are increasingly being tendered together.

Figure 1.8 ▷ Composition of levelised cost of electricity for a utility-scale solar PV plant with final investment decision secured in 2022



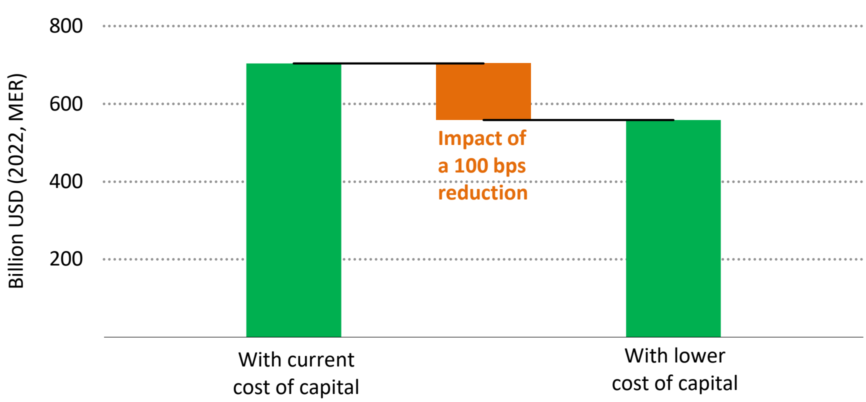
The cost of capital accounts for around half of the total levelised costs in EMDE, significantly more than in advanced economies

Financing costs constitute around half or more of the levelised cost of electricity (LCOE) for utility-scale solar PV projects taking final investment decision in 2022 in EMDE. This is considerably higher than in advanced economies (Figure 1.8). The impact of higher financing costs on LCOEs can be offset in some cases by lower capital costs, which are very competitive in countries such as India or Brazil. But efforts to decrease the cost of capital in EMDE are nonetheless crucial to the overall attractiveness of these investments, with knock-on effects on generation costs and the affordability of electricity – and of energy transitions – for consumers (Box 1.5).

Box 1.5 ▹ What difference would a lower cost of capital make for the overall cost of EMDE energy transitions?

Efforts to reduce the cost of capital for clean energy projects in EMDE can facilitate the achievement of multiple sustainable development goals. Narrowing the gap of the cost of capital between EMDE and advanced economies by energy-sector-specific interventions can also substantially bring down the overall cost of realising sustainable energy at scale. We estimate that a 1 percentage point (or 100 basis point) reduction in the cost of capital in EMDE leads to a reduction of USD 150 billion in average annual financing costs in the NZE Scenario between 2024 and 2050 (Figure 1.9).

Figure 1.9 ▹ Effect on annual average EMDE financing costs to 2050 in the NZE Scenario of a 1 percentage point reduction in the cost of capital



Lowering the cost of capital by one percentage point (100 basis points) could reduce annual average clean energy financing costs in EMDE by USD 150 billion

Note: bps = basis points; 100 basis points = 1 percentage point.

This reduction requires considerable efforts but is achievable and represents a 10-20% decrease in the cost of capital of the different sectors, compared with current values.

This reduction is obtained in part given i) the large weight that the cost of capital has in the total investment of solar PV and wind; and ii) the fact that these two technologies represent 15% of the investment needs of the NZE Scenario. An even more ambitious lowering by 2 percentage points could almost double this reduction to USD 300 billion per year.

In 2023, USD 35 billion were spent on clean energy in Africa, so a USD 150 billion reduction in clean energy financing costs is equivalent to more than four times the clean energy investments in this region this year. Bringing down the cost of capital therefore represents a huge opportunity to move countries more quickly down the pathway to a safer and more sustainable energy future.

1.3 Bringing down the cost of capital

As discussed, there are a host of project- or sector-specific risks, alongside country and macro factors, that can push up the cost of capital for clean energy projects in EMDE. We analyse these in detail in Chapter 2 and summarise them in this section. Our analysis and the insights from the Cost of Capital Observatory reveals several themes and specific areas that need to be resolved by national policy makers in EMDE, assisted by much greater financial and technical assistance from the international community. These actions need to be co-ordinated and coherent; country-led platforms for engagement with international partners and investors can play a useful role in this context.

- **A clear vision and plan for investment in energy transitions, backed by reliable and timely data, and an emphasis on project preparation:** The transformation of the energy sector requires long-term goals that are tailored to EMDE country contexts and ambitious enough to align with the Paris Agreement. To be credible, they need to be accompanied by a strong focus on implementation, including near-term milestones that lead the way to the long-term goal and integrated planning for investments, anticipated sources of finance, employment, skills, supply chains and the social implications of change. Enhanced institutional capacity for ministries and regulators, with a particular focus on early-stage project feasibility and preparation, is essential to generate a regular flow of clean energy projects. Accurate and timely availability of data on the energy sector and the broader economy is also crucial to bring transparency and reduce uncertainty for clean energy investors.
- **Strengthened policy and regulatory frameworks:** Regulatory risk is one of the top three sector-related risks that practitioners identify in response to the IEA's Cost of Capital Observatory. These need to be addressed to reduce the cost of capital for clean energy projects in EMDE. It is worth noting that regulatory stability is hard to achieve, and regulation needs to change as sectors evolve: tenders for renewable capacity, for example, need to adjust as the share of renewables in generation increases. But investors should expect transparency, predictability and an open dialogue with

stakeholders. Well-designed and standardised contracts are also key to ensure project bankability and, where possible, these should be set in local currency to reduce the currency mismatch for domestic off-takers. Pricing reform to phase out inefficient fossil fuel subsidies and to raise and expand the scope of carbon pricing can play a vital role to incentivise investment in the low-emissions economy.

- **Stepping up international co-operation and technical assistance**: EMDE do not always have the necessary institutional capacity or know-how to collect and disseminate relevant energy sector and economic data, and address the technicalities of regulation, contracts or business models in clean energy sectors. In such cases, co-ordinated technical assistance by donor institutions is vital to ensure transparency, sound data-driven decision-making, and robust policy and regulatory design that can help reduce the cost of capital. Increased transparency and accountability among donors could help avoid competing support and overlapping tasks. Policy makers in advanced economies should carefully assess the impact of their own domestic clean energy support programmes on incentives for investment in EMDE and ensure there are channels for increased international capital flows and for the participation of EMDE in emerging clean energy supply chains.
- **Targeted interventions for the least developed countries and nascent markets**: With low per capita incomes, a multiplicity of governance and development challenges, and a lack of bankable projects, least developed countries require targeted financial and technical support to kick-start clean energy investments, especially those that can help achieve universal energy access by 2030, alongside capacity building for administrations. As many countries are unable to take on more debt and have limited access to international financial markets, grant funding plays an essential role.
- **Expand the reach and ambition of institutions that provide payment guarantees**: Payment risk is another of the top three sector-related risks identified by investors in projects in EMDE, particularly renewables, storage and grids. Extending the provision of guarantees that cover payment delays, especially in countries with nascent or growing sectors, would reduce the cost of capital and enable a step change in investment. This could be done by increasing the reach and ambition of existing multilateral institutions such as MIGA or partial-risk guarantees by institutions such as the African Development Bank (which can cover non-honouring of financial commitments by state-owned or other entities) or using third-party creditworthy institutions such as Solar Energy Corporation of India (SECI) to manage off-taker risk.
- **Step up international financial support, including a tripling of concessional funds**: Used strategically and judiciously, international concessional funding is a crucial enabler for clean energy projects that might not otherwise attract private funding. Not all projects need this kind of support, and it is not a substitute for policy actions or institutional reforms. But it can help to move projects forward where they involve technologies that have yet to scale and are not yet cost-competitive in nascent markets; that are in frontier markets with higher levels of country and political risk; or that involve macroeconomic risks, such as foreign exchange risk, that raise the cost of the project. Our estimates

show that concessional funding for clean energy needs to triple in EMDE over the next decade to realise the benefits of a Paris-aligned pathway (Box 1.6).

Box 1.6 ▹ How much concessional funding is required in EMDE?

Concessional funding includes a range of guarantees, senior or subordinated debt or equity, performance-based incentives, viability gap funding, and other investment grants. The IEA and International Finance Corporation (IFC) estimated in 2023 that USD 80 billion to USD 100 billion in concessional funding would be required in EMDE to mobilise the amount of private finance (USD 900 billion to USD 1 100 billion) required in the NZE Scenario by the early 2030s (IEA, 2023b).

Table 1.1 ▹ Concessional funding needs for EMDE in the NZE Scenario

	Annual average required (USD billion)	
	2026-2030	2031-2035
Total EMDE	89	111
By region		
Southeast Asia	8	11
India and other Asia	18	23
Africa	38	48
Latin America	13	15
Middle East & Eurasia	12	14
By sector		
Low-emissions power, grids and storage	33	41
Grids and storage	17	22
Low-emissions fuels	10	12
Efficiency and end use	29	36

Source: IEA (2023b).

This amount does not cover all potential concessional funding needs for the energy transformation,[5] notably for state-owned enterprises such as public utilities that rely entirely on public financing to modernise and expand grid infrastructure. In 2022, DFIs accounted for about 15% of total financing of grid investments in EMDE, as revealed in a detailed review of DFI financing of these public utilities. More than half of all funding to these utilities during that year was provided on concessional terms. On this basis, we estimate that meeting the investment needs under the NZE Scenario would require a further USD 10 billion in concessional funding by the early 2030s for grid investments by public utilities not able to access commercial finance.

[5] Areas beyond the energy transformation are also high priorities for concessional funding; adaptation and resilience-building projects are typically difficult to structure in ways that attract private financing.

The NZE Scenario therefore requires an estimated USD 90 billion to USD 110 billion in concessional funding from the international community (Table 1.1). This represents at least a tripling in public climate finance for energy, transport and industry compared with the most recent climate finance data published by the Organisation for Economic Co-operation and Development (OECD). These concessional funds will need to leverage much greater amounts of private finance, aiming for a multiple of six to seven rather than the meagre multiple of 0.3 observed today.

In addition to the broad themes described above, there are risks in specific areas that need to be addressed (Table 1.2). Chapter 2 goes into detail on these sectors, bearing in mind that country contexts differ, and every country and jurisdiction will need to develop its own set of targeted measures for its prevailing circumstances.

Table 1.2 ⊳ Summary of key risks and measures to reduce the cost of capital of clean energy projects in EMDE

Key risks and barriers	Key recommendations to reduce the cost of capital
Utility-scale solar and wind	
Growing and maturing markets: • **Regulatory risk**: the level of clarity and predictability of policies and regulations • **Off-taker risk**: perceived and real risks related to the payment of power purchased by off-takers • **Transmission risk**: ability to access the transmission grid in a predictable manner	***Growing markets:*** • **DFI and government:** Reduce off-taker risks by expanding credit enhancement mechanisms and payment guarantees • **Government:** Continue developing the market with procurement programmes tied to a clear long-term strategy • **Private and government:** Increase public funding to expand transmission infrastructure while testing business models for privately financed transmission ***Maturing markets:*** • **Government:** Incentivise grid flexibility, including via renewable capacity tenders that incorporate storage • **Government:** Ensure timely and full payments to generation companies with ad hoc solutions if needed • **Government:** Prepare tenders to allocate transmission lines around green corridors
Grids	
Publicly led markets: • **Financial sustainability risk**: poor financial well-being of state-owned corporations • **Tariff risk:** tariff design not being cost-reflective, further stressing the state-owned entity finances and sustainability • **Regulatory risk:** no robust procedure for private participation, business model, technical procedures and system planning	***Publicly led markets:*** • **DFI and government:** Improve state-owned entities' financial health in collaboration with DFIs, by restructuring, involving private sector where feasible, and remunerative tariffs • **DFI and government:** Deploy blended finance strategically to mitigate project risk and unlock investments • **Government** Where private capital mobilisation is suitable, develop a robust regulatory framework that includes project preparation assessment with credible risk scenarios by clearly defining expected outcomes and cost allocation
Privately led markets: • **Remuneration risk**: poor adequacy of remuneration to reflect costs and adjust to macroeconomic circumstances • **Regulatory risk**: predictability and robustness of the regulatory framework • **Permitting risk:** lack legal framework that cause risk of delays	***Privately led markets:*** • **Government:** Adopt cost-reflective and predictable remuneration in order to ensure profitability • **Government:** Establish transparent and reliable regulations, providing clarity on licensing, permits, cost allocation and revenues • **DFI:** Establish blended finance facilities to manage remuneration risk and mobilise private finance
Energy efficiency in buildings	
• **Regulatory risk**: lack of comprehensive building codes, low capacity to implement them, and the size of the "informal" construction sector	• **Government:** Strengthen regulatory frameworks for buildings efficiency, including through adoption of building codes and stringent minimum performance standards

Key risks and barriers	Key recommendations to reduce the cost of capital
• **Difficulty accessing financing**: lack of financing options and appropriate models including for refinancing • **Skewed incentives**: lack of incentives due to subsidised energy; split incentives between owners and renters	• **DFI, government and private:** Allocate greater funds to on-lending programmes to promote local and easily available financing options • **Government:** Rationalise energy subsidies to curb inefficient energy use and encourage adoption of energy efficient solutions
Electric mobility	
• **Lack of financing options**: Lack of access to debt financing and high cost of borrowing • **Ecosystem risk**: lack of a vast electric vehicle charging infrastructure with proven business service models, and lack of dedicated private charging due to poorly defined property rights • **Regulatory risks:** Lack of clear policy signals on emissions reduction targets	• **Private and government:** Expand consumer access to low-cost auto loans, leasing models and a widely available charging network • **Government:** Phase out subsidies for transport fuels, and provide targeted support for the uptake of electric vehicles and related charging infrastructure • **DFI and government:** Increase concessional support for electrification of vehicles used in public transport
Advanced biofuels	
• **Technological risks:** first-of-a-kind advanced biofuel projects tend to have high risk premiums, with difficulties securing long-term offtake agreements or feedstock supplies • **Feedstock availability risks:** complexity in securing streams of waste or residue and long-term offtake contracts	• **Government:** Develop renewable fuel standards or biofuel mandates to provide stable market conditions for investors • **Government:** Provide targeted tax credits or first loss guarantees for first-of-a-kind projects • **DFI and government:** Encourage mutual recognition of emissions intensity assessments, based on clear definitions of sustainable feedstocks and third-party verification of life-cycle emissions
Utility-scale hydro	
• **Permitting delays:** Identifying viable sites and conducting environmental due diligence can cause significant delays to construction of dams • **Revenue risk:** Many dams have multiple uses beyond hydropower plants, but these uses are not reflected in most business models • **Off-taker risk:** Concerns over reliability of the off-taker	• **Government:** Improve long-term planning for hydropower projects, including site mapping with environmental data • **DFI and government:** Create robust, streamlined sustainability standards and monitoring procedures • **Private and government:** Ensure that business models reflect the multiple benefits of hydropower facilities
Battery storage	
• **Regulatory risk:** battery storage systems do not always have equal access to the power market, and a long-term strategy for flexibility might be missing • **Off-taker risk**: delayed payments by or under recoveries from distribution companies are a key risk	• **Government:** Establish clear and stable regulatory framework that defines the role of utility-scale battery storage and allows equal power market participation • **DFI and government:** Develop the market through well-designed and regular procurement programmes, with concessional finance where required • **DFI and government:** Expand off-taker guarantee and credit enhancement mechanisms by offering guarantees or establishing creditworthy intermediates

Identifying risks that influence the cost of capital

A sector-by-sector analysis

SUMMARY

- This chapter considers seven strategic clean energy sectors in EMDE for individual analysis, recognising that business models, risks and policy solutions vary across different parts of the energy economy, as well as between economies at different stages of development.
- Regulatory risk is a major impediment to scaling up clean energy investments. Unclear targets, inconsistent application of policies, incomplete regulations or complex procedures to obtain project approvals increase risk perceptions and lead investors to demand higher expected returns on investment, or to invest their money elsewhere. The best ways to address these concerns vary by sector and cover an array of solutions – from expanding tenders for renewable generation capacity that incorporate storage and reward flexibility, to building codes and stringent minimum performance standards for efficiency in buildings or fuel standards for biofuels.
- EMDE governments are in the driver's seat, but enhanced technical support and capacity building by international donors – whether development finance or other institutions – is essential. Adapting solutions to the local context is key, but international actors have a lot of experience to share. For example, following Kenya's example, other African countries could – with the help of donors – test privately financed business models for power transmission (as Latin American countries did a few decades ago) to step up investments.
- Least developed countries have unique characteristics and challenges that demand additional attention and targeted support to kick-start clean energy investments. Grant funding needs to play an important role, including to strengthen institutions and administrative capacity, and to help achieve universal energy access by 2030.
- Delays in payment for power purchased by off-takers (generally state-owned utilities) are another major concern for investors and financiers of renewable generation and storage in many EMDE. Increasing the availability of guarantees that cover payment delays by public sector entities will be key to reduce the cost of capital and unlock much more investment in countries with nascent or growing sectors.
- Where technology risk is high, or market failures large, concessional funds will also be key. We estimate these funds need to triple current levels to kick-start commercially proven technologies in new markets, such as energy efficiency in buildings or the electrification of public transportation. These funds are scarce and should also be used strategically to mobilise more private capital to projects.

2.1 Introduction

Reducing the cost of capital for clean energy projects in emerging market and developing economies (EMDE)[1] will mean addressing risks across various parts of the energy economy, for projects that are financed with different business models, where the scale of projects varies considerably, and where the most prevalent risks are not always the same. In Chapter 1, we highlighted that two of the largest investment requirements for EMDE in the period to 2035 are utility-scale solar and wind, and energy efficiency in buildings. These are, however, very different sectors for investors. Utility-scale solar and wind are financed largely on a project finance basis, for tens of millions of United States (US) dollars, and the biggest sector-related concerns for investors are off-taker and transmission-related risks. Investments in energy efficiency in buildings are generally financed by households or real estate developers, through their own savings or commercial loans. The biggest challenges are the lack of incentives due to subsidised energy, absence of building codes or weak financing models.

These examples highlight why it is essential to dig into the features of different parts of the energy sector to examine their specific elements, business models and risks. This chapter discusses seven large clean energy sectors that have significant strategic value for secure and affordable energy transitions in EMDE and that are also large in terms of cumulative clean energy investment needs between 2024 and 2035 in the Net Zero Emissions by 2050 (NZE) Scenario (the number in brackets).

- utility-scale solar PV and wind (22%)
- transmission and distribution grids (13%)
- energy efficiency in buildings (14%)
- electric mobility (10%)
- low-emissions fuels (8%)[2]
- utility-scale hydro (7%)
- battery storage (4%).

A summary of some key characteristics of these sectors is included on the next page (Table 2.1), followed by detailed consideration of each of them in turn. These individual sections describe first the current investment levels and trends in EMDE as well as the outlook for investments and the most common sources of finance. They then consider the factors influencing the cost of capital and the key recommendations to reduce the cost of capital in each area.

[1] References to EMDE in this report exclude the People's Republic of China (hereafter, "China"), unless otherwise specified.

[2] Low-emissions fuels include modern bioenergy (liquid biofuels and biogases), low-emissions hydrogen and low-emissions hydrogen-based fuels. We focus the discussion and recommendations on advanced biofuels as there is significant potential in EMDE to leverage agricultural residues and municipal waste as sustainable feedstocks, thereby moving away from conventional biofuels.

Table 2.1 ⊳ Key characteristics of clean energy projects by sector in EMDE

Sector	Dominant business model	Role of cost of capital
Utility-scale solar and wind	• Feed-in tariff or long-term physical power purchase agreement, financed on a project finance basis	Very important, as assets are capital-intensive (low operating expenses) and up to 75% debt financed
Grids	• Whole-of-grid concessions managed by public utilities (important presence of private utilities in Latin America, though less common in other EMDE)	Assets are capital-intensive with a high impact on affordability
	• Independent power transmission projects (a form of public-private partnership, used in various Latin American countries and in India)	Very important, as assets are capital-intensive and remuneration is fixed by the regulators
Energy efficiency in buildings	• Funded on balance sheets by developer or tenant, mainly using equity financing	Relatively low in the investment decision of consumers and small and medium-sized enterprises
Electric mobility	• Electric vehicles (EVs) financed by households or (public or private) transport companies through savings and some level of consumer finance • Enabling infrastructure financed mostly by public entities or utilities, financed on balance sheets	Quite important in EMDE for consumers. More important for the establishment of the charging infrastructure by public companies that need cheap access to finance
Low-emissions fuels	• Usually financed on balance sheets	Relatively low, as feedstocks and operations form largest share of cost
Utility-scale hydro	• Mainly developed by public sector entities on balance sheet, underpinned with power purchase guarantees and long-term contracts	Significant, but the primary obstacles relate to lengthy permitting, site identification and environmental concerns
Battery storage	• Remuneration from provision of battery storage services supported by feed-in tariffs or capacity payments (especially in areas with no wholesale markets), financed on a project finance basis	High, capital-intensive, leverage ratio is around 70-80%

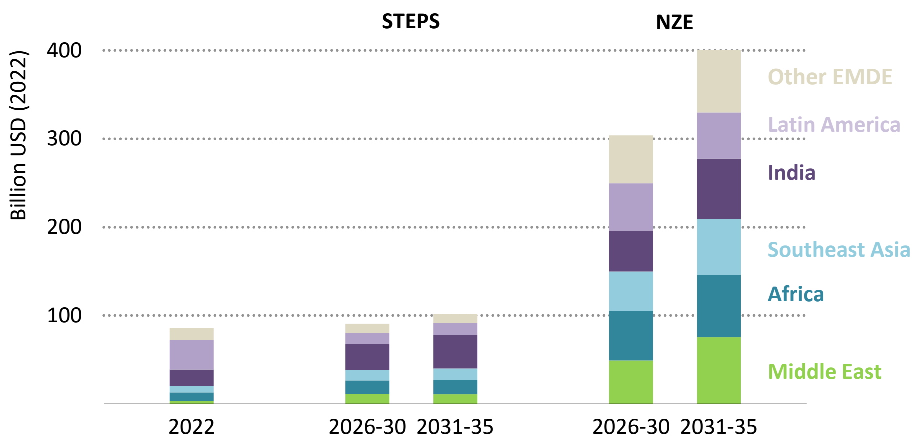
2.2 Utility-scale solar PV and wind

Investment outlook, sources of finance and sector development

Deployment of wind and solar photovoltaic (PV) has seen impressive growth in recent years; these technologies witness the largest growth in capacity across IEA scenarios, delivering cost-effective sources of electricity for development and growth as well as emissions reductions. Since 2010, the share of wind and solar PV in electricity generation has grown from zero to 6% in 2022 among EMDE and is on track to rise to 23% by 2035 under the Stated Policies Scenario (STEPS). However, wind and solar PV generation in the STEPS is only one-third of what it is under the NZE Scenario.

Investment in utility-scale solar PV and wind also makes up the largest share of future investment needs. Almost a quarter of clean energy investment needed from now to 2035 in the NZE Scenario is required in these two technologies. While investment stays relatively flat in the STEPS, it will need to quadruple in the NZE Scenario compared with current levels (Figure 2.1). Generally, solar PV and wind power assets have relatively high upfront investment costs but lower operating expenses over time, with basically no fuel expenditures, and rely on high levels of debt. For example, the share of debt of utility-scale solar PV and onshore wind in EMDE could be as high as 75%. Reducing the cost of capital is key to permit an accelerated buildout and to lower electricity generation costs as financing costs make up a large share of the levelised cost of electricity (LCOE) for solar PV and wind – about 50% of LCOEs in Mexico or South Africa, compared with about a third in advanced economies.

Figure 2.1 ▹ Investment in utility-scale solar PV and wind in EMDE in the STEPS and the NZE Scenario, 2022-2035



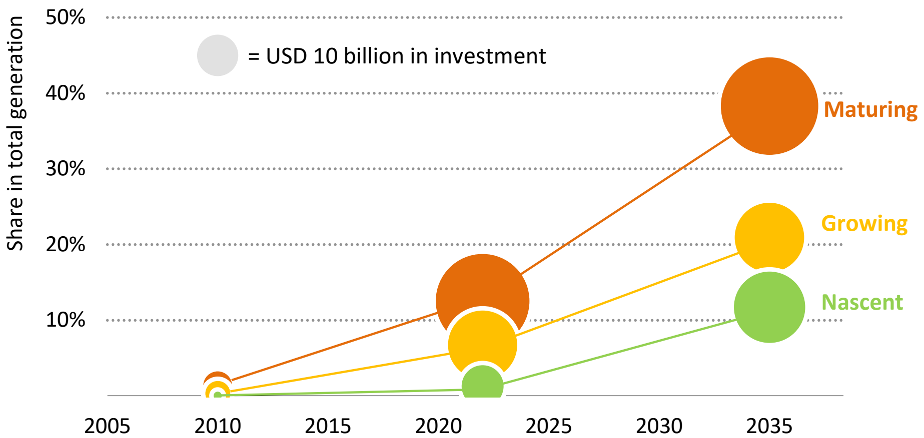
Investment needs to quadruple in the next ten years to meet net zero emissions targets

Some EMDE have done much better than others at attracting capital to utility-scale solar and wind, especially from the private sector. The overall investment framework varies considerably among geographies. To capture these differences, we grouped countries into three (Figure 2.2):

- **"Nascent" markets**: countries that have very limited or virtually no deployment of solar PV and wind so far (e.g. various countries in Africa, the Middle East and the Caribbean). Countries in this group also tend to have the lowest income per capita among EMDE.
- **"Growing" markets**: countries that are experiencing an acceleration in deployment but where solar PV and wind still contribute only relatively low shares of generation (e.g. Mexico and South Africa)

- **"Maturing" markets**: countries that have already had considerable growth in solar PV and wind (e.g. Brazil, Costa Rica and India).

Figure 2.2 ▷ Wind and solar PV generation and investments in EMDE in the STEPS, 2010-2035



Maturing markets represent countries with a share of solar PV and wind of at least 10% of power generation and the largest growth investment potential

Note: The "nascent" group includes EMDE where wind and solar PV have a share in total generation that is less than 5% today, while the "growing" group has a share between 5% and 10% (or above but where regulatory and policy uncertainties remain high or have worsened), and the "maturing" group has a share of over 10% and a relatively supportive regulatory and policy environment.

While the share of wind and solar PV generation is a useful indicator of the maturity of markets, there are exceptions. Countries can have varying degrees of regulatory sophistication and policy clarity that do not always match the expected uptake of renewable sources in generation. For example, despite a share of wind and solar PV generation above 10%, Viet Nam is considered to be a growing market in this report as a result of associated policy and regulatory uncertainty that impact the outlook for investment in this sector. The country managed to attract considerable investment to the sector between 2018 and 2021, mainly through a relatively generous feed-in tariff, but the renewable deployment boom was not matched with increased investment in transmission. Other issues around infrastructure planning and regulations have also led to curtailment and a slowdown of new investment.

The cost of capital is typically not the binding constraint for accelerating deployment of solar PV and wind in the group of countries characterised as nascent markets. These countries generally have very weak investment frameworks alongside other overarching challenges such as conflict or post-conflict risks, and very little clarity, if any, on policies or targets for renewables or other conditions that are required for project development by the private sector. These markets represent only a small share of the overall investment. We also focus our discussion on solar PV and onshore wind only, as offshore wind is still a nascent sector across most EMDE (Box 2.1).

Box 2.1 ▷ Offshore wind in EMDE

In 2022, only 0.1% of the total electricity generation in EMDE came from offshore wind. This is on track to rise to just over 1% by 2035 in the STEPS. Owing to high capital costs and project complexity, only around a quarter of the USD 25 billion spent on wind power in EMDE was in offshore wind in 2022 – compared with around a third among advanced economies and in China. In the NZE Scenario, offshore wind investment in EMDE increases more than ten-fold to USD 65 billion per year between and 2031 and 2035, although its share of total EMDE wind power investment remains at around one-quarter. EMDE countries with significant offshore wind potential include countries that are growing rapidly such as Viet Nam, Indonesia and India, and where its development will be important to meet electricity demand growth.

Some of the key risks for offshore wind investment are not unique to EMDE, and include increased financing costs and supply chain constraints that have affected the whole value chain of the offshore wind sector. At present, 12 gigawatts (GW) of offshore wind capacity are facing delays or cancellation in the United Kingdom and United States alone. However, these factors are amplified by the nascent nature of offshore wind projects in the few EMDE that currently undertake them, especially in countries that still have ample sites available for onshore development.

Scaling up the offshore sector and reducing risk perceptions will require that auction designs have sufficient flexibility to accommodate changing macroeconomic conditions and increase investor confidence in the reliability of demand for projects through, for example, well-designed and regular auctions. EMDE countries will also have to provide greater policy certainty on the role of offshore wind in their respective clean energy transitions, ensure payment certainty by off-takers and create procurement programmes with significant use of concessional funds given the nascent nature of offshore wind in many of these markets. Moreover, governments will have to closely collaborate with wind developers to ensure the availability of adequate infrastructure and construction equipment especially when undertaking the first offshore projects. In addition, it also requires governments to integrate new aspects such as marine spatial planning and seabed survey licensing, which have historically not been part of energy planning processes.

Financing conditions for utility-scale solar PV and wind projects are influenced by both country- and sector-specific risks. The former includes issues around macroeconomic performance or debt management, as well as currency fluctuations and issues that affect all investment, not only energy. As explained in Chapter 1, this report focuses on sector-related risks. In the IEA's most recent Cost of Capital Observatory, when asked what the risk was to be addressed first to reduce the cost of capital for utility-scale renewable power projects in EMDE, investors identified the following three:

- **Regulatory risk**: the level of clarity and predictability of policies and regulations.
- **Off-taker risk**: perceived and real risks related to the payment of power purchased by off-takers.
- **Transmission risk**: ability to access the transmission grid in a predictable manner.

For maturing markets, currency risk is also critical, and it impacts their ability to attract international capital. Other risks, such as problems to obtain land or volume risk, are also prevalent, but were identified as less pressing. The following two subsections discuss these factors in more detail and provide recommendations to reduce the cost of capital in growing and maturing markets.

2.2.1 Utility-scale solar and wind in growing markets

The countries categorised as growing are those that have utility-scale solar PV and wind sectors that have been evolving over recent years, but these sources still represent a small share of the total generation (between 5% and 10%). These include, for example, Mexico, most countries in North Africa, South Africa and Thailand. Most countries in Africa are categorised as nascent, though there are some exceptions, such as Senegal and Kenya, where the share of solar PV and wind in generation is already high.[3]

Utility-scale solar PV and wind are generally financed by revenue-supporting mechanisms, such as feed-in tariffs or long-term physical power purchase agreements (PPAs), financed on a project finance basis. Competitive auctions are growing, but they are not universal still.

Key factors influencing financing costs

Most countries categorised as growing markets have targets for renewables, and some award long-term contracts through competitive auctions and have – or have had – multistage procurement programmes such as Mexico, Morocco and South Africa. However, many of these countries often do not have implementation plans in place or they are implemented with delays. In some cases, investment flows have fluctuated significantly due to the regulatory uncertainty in these markets. Investment for utility-scale projects stalled in Mexico in recent years, in part due to the Covid pandemic but also because changes in laws relating to electricity generation and supply that have restricted private sector operations and impacted renewable generation companies (Bloomberg Linea, 2023). Efforts to favour the state-owned utility company have led to the cancellation of permits of generation companies (Bloomberg Linea, 2022). There have also been issues with land-use and inconsistency of rules across local jurisdictions. The IEA's Cost of Capital Observatory found

[3] In Senegal, for example, this share was above 20% in 2022, but as its regulatory and policy environment is still under development, in this report we categorise Senegal as a growing market.

that reducing regulatory risk was a key issue behind the relatively elevated cost of capital for utility-scale solar PV projects in Mexico.

Off-taker risk, another key concern for investors, refers to delays or arrears in the payment of power purchased by off-takers, often state-owned enterprises (SOEs) and in most cases in poor financial and operational conditions. These risks can be mitigated through mechanisms such as escrow accounts that earmark revenues to pay for the electricity generation, using for example creditworthy intermediaries as done by India or other risk-mitigation mechanisms offered by domestic or international institutions. In particular, the Multilateral Investment Guarantee Agency (MIGA) of the World Bank has been offering products to cover the non-honouring financial obligations by public sector borrowers as well as political risk insurance for private sector projects for more than 20 years. MIGA has a successful track record: it has issued USD 70 billion in guarantees since its inception and paid only 11 claims, all related to its political risk insurance product (CGD, 2023). Among the regional development finance institutions (DFIs), for example, the African Development Bank also offers guarantees for private investors.

An advantage of MIGA, compared with other private or public insurers, is that the host countries take into consideration the impact that calling on a MIGA guarantee could have over the perceptions of the World Bank Group or the international community, investors in particular. If arbitration happens, though, one improvement to MIGA's payment guarantee product could be to add a stand-by liquidity facility ensuring payments to investors while the process is in place (G20, 2023). There is significant potential to expand the use of MIGA's guarantees and insurance products as it supported on average less than 45 new projects every year across all regions and sectors of the economy over the last five years (MIGA, 2023). MIGA's coverage in lower income and riskier countries is limited, and guarantees take time to complete. A 2023 report by the G20 recommended tripling MIGA's annual guarantee and distribution activities (G20, 2023), an effort that will also require increasing the entity's administrative capacity to deliver.

Transmission risks are another element that can increase the cost of capital for utility-scale projects in EMDE. If a project cannot be connected to the transmission grid in a timely manner or investors are faced with issues around grid balancing and curtailment, it can create difficulties for the financial appraisal and the estimation of revenue generation. This is not a risk that is unique to EMDE, but it can be exacerbated by slow permitting processes, the deteriorating quality of existing grids and the low level of investment in grid infrastructure. In growing markets for solar PV and wind, this risk tends to increase with an increasing share of solar PV and wind in power generation.

These risks, together with higher base rates, translate into a high cost of capital. The weighted average cost of capital (WACC) for utility-scale solar projects in Mexico and South Africa was around twice that of advanced economies. For example, the average interest rate of a ten-year government bond in Mexican pesos was around 9% in 2022, and around 10% in South Africa, compared with 3% for a USD-denominated ten-year bond issued by the United States. Higher base rates and higher risk premiums result in higher financing costs in EMDE.

2.2.2 Utility-scale solar and wind in maturing markets

Maturing markets comprise countries where wind and solar PV already contribute to over 10% of the total electricity generation along with relatively strong policy and regulatory frameworks. They include countries such as Brazil, Costa Rica, Chile, India and Morocco. In maturing markets, investment into utility-scale wind and solar PV are 75% higher in 2035 in the NZE Scenario than in the STEPS.

These countries generally have had strong and relatively stable supporting regulatory policies for the good part of the past decade that have helped the rapid deployment of wind and solar capacity. These including measures to stimulate the demand for low-emissions electricity; such measures include India's Renewable Purchase Obligations that mandate the purchase of renewable electricity by distribution companies. Such markets also tend to have stated targets for the deployment of clean energy that provide a clear policy signal to the industry.

Countries with maturing markets for solar PV and wind also tend to have an array of supportive elements beyond sector-specific policies. This includes an active and often competitive private sector, strong or rapidly developing governing institutions, a strong judicial system that enforces the sanctity of contracts, and a growing domestic financial market that is a key source of investment flows. In such countries, the cost of capital associated with wind and solar PV deployment might be closer to the best country case among EMDE, although still higher than that in advanced economies. As an example, despite plenty of solar resources, domestic solar module manufacturing and steadily growing electricity demand, the cost of capital in India for utility-scale solar PV is still more than double that in Europe.

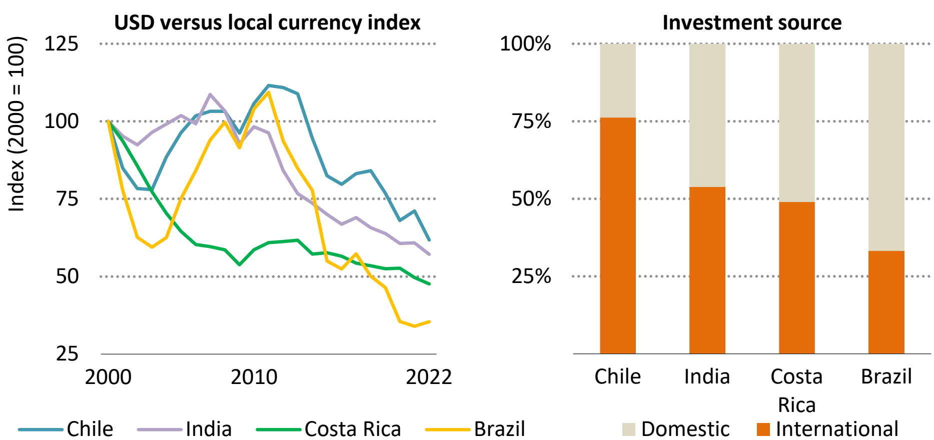
Key factors influencing financing costs

In maturing markets, regulatory risk relates mainly to unexpected changes or lack of clarity in regulation and tariff structures, as well as delays in permitting, licensing and approvals required to commence utility-scale projects. As an illustration, when India started levying a customs duty on the imports of solar PV modules to encourage domestic manufacturing starting in April 2022, it led to shortfalls in the supply of modules, impacting capacity growth (PV-Tech, 2023).

Off-taker risk forms a second major aspect influencing the cost of capital for countries with maturing solar PV and wind markets. For utility-scale electricity generation projects, distribution companies form the largest consumers of the generated electricity. Their ability to pay in full and on time is critical to the financial health of generation companies. However, many distribution companies in EMDE tend to be in precarious financial health for a variety of reasons, including the lack of tariff reform, transmission and distribution losses, power theft, and inefficient management. As a result, there is a risk that these off-takers are not always able to make payments on time, affecting the ability of generation companies to service their debt and meet their operational requirements.

India provides a useful illustration of this. As of November 2023, there were USD 9.6 billion in outstanding dues to electricity generation companies from distribution companies (DISCOMs) (Ministry of Power, 2023). On average, payments by DISCOMS were made 160 days late nationally, almost four times as high as the targeted 45 days (Government of India, 2023). Already in 2015, the Indian government initiated the Ujwal DISCOM Assurance Yojana scheme which allowed the financial restructuring of DISCOMs. In 2022, the government further adopted the Late Payment Surcharge rules that enforce a penalty on DISCOMs for late payments to generation companies and within a year of enforcement, the total outstanding dues by DISCOMs decreased by a third (Mercom, 2023).

Figure 2.3 ▻ Index of US dollars relative to the exchange rates of key countries in the maturing archetype, 2000-2022, and sources of investment for wind and solar PV generation, 2022



Currency risk can be a key obstacle to attracting international capital, especially as local currencies continue to depreciate

In countries with maturing markets for utility-scale wind and solar PV, currency risk also plays a significant role, as domestic markets often are not deep enough to fully provide the capital required to meet clean energy deployment targets, and international capital becomes more important for further buildout. Among the selected countries in this group of countries, international investment spending – often made in currencies such as US dollars or euros instead of local currencies – is currently responsible for around half of the total investment for utility-scale wind and solar PV deployment. Looking forward, international investment spending will need to triple by 2035 compared with 2022 under the NZE Scenario, far outpacing the growth in domestic spending. Given these dynamics, local currency devaluation and exchange rate fluctuations contribute significantly to uncertainty around expected returns, and in turn increase the cost of capital. In addition, there is an associated transaction risk as procurement costs for imported equipment can rise unexpectedly as purchases are often made in US dollars or other internationally accepted currency.

In fact, local currencies of some countries with maturing markets have devalued by half against the US dollar since 2000 (Figure 2.3). The impact of this was particularly evident in Brazil, whose currency devalued by nearly half within five years starting in 2013 and which started to auction solar PV capacity for nearly 900 megawatts (MW) in 2014. However, as the Brazilian real plunged, the value of the PPAs that were awarded fell by 36%, resulting in the cancellation of several projects as they had become economically unviable (Warren, 2017).

As this report focuses on interventions within the remit of energy policy makers, the next section discusses key recommendations to reduce the cost of capital by measures within the energy sector. Meanwhile, Box 1.4 in Chapter 1 of this report discusses currency risks. In addition to these three key risk categories, a key factor that influences the cost of capital in this archetype includes the adequacy of grid interconnections and related infrastructure.

2.2.3 Key recommendations to reduce the cost of capital

Reducing the cost of capital requires addressing multiple risks and improving various dimensions of the investment proposition of utility-scale renewables in EMDE. Some of these considerations apply across various countries and also affect other power-related investments beyond generation such as grids. National governments, with the help of DFIs, need to strengthen efforts to improve the fiscal status of DISCOMs – especially in Africa and Southeast Asia, as well as in some Indian states. This can be done through financial restructuring, tariff rationalisation and reform, reduction of transmission and distribution losses, improved metering, and cost reductions. Other measures depend on the country's grouping:

Measures needed in countries with growing markets:

- **Reduce off-taker risk by expanding credit enhancement mechanisms**. Covering non-payment delays is key to help a sector where generally low-creditworthy SOEs are the main counterpart in PPAs to private investors. For instance, a capital increase for MIGA, or other similar institutions, could enable an increase in its ambition – provide more guarantees in a broader set of countries and slightly riskier projects – and get transactions done faster. Well-designed PPAs, following international standards, can also help to reduce risk perceptions and in turn lower the need for payment or other guarantees.
- **Continue developing the market with competitive procurement programmes tied to a clear long-term strategy**. Providing visibility over the project pipeline and bankability of long-term contracts is key to facilitate transparent price formation and learning that

helps reduce the cost of capital. Where guarantees are needed, these should be incorporated in the packages offered at the procurement stage.

- **Expand transmission infrastructure that can enable renewable power projects and electricity integration between countries, while testing out business models for privately financed transmission**. (see recommendations in the Grids section).

Measures needed in countries with maturing markets:

- **Incentivise grid flexibility**. Introduce measures to deploy power system flexibility with appropriate regulation, market rules and technical standards. Further, adapt solar PV and wind tenders to incorporate and reward the supply of storage and solutions that improve the system flexibility, frequency regulation and demand response.
- **Continue ensuring timely and full payments to generation companies**. Off-taker risk is a relatively lower risk in various Latin American countries such as Brazil, Chile, Costa Rica and Uruguay, but remains a prevalent concern in countries such as Argentina and some states in India, where tailored risk mitigation solutions may be required.
- **Prepare tenders to allocate transmission lines around green corridors**. As the share of renewables increases, it is easier to earmark transmission lines as "green", given these are needed almost exclusively to evacuate existing or expected solar and wind. Their green characteristics could attract high levels of private international capital.

S P O T L I G H T

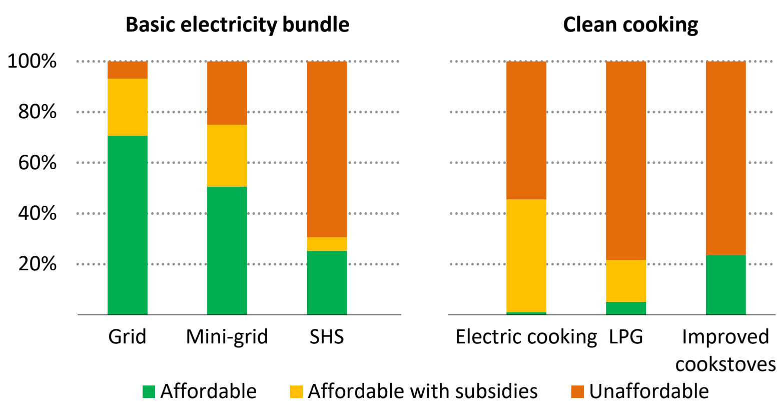
Achieving universal energy access by 2030

Today 760 million people lack access to electricity (80% of whom live in sub-Saharan Africa) and over 2 billion people lack access to clean cooking, primarily in developing Asia and sub-Saharan Africa. Providing access to these households requires spending of roughly USD 38 billion per year – which although a small number in terms of overall energy investment, reflects a fivefold increase on spending levels from today. The spending gap is particularly acute in Africa, especially in relation to clean cooking: around half the people without clean cooking are in Africa, but the region accounts for only 7% of clean cooking investments over the last five years (IEA, 2023a).

Under the NZE Scenario, which achieves the objective of Sustainable Development Goal (SDG) 7, for universal energy access by 2030, 45% of those currently lacking access to electricity are connected via the grid. For the remaining share, 30% rely on mini-grids and 25% will access electricity via stand-alone systems – mostly solar PV based. Nearly half – 45% – the households that gain access to clean cooking do so via liquefied petroleum gas and 12% via electric cooking, with improved cookstoves playing a key transitional role in rural areas where fuel and electricity infrastructure are lacking. The financing models for these distributed systems are significantly different from other parts of the energy system given their smaller scale and the concern around non-payment risks associated with the end users.

Affordability constraints act as a major brake on future energy access projects (Figure 2.4). For example, only around half of households receiving a new electricity connection in Africa would be able to afford the most basic electricity services without financial support; most clean cooking projects (except for improved cookstoves) would not be affordable (IEA, 2023b). Existing financial support for energy access comes in the form of reduced connection charges, social tariffs or, less frequently, subsidised appliances, often provided by governments and DFIs. However, rising debt levels in EMDE limit governments' ability to increase financial support, with concessional capital likely playing a larger role. Without this financial support, many projects would be rendered too expensive for households to maintain while also being not commercially viable for private sector involvement.

Figure 2.4 ▷ Affordability of energy access projects based on existing subsidy regimes in Africa



Affordability acts as an increasingly significant constraint in achieving universal energy access, particularly in relation to clean cooking

Notes: SHS = solar home system; LPG = liquefied petroleum gas. "Basic electricity bundle" refers to a system with multiple light bulbs, a radio and a phone charger (IEA, 2023c). In the analysis it is assumed that upfront costs are spread over the infrastructure or product lifetime. The analysis is based on household income data by percentile (World Bank, 2023)and a solution is considered affordable if its cost is lower than or equal to 5% of household income.

Given the price sensitivity of consumers, keeping the cost of capital low is paramount. Taking advantage of climate finance and growing carbon markets can be one means to reduce equipment costs and increase the revenue streams of projects. However, many energy access projects involve local small and medium-sized enterprises (SMEs) that can struggle to access affordable capital. International companies have the resources and historical track record to facilitate access to concessional funding, notably grant support or blended private equity, that can allow them to keep costs down. But local SMEs rely on domestic commercial banks that are risk-averse and lack familiarity with energy access business models and offer cripplingly high interest rates and collateral requirements.

While reducing the cost of capital will help increase the involvement of the private sector for commercially viable projects, the reality is that grant or other highly concessional funding will need to play a substantial role. This is particularly true for clean cooking and electricity access projects for lower-income households including in fragile and conflict-prone states. In 2019 (latest available data), grants accounted for 37% of financing for mini-grids and off-grid projects, and 52% of clean cooking projects (SE4All, 2021). However, this grant support is often limited to a handful of large projects – for example, grant capital in 2019 supported only 12 clean cooking projects. To reach SDG 7, the scale and accessibility of this grant capital needs to expand, with an emphasis on the last mile.

2.3 Grids

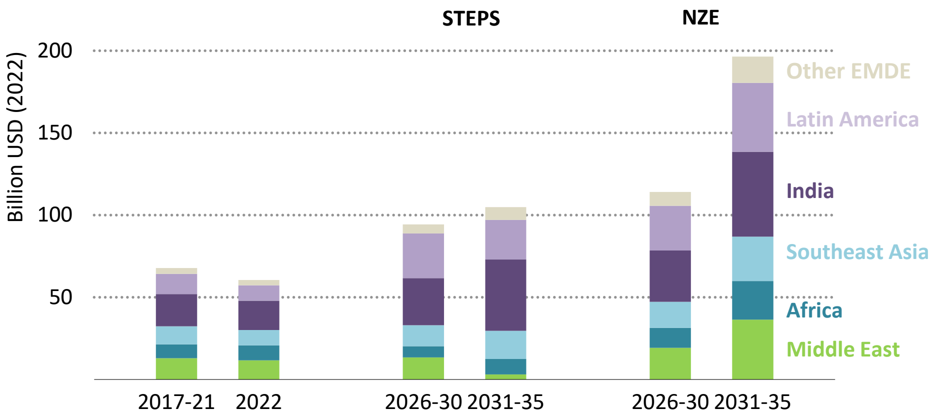
Investment outlook, sources of finance and sector development

EMDE collectively invested USD 67 billion in electricity networks in 2022, a quarter less than before the pandemic. This level of spending falls well short of the amounts required to accommodate growing electricity demand and the expanding deployment of renewables, which have been experiencing annual growth of more than 10% since 2017 and which need to triple in the NZE Scenario by the early 2030s (Figure 2.5). The cost of not doing so would slow the development of renewables, raise costs and heighten security concerns (IEA, 2023d). Reducing the cost of capital is key to achieve the energy transition, given grids are very capital-intensive assets.

On a global scale, the financing for transmission and distribution from SOEs amounted to USD 45 billion in 2022, with DFIs contributing USD 6 billion, one-third of which was concessional. To mobilise sufficient capital required in the NZE Scenario, a yearly USD 20 billion in DFI financing will be needed over the 2031-2035 period, a significant amount of which would be concessional.

The market structure and financing of transmission and distribution grids varies globally, ranging from regions with vertically integrated state-owned national utilities (or SOEs) to regions more open to private participation. These variations result in unique financial frameworks, risks and financing costs that are contingent on the specific region (see Box 2.2 on Africa). Table 2.2 describes the most typical business models applied in the transmission and distribution sector in EMDE.

Figure 2.5 ▹ Investment in electricity grids in EMDE in the STEPS and the NZE Scenario, 2017-2035



Investments in electricity grids in EMDE need to be scaled up to align with the NZE Scenario

Unbundling is more likely to be successful in a structure that ensures dependability of cash flow and affordability. Additionally, implementing a model with a higher private participation requires changes in legislation, redefining responsibilities across different entities such as regulatory bodies and transmission and distribution companies. However, there are numerous cases where introducing private sector participation led to increased investment in grids. This was the case in various Latin American countries, the Philippines and some portions of the Indian network. To be successful, these approaches need to be adapted to the local context.

The cost of capital in markets led by public entities and those with higher private participation is influenced by distinct factors, the reason we separate the discussion into two analytical groups. Many countries may fall into an intermediate stage rather than strictly aligning with one of these groups, but these two serve as reference points or guides for understanding the variations in cost of capital across different market structures:

- **Publicly led grid financing**: examining state-owned companies and their vertically integrated transmission and distribution business models, using the case of Indonesia.
- **Privately led grid financing**: exploring transmission and distribution business models in countries with substantial private sector participation, featuring concessions and independent power transmission (IPTs), using the case of Brazil.

Table 2.2 ▹ Diverse models for transmission and distribution projects cater to country-specific contexts, and macro components

Main business model	Ownership and control	Financing	Cost of capital drivers	Countries
Mainly state owned	• Transmission and distribution owned by government/public entity • Vertically integrated • Pricing, investment and operational decisions controlled by government • No competition	• Infrastructure financed through SOEs/ government budget, so financial health of the system is key • Limited private participation	• Financial health of the SOE/government • Cost-reflective tariffs • Payment risk	Indonesia, Viet Nam, Thailand, Egypt, Morocco, most countries in sub-Saharan Africa, Uruguay
State owned and whole concessions	• Entity is granted a concession to operate and manage the transmission or distribution line • Vertical separation • Pricing, investment and operational decisions controlled by government • Low-medium competition	• Concessionaire responsible for financing its corresponding zone, which can be a mix of public and private financing • Medium private participation	• Regulation framework • Cost reflective tariffs • Visibility of grid enhancement investments and operation costs • Off-taker risk, demand risk	Philippines, Pakistan, Uzbekistan
Concessions and IPTs	• Sections of transmission/distribution are tendered to private entities • Flexible and modular approach to transmission extensions: ownership can be transferred to state or remain private • Medium-high competition	• Concessionaire responsible for funding, private-public joint ventures, special purpose vehicles • Project finance for IPTs: funding against project viability and cash-flow return	• Regulation framework • Cost-reflective tariffs	Brazil, Peru, Colombia, Chile, India (interstates)

Note: IPT = independent power transmission.

2.3.1 *Publicly led grid financing*

In publicly led grids, as observed in most African and Southeast Asian countries – notably Indonesia and Viet Nam – operations rely heavily on SOE balance sheets, and ultimately governments. Typically, it also involves concessional debt acquired through DFIs and export credit agencies. Where financial structure is not isolated from the corporate balance sheet, financing capacity and cost of funding are directly linked to the financial health and liquidity of the SOE rather than the grid project itself. The government's debt ratio and repayment ability play a crucial role in determining the level of the cost of capital. Grid investment costs are typically recouped through regulated tariffs (as in privately financed concessions), which are passed on to off-takers to cover operation, maintenance and financing costs. Thus, when evaluating the bankability and risks of a transmission investment, the design of tariffs also emerges as a significant factor.

Capital structure of a transmission and distribution project development would typically rely on concessional finance from development banks and state-owned company loans. Additionally, grants and guarantees may also be part of the financial structure.

The most pressing risks affecting cost of capital in publicly led grid systems are identified as the following:

- **Financial sustainability risk:** level of financial well-being of state-owned corporations
- **Tariff risk:** tariff cost-reflectiveness and sustainability.
- **Regulatory risk**: related to planning, business model design and procedures for private participation.

Key factors influencing financing costs

Transmission and distribution projects in publicly led markets are generally funded through the balance sheet of SOEs and development finance debt, often at preferential rates contributing to an overall low cost of capital for these initiatives. Information on the overall cost of capital (excluding concessional sources) is very limited, though, making it challenging to assess the impact of risks on the currently low financing cost.

In considering the risks that impact on cost of capital, the financial well-being of state-owned corporations is crucial. State-owned entities' financial health is often poor, with grid returns being both insufficient and uncertain. Many government corporations depend heavily on concessional debt and a significant share of the revenues coming from subsidies. One example is Indonesia, which reported 20% of revenue coming from subsidies (PNL, 2022).

Mobilising private investment into publicly led sectors faces challenges because of the inherent weakness of regulatory frameworks. In Indonesia, despite the legal provision allowing the private sector to operate grids, as per the 2009 Electricity Law, there is no robust regulation concerning technical procedures and financial charges for network access, and this model has only been applied for generation projects in Indonesia. Moreover, the lack of a regulatory track record presents a significant obstacle in establishing trust from investors.

The predictability and planning of projects also translate into an important risk, as project closures deviate from the initial budget and scope. The uncertainties in these projects directly impact the perception of project risk and contribute to fluctuations in capital costs. However, this risk can be better managed if lending is directed towards specific objectives of the project development. Some projects in Indonesia, for example, have adopted a results-based lending approach, a first of its kind for grid projects, which prioritises delivering specific and measurable results and encourages performance improvements. Publicly led grids in EMDE face significant challenges including financial challenges of their state-owned corporations, uncertainties in project closures and a deficient regulatory framework. These factors collectively elevate perceived risks which ultimately translates into higher financing costs for SOEs.

Box 2.2 ▷ Looking beyond financing costs to boost Africa's grid investments

Grid investments in Africa need to more than triple by 2030 to meet sustainable development goals, including universal access. This investment is essential to improve reliability of existing infrastructure and to support the growth of renewable power generation. However, it requires a major step change from the past, with grid investments in Africa growing at only 5% between 2019 and 2022. While strategies to lower the cost of capital will play an important role, a holistic approach is necessary that improves the financial health of utilities, protects vulnerable consumers while introducing market-based pricing signals, and upgrades the regulatory environment.

The vast majority of investment in grids in Africa today – nearly 90% – is carried out by SOEs. Many of these utilities are highly indebted with low liquidity and reliant on budgetary support. Only about one in three utilities in Africa recovers its operational and debt servicing costs, including subsidies from central government; excluding such subsidies, the ratio drops to one in four. High debt levels are often driven by low collection rates, the lack of cost-reflective tariffs and costly electrification projects.

Strengthening the financial position of these SOEs would be one of the impactful measures to increase spending on grids. Steps to support this can include the introduction of cost-reflective tariffs – currently present or under discussion in 26 countries in Africa - and the expansion of decentralised approaches, such as mini-grids and stand-alone systems, for energy access projects in rural areas that are costly to reach with a grid connection and often end up as loss-making for a utility due to low demand.

The private sector can also start to play a larger role in the sector. Today, although 30 countries allow private participation in generation, only four allow private participation in transmission. Many utilities in Africa also lack access to capital markets to raise private debt since their credit ratings are below investment grade. Innovative approaches are being tested, such as the first-of-its-kind IPT in Kenya. Under this approach, demand risk is effectively allocated to the state-owned transmission company. That said, the project is most likely to be successful if developed near industrial off-takers, which are considered less risky from demand and affordability perspectives. If successful, it could help reduce the perceived risk around private sector involvement in grids in Africa and serve as a model for other countries in the region.

2.3.2 Privately led grid financing

Countries classified as privately led are those where portions of the grid are tendered to private entities, and the concessionaire bears the responsibility for financing and operating the transmission and/or distribution infrastructure for a certain period of time. Unbundling and/or privatisation has been undertaken through various business models: concessions (private sector in charge of investing and operating current and new lines in an entire geographical zone for 25 years or more), privatisations (similar to a concession but generally for an indefinite period), IPT (private sector in charge of investing and operating a new line over 20-25 years) and merchant lines (taking full volume and price risk against the wholesale power market). Various countries in Latin America, India, and some countries in South and Central Asia such as Pakistan and Uzbekistan have substantial private sector participation in transmission or distribution grids, or both.

Unlike concessions, an IPT model is characterised by being modular and involves tendering for a specific transmission line, or a package of lines, offering more flexibility in terms of asset ownership and risk allocation. This is a model applied only to transmission though, not distribution. It is also a business model that can be tested while the majority of the grid continues to be operated and financed by the SOE. The IPT is similar to the independent power producer model in generation, which has been relatively successful at attracting private capital in various EMDE. Brazil, Colombia and Peru are examples of countries that apply the IPT model in transmission, and Kenya has also pioneered with two private transmission projects for around 230 kilometres that will start construction in 2024.

Common financing structures for these transactions include commercial lending, multilateral lending and bonds from local capital markets. Funding typically comprises a blend of public bank loans – backed by guarantees from commercial banks, bonds and shareholder capital.

In privately led grid systems, the main risks encompass:

- **Remuneration risk**: level of adequacy of remuneration to reflect costs and adjust to macroeconomic circumstances.
- **Regulatory risk**: predictability and robustness of the regulatory framework.
- **Permitting risk**: lack of legal framework that can cause risk of delays.

Key factors influencing financing costs

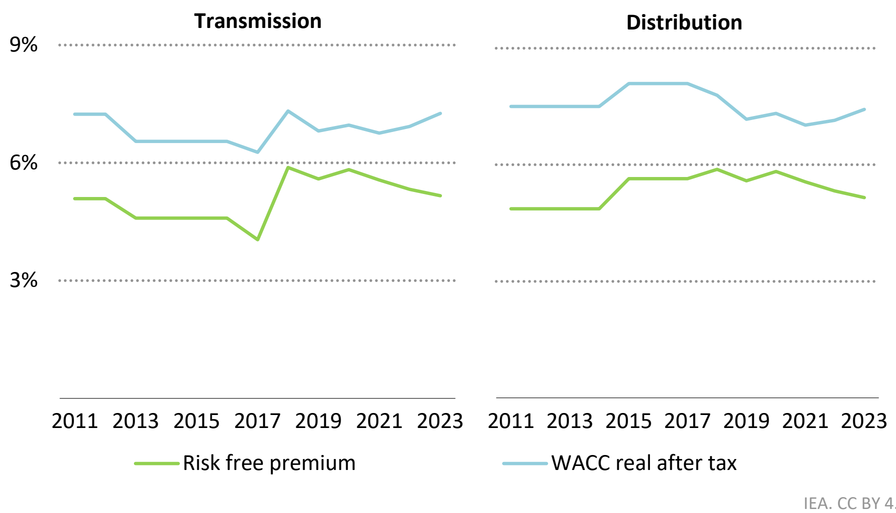
In the privately led financing models, revenues – and in turn financing costs – are determined differently:

- In the case of transmission and distribution concessions, revenues are set by the regulatory authority, typically based on operational performance, investment costs and a fair return on investment. Revenue is adjusted by a periodical tariff review, hence its reliability over time significantly affects the overall financing costs of the project.
- In IPTs, revenues are mainly determined upfront by the winning bid of a competitive tendering process. These are not adjusted over time so regulatory risk tends to be lower. Incentives are tied to the availability of lines during the contract period (above 95%) rather than usage, shifting demand risk away from the grid developer. These projects are also generally financed through project finance structures.

Latin America in particular has attracted a higher share of financing from private sources than many EMDE (IEA, 2023e), and Brazil is an example where the two privately financed models co-exist. In the case of concessions, the regulatory body determines a WACC that is used to calculate the revenue cap. Argentina and Colombia also have concessions in power distribution and use similar WACC calculations to compute the regulated revenue. Other countries such as Bolivia, Chile and Guatemala regulate a return over assets using the industry as a proxy.

The returns in Brazil's concessions have proven to be quite stable over time (Figure 2.6), contributing to investors' confidence, attracting more players, and a greater success rate for auctioned lots after 2017. A regulated return that accurately captures risks in grid projects is likely to mobilise more investment and have a positive impact on the cost of capital.

Figure 2.6 ▹ Regulated WACC and risk-free premium in Brazil



Brazil's regulatory body determines the WACC for concessions. Stable and predictable WACCs have been key to attract private investment to transmission and distribution

Sources: (ANEEL, 2023). Risk-free premium calculated by Brazil's regulator ANEEL, based on national treasury bond indexed to consumer index prices.

As for IPTs, the discount rates for the winning bids have been gradually growing since 2015, showing a more competitive environment and a greater success rate for auctioned lots.

Risks of permitting delays and legal access to projects also have a significant impact on financing costs, for both concessions and IPTs. Delays are frequently encountered, especially if the legal procedures are complex and there is a lack of solid regulatory infrastructure to facilitate the process. Project development delays are also a risk and can translate into a fine by the regulatory body, which ultimately affects the perceived risk of the investment.

2.3.3 *Key recommendations to reduce the cost of capital*

Similar to some challenges faced in the power generation sector, addressing the financial predictability of projects is key for grid investments. Countries, particularly in Africa and Southeast Asia, require concrete efforts from national governments and DFIs to enhance the fiscal health of state-owned transmission and distribution companies. Some key measures include financial restructuring, cost-reflective tariff adequacy and developing a reliant regulatory framework.

Measures needed in publicly led grids:

- **Improve the financial health of SOEs in collaboration with DFIs.** Additionally, perform tariff reforms to ensure profitability crucial element for the financial sustainability of the SOE. Establish cost-reflective and predictable remuneration, ensuring off-taker affordability is the main objective.
- **Employ blended finance mechanisms that involve DFIs** as a strategic approach to mitigate project risks effectively and enable the unlocking of crucial additional investments in projects that are most needed. Use innovative financial approaches to help capture more commercial resources and cover financing gaps. Additionally, design targeted funding tied to specific and measurable results, encouraging performance and planning improvements.
- **Kick-start private finance participation** in order to increase investment and alleviate the financial burden of the public sector. While full restructuring or privatisation might not always be politically feasible, targeted investment programmes in transmission, such as those observed in Brazil and Kenya, enable the involvement of private capital to accomplish specific policy objectives. Private participation models such as IPTs can facilitate investments in grid infrastructure, offering investors certainty while remaining accountable to the government, and can be used to test the model in the market. It is crucial to supplement these models with robust regulatory monitoring tools to ensure the timely and cost-effective delivery of projects, as described below in the measures for a privately led grid sector.

Measures needed in privately led grids:

- **Introduce or maintain cost-reflective and predictable remuneration in order to mitigate risks of tariff regulation.** Developing a remuneration system that accurately reflects costs and aligns with appropriate incentives (e.g. grid performance in the case of concessions and line availability in the case of IPTs). Regular adjustments, synchronised with economic indicators and responsive to regional conditions, are essential elements, as demonstrated in the Brazilian context.
- **Set up a robust regulatory framework that encourages more power infrastructure development.** Maintain clear and transparent guidelines for concessions. A strong regulatory framework, intricately tied to comprehensive national planning with a clear project pipeline, has demonstrated the capacity to attract a substantial share of

required financing from private sources. Also, simplifying permitting to effectively mitigate project risk.

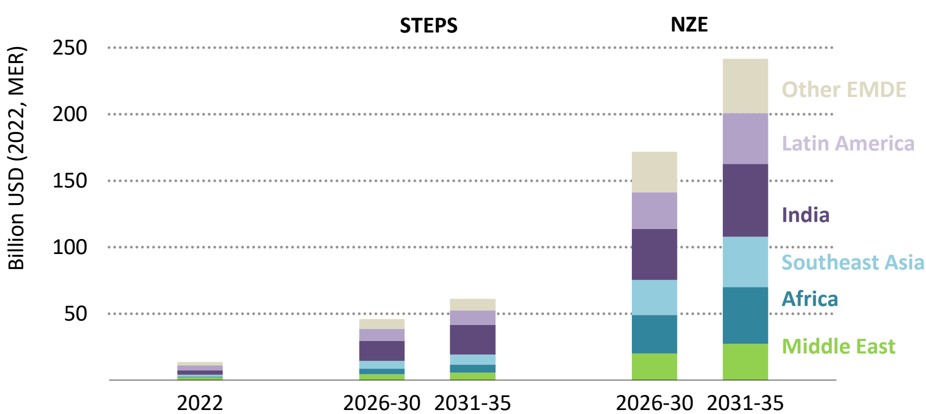
- **Use blended finance** to manage risks and mobilise private capital, particularly in regions that are in early stages of private participation. Direct the blended finance to specific projects in order to build a reliable track record and increase the overall attractiveness of investments in the region.

2.4 Energy efficiency in buildings

Investment outlook, sources of finance and sector development

In rapidly urbanising EMDE, investment in energy efficiency and electrification in the buildings sector is critical to keep the pathway of the NZE Scenario within reach, especially as urban residents tend to consume more energy than those in rural areas, in large part because of differences in income levels (Figure 2.7). Emissions from the buildings sector currently accounts for about 30% of the global energy sector CO_2 emissions. While STEPS points to a slight decrease at the global level, the scenario also anticipates a 10% increase of CO_2 emissions from the sector by 2035 in EMDE.

Figure 2.7 ▷ Investment in energy efficiency and electrification in EMDE in the STEPS and the NZE Scenario, 2022-2035



Investment in electrification and energy efficiency in EMDE in the STEPS is well below what is needed under the NZE Scenario.

Buildings vary in size and scale, spanning from small residences to commercial skyscrapers. With a long lifespan, their design typically locks in emissions and energy consumption patterns for many decades, and the efficiency and emissions characteristics of the building inventory play a progressively crucial role in sustainable development in EMDE. However, investments in building efficiency and electrification in these regions notably lag those in advanced economies and fall short of the levels necessary by the end of the decade to align with an NZE Scenario trajectory.

Investment in buildings is typically carried out by either companies or households and can be classified in two main aspects: the initial envelope investment (i.e. when the building is built) and the retrofit of existing buildings. The split between these two varies by country, depending on the state of development of the housing sector, urbanisation and industrialisation. Investment in retrofitting the existing building stock accounts for a relatively small fraction of overall spending in buildings in EMDE.

Key risks associated with the buildings sector that impacts investments include:

- **Regulatory**: the lack of proper building codes, the capacity of regulatory institutions to implement them and the size of the "informal" construction sector in EMDE.
- **Subsidised residential energy prices** in some regions (e.g. Middle East).
- **Skewed incentives:** including split incentives between owners and renters, and lack of appropriate financing models.

Owing to the lack of adequate energy-efficient building stock in the region, this sector is considered as nascent in EMDE. Very few developing economies have introduced energy efficiency standards for new buildings; India is a notable exception.

Key factors influencing financing costs

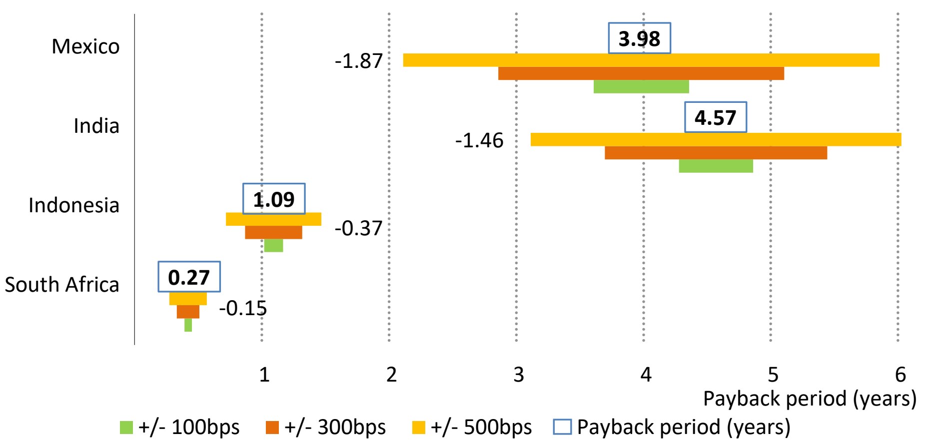
The discussion around the cost of capital for financing energy efficiency and electrification in the buildings sector is less straightforward than for other sectors. Investment in buildings – including new construction, retrofits and appliances – is typically made on the balance sheet of the developer or the tenant, mainly using equity. And the cost of equity or the hurdle rate of a rather small entity, household or SMEs is difficult to accurately quantify.

Achieving greater levels of investment will necessitate increased utilisation of low-cost debt financing. But the extent to which the cost of financing influences investment decisions in the efficiency sector, relative to factors such as regulation or the challenges of implementing efficiency measures, remains uncertain.

In the NZE Scenario, about one-fifth of global investment in buildings, appliances or retrofits is made off balance sheet by 2030 either through energy service contracts or leasing agreements, while more than half is still financed through equity, as the development of green consumer finance (green loans/mortgages) does not yet allow households or companies to use more debt to fund investments in energy efficiency. Commercial banks that need to play a critical role in providing debt for energy efficiency in EMDE are experiencing difficulties in evaluating underlying credit quality for small companies and assets and aggregating loans in portfolios to access refinancing, for instance through green bonds.

For tenants, the upfront cost of new and more efficient equipment is a significant barrier, despite savings over the lifetime of the product (Figure 2.8). The payment options available for consumers, such as on-bill financing schemes with utilities, are also less prevalent in EMDE than in advanced economies. Monetising energy savings into cash flows to secure lower-cost financing from commercial banks can help to reduce payback periods by months, or even years. Such savings can often be best valued through project structuring that aggregates efficiency measures into project sizes that facilitate due diligence and reduce transaction costs.

Figure 2.8 ▻ Payback period for investments achieving at least a 20% energy efficiency improvement and sensitivity to the cost of capital



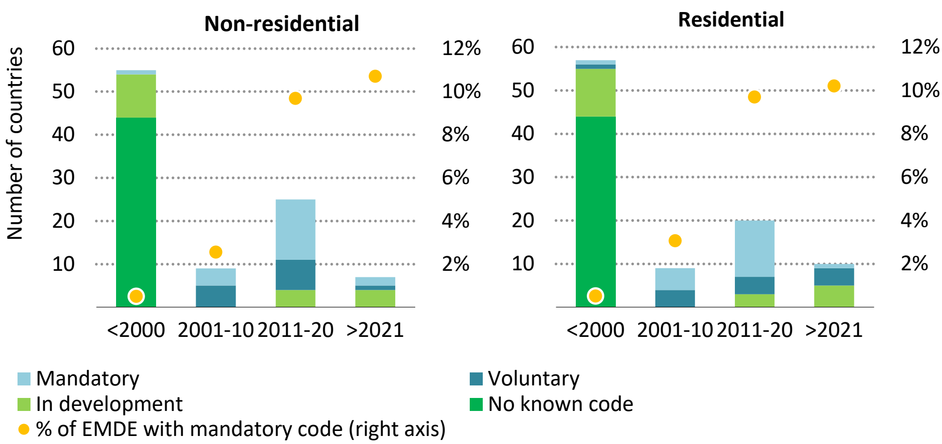
High borrowing costs can have a significant impact on the payback periods for resource efficiency in different economies

Notes: bps = basis points. Estimates assume at least 20% savings in energy, water and materials in the lower-middle-income segment, using the International Finance Corporation's Excellence in Design for Greater Efficiencies (EDGE) tool's default assumptions for each country. WACC: Mexico, 11%; India, 16%; Indonesia, 15%; and South Africa, 14%. Payback periods will be influenced by cost of financing (materialised by the WACC), but all countries do not start from the same baseline. Countries like India and Mexico that have started implementing energy efficiency measures earlier have already deployed the most cost-effective options. Additional implementation will require more investment with longer payback periods compared to countries that are less advanced in this space. Source: Calculations based on the EDGE online tool (2021).

In many cases achieving resource-efficient construction will be cost-effective, and studies point to improved financial returns stemming from investment in green buildings and better performance on indicators such as occupancy rate, time to sell and selling price overall. The upfront cost and the cost of capital of efficiency measures are of course two of the many barriers, but examples in advanced economies show that the cost of financing is not the only variable that determines the decision to undertake an energy efficiency investment (as shown for example by the relatively low adoption rates of zero or low interest financing options in countries like France or the United States).

Local banks play a key role in financing green construction, but in many developing economies, they lack experience in project evaluation. Strengthening their understanding of the energy efficiency market and enhancing due diligence capabilities are crucial. These improvements enable them to allocate green financing effectively, aggregating funds into portfolios that appeal to a broader range of investors, potentially reducing capital costs. Expanding the offering of concessional guarantee mechanisms to energy efficiency portfolios would also help local banks secure cheaper financing.

Figure 2.9 ⊳ Building energy codes in EMDE



Despite recent progress, the adoption and enforcement of stringent and mandatory building codes in EMDE has been sluggish but yields the most impact on investment

Some banks have been established with the specific purpose of investing in assets that accelerate the transition to a low-emissions economy, offering green construction loans, first loss guarantees, or mortgages with a longer tenor or a lower interest. In Mongolia, for instance, the Mongolia Green Finance Corporation was established with support from the Green Climate Fund to help secure financing for building insulation, energy efficiency for businesses and mortgages for green affordable housing.

Green building certification schemes can also be harnessed to facilitate refinancing of green construction projects. For instance, in 2017, two banks in Colombia issued a substantial USD 260 million green bonds dedicated to financing certified green housing developments and two environmentally friendly office buildings. This initiative showcased the feasibility of securitising investments in green buildings, effectively marketing them to private investors and contributing to an overall reduction in the cost of financing. Such innovative financial instruments demonstrate the growing recognition of the value and sustainability of green building projects, paving the way for broader adoption and support from both public and private stakeholders.

2.4.1 *Key recommendations to reduce the cost of capital*

Lowering the cost of capital in buildings energy efficiency can improve the return profile and may tip the perception that investing in efficiency is expensive and offers low returns, even though the cost of capital itself is not the main barrier in this sector. The cost of capital will benefit from the overall improvement of the landscape for energy efficiency in any given region. Some of the key measures include:

- **Strengthen regulatory frameworks for buildings efficiency**, including through building codes and minimum performance standards. The key aspect of energy efficiency adoption remains enabling policies and the adoption of stringent mandatory building codes, explicitly covering energy efficiency. While encouraging progress has been made in recent years, many EMDE have yet to adopt building codes (Figure 2.9). Furthermore, the adoption of building codes has not necessarily led to effective implementation owing to the lack of capacity by regulatory and municipal institutions.
- **Promote a diversity of local and easily available financing options** to build capacity and lower the cost of capital. Reliance on public, highly concessional financing will be high in nascent, risky markets, where no return is expected. Transactions will typically be conducted by very specialised companies, such as energy services companies, often tied to public utilities. With a bigger market and appropriate enabling mechanisms in utility regulation, public companies can start using on-bill financing mechanisms with the support of credit lines from DFIs. In nascent markets, the signalling impact of procuring energy-efficient public buildings also serves as a pioneering influence.
- **Phase out inefficient energy subsidies** to curb inefficient energy use and encourage adoption of energy-efficient solutions. Subsidies, where necessary, can be better targeted to low-income households. Furthermore, with the active involvement of distribution companies, households can be incentivised to adopt energy efficiency measures through innovative financial tools and awareness-raising initiatives.

2.5 Electric mobility

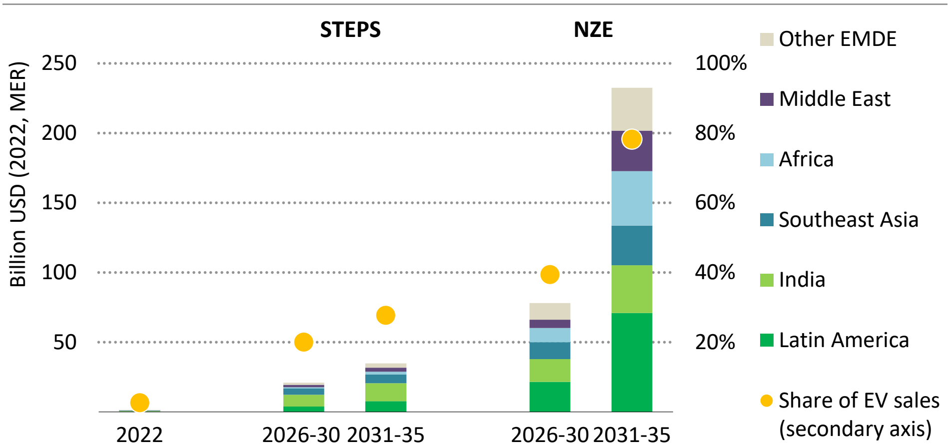
Investment outlook, sources of finance and sector development

Electric mobility is the main vector to decarbonise transport, in particular personal mobility, yet EMDE currently make up only a small portion of the global electric car market (Figure 2.10). Despite a recent uptick in demand for electric vehicles (EVs), sales remain low. The primary mode of electrified urban road transportation in the majority of EMDE consists of two- and three-wheelers, which have experienced significant success and are commonly employed for shared mobility in regional commuting. Purchasing patterns for cars in most EMDE are characterised by low rates of personal car ownership and a trend of acquiring used cars. The key risks affecting the development of electric mobility in EMDE can be categorised as follows:

- **Financing risk and affordability**: including limited access to debt financing and high cost of borrowing in EMDE.
- **Ecosystem risk**: the absence of proper EV charging infrastructure and proven business models and lack of dedicated private charging due to poorly defined property rights.
- **Regulatory risks:** lack of clear policy signals on emissions reduction targets from the transport sector and support in the development of manufacturing capacity to boost the role of EMDE in the EV value chain.

In the NZE scenario, a combination of policy support and strong underlying economics drives the transition towards efficient and electrified vehicles with lowered manufacturing costs and expansion of debt-financing and auto-leasing services. India and Latin America become two of the largest EV markets in EMDE to 2030, from a low base. By 2035, all light duty road passenger vehicles (EVs and two- and three-wheelers) sold are electric.

Figure 2.10 ▹ Investment in electric vehicles in EMDE in the STEPS and the NZE Scenario, 2022-2035



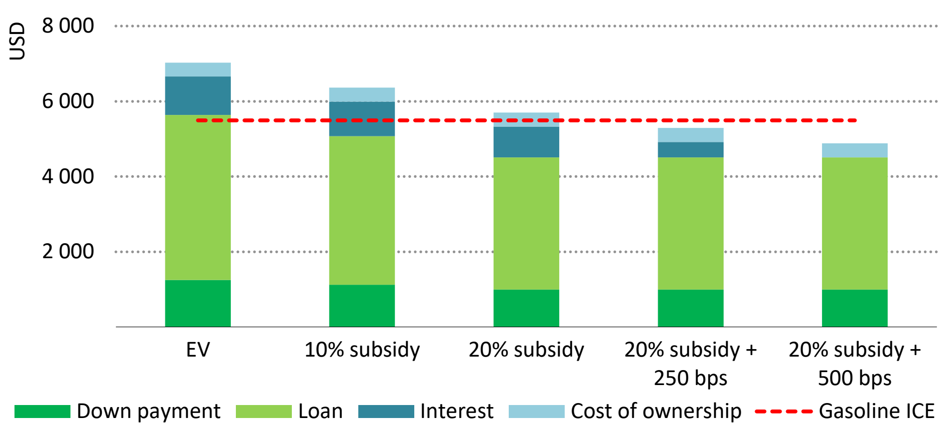
Investment in electric mobility ramps up significantly in the 2030s in the NZE Scenario, as adoption picks up in EMDE

Key factors influencing financing costs

Acquiring EVs poses a significant challenge for most consumers in EMDE, primarily due to the high upfront costs, including higher financing costs compared with advanced economies and a premium when compared with internal combustion engine vehicles. The value proposition for EVs is distorted in some markets by subsidies for gasoline and diesel. Effective decision-making in investments related to swift energy transitions hinges on addressing the inherent risks to electric mobility listed above.

In advanced economies, the average EV purchase price is around 1.5 times higher than for comparable passenger vehicles. For the same price of EVs, the consumers in EMDE bear higher financing costs than those in advanced economies due to higher interest rates and lower availability of debt (Figure 2.11). They also have less access to service models such as leasing. While financing terms vary considerably by geography, the cost of consumer debt can range from 4% to 18% (in real terms). By contrast, consumers in other markets can often finance over 90% of the purchase cost with auto loans or pay less upfront capital with a lease contract though local service agencies or on commercial terms.

Figure 2.11 ▹ Annualised total cost of ownership for EVs in EMDE, by incentive level and financing cost reduction



Lowering the cost of borrowing by just 100 basis points can move up the break-even point between EVs and ICEs by several years

Note: bps = basis points; ICE = internal combustion engine vehicles.

As with investment in energy efficiency in the buildings sector described above, the cost of financing is not the primary barrier to wider EV adoption in EMDE, but the lack of available cheap debt hinders deployment of an asset that is typically financed through consumers or SMEs' own equity. Deploying the right incentive mechanisms, including the availability of cheaper debt, can help to remove those barriers and foster wider adoption.

2.5.1 Key recommendations to reduce the cost of capital

Reducing the cost of capital for electric mobility in EMDE requires addressing these key aspects:

- **Expand consumer access to low-cost auto loans, leasing models and widely available charging infrastructure.** While battery costs have been going down significantly, and manufacturers have tended to lower prices, acquiring an EV remains a very significant purchase for consumers in most of EMDE. Reducing financing costs through standardised low-cost financing or mainstreaming the use of leasing programmes, where customers pay a small rent per month, will increase EV adoption in EMDE.
- **Offer fiscal incentives and subsidies to promote the adoption of EVs while simultaneously initiating the gradual reduction of subsidies allocated to fossil fuels.** Several advanced economies have implemented fiscal measures, such as bonuses, to encourage the widespread adoption of EVs, and these initiatives have demonstrated notable success. Leveraging fiscal incentives as a strategic tool to accelerate the transition from internal combustion engine vehicles to EVs and develop a reliable charging infrastructure can effectively expedite the adoption process by advancing the break-even point between the two technologies.
- **Increase concessional support availability for electrification of mass transit public transportation.** Some successful concessional support has been directed to the electrification of public transit, especially in India, where DFIs have been working with the government on its e-bus procurement programme, which aims to eventually deploy 50 000 electric buses, along with the necessary charging infrastructure. Similar initiatives were carried out in other places such as Chile and Colombia. For private sector manufacturers, the support of concessional finance, combined with a relative certainty over e-bus orders, can help secure cheaper capital. Using the availability of the green debt market or blended finance mechanisms may also help lower the overall cost of financing at the system level.
- **Implement mandatory emissions reduction targets for transport.** Several EMDE have incorporated vehicle efficiency and the electrification of transport as integral components of their economic development plans. Nearly 70% of them have established targets for the deployment of EVs. In the NZE Scenario, strong policy measures such as mandatory emissions reduction targets for new cars and mandatory EV quotas are rapidly put in place. These aspirations face obstacles tied to securing initial capital from a segment of buyers, particularly consumers and SMEs, who face a more constrained access to finance. Direct support from policy makers will drive faster EV adoption and foster the development of a greater local EV manufacturing capacity. Some countries, mostly advanced economies, are considering low-cost leasing models to allow low-income households to access electric mobility (e.g. the EUR 100 a month lease programme in France).

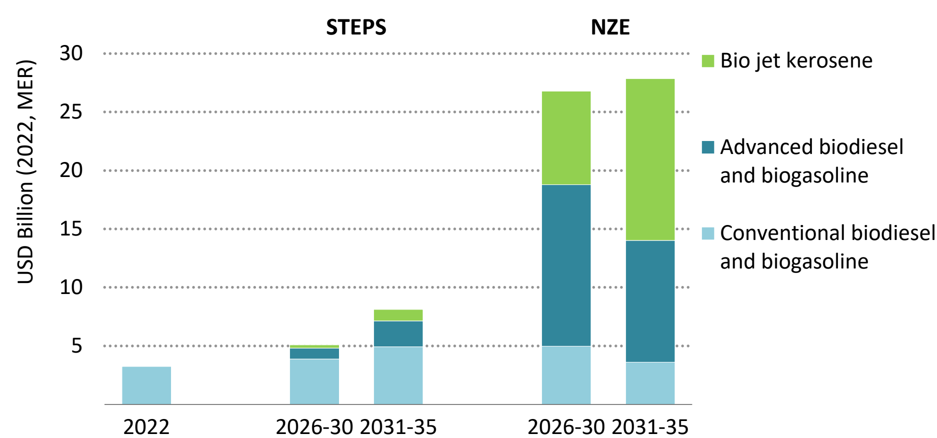
2.6 Advanced biofuels

Investment outlook, sources of finance and sector development

Liquid biofuels play an important role in decarbonising transport. They can often be used in existing engines with little to no modification, and there is growing interest and investment in "drop-in" biofuels that can entirely substitute for diesel and gasoline. Total liquid biofuel demand reached a record high of around 2.2 million barrels of oil equivalent per day (mboe/d) in 2022. Most of this production currently uses so-called conventional feedstocks, such as sugar cane, corn and soybeans. Expanding production to advanced feedstocks is critical to ensuring minimal impact on land use, food and feed prices, and other environmental factors. In the analysis below we focus the discussion and recommendations on advanced biofuels as there is significant potential in EMDE to leverage agricultural residues and municipal waste as sustainable feedstocks, thereby moving away from conventional biofuels.

Investment in liquid biofuels, excluding feedstocks, totalled USD 3 billion in 2022, comparable to the last five years. Around 35% of global spending was in EMDE. The largest producers are Brazil, Indonesia and Argentina, which collectively produced 0.60 mboe/d (or 30% of the global total). In the NZE Scenario, investment rises significantly to 2030, with a much larger share produced from waste and non-food crops. Aviation biofuels make the most dramatic strides between now and 2030 in this scenario (Figure 2.12).

Figure 2.12 ▷ Investment in liquid biofuels in EMDE in the STEPS and the NZE Scenario, 2022-2035



Investment in liquid biofuels grows ten-fold in the NZE within a decade. Advanced biofuels lead growth, and require more financial support than conventional projects

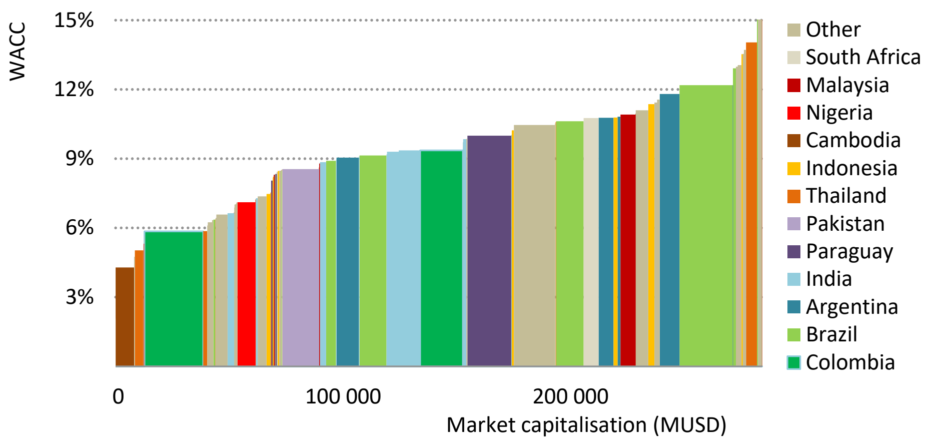
Note: Figure shows advanced versus conventional biofuels production in EMDE rather than a regional breakdown to highlight the importance of directing investment in advanced feedstocks.

Blending mandates, low-emissions fuel standards and accompanying subsidies drive biofuel project economics, and these differ by jurisdiction and production pathway. Regulations that differentiate biofuels based on their life-cycle emissions (including indirect land-use change) are crucial to shift investment towards advanced projects that use sustainable feedstocks. There are many opportunities in EMDE; in Southeast Asia, for example, used cooking oil and residues from sugar production (such as bagasse) or from palm oil production (such as palm kernel shells) are a largely untapped, energy-rich resource. Shifting towards such feedstocks is important to avoid competition with food production and risks to biodiversity.

Key factors influencing financing costs

The cast of biofuel producers is diverse, ranging from farming co-operatives and small independents to large agricultural conglomerates and major oil and gas companies. Some companies are "pure-play" biofuels companies with a strong presence across the whole supply chain, whereas in other cases biofuels may make up a small part of a company's overall portfolio. The cost of capital naturally varies considerably across these different types of firms (Figure 2.13).

Figure 2.13 ▹ Weighted average cost of capital for a sample of biofuel producers in EMDE



There is a wide variation in the cost of capital for biofuels producers, which range from small independent farming co-operatives to large-scale energy and agricultural firms

Notes: MUSD = million US dollars. Sample includes companies producing conventional and advanced biofuels domiciled in EMDE, with a market capitalisation up to USD 25 billion.

Source: IEA analysis based on (BNEF, 2023).

Most of the total costs of both conventional and advanced biofuels are taken up by feedstock procurement and ongoing operational expenditures, and so biofuel projects are less sensitive to changing interest rates than wind or solar projects. Capital and financing costs make up between 10% and 20% of the levelised cost of fuel for conventional biofuels, but for advanced biofuels these costs form a larger share. For example, cellulosic ethanol plants require more significant investment in processing equipment than fatty acid and methyl ester (FAME), and they also employ wastes and residue feedstocks which are generally plentiful and inexpensive. The share of capital costs in the total cost of fuel for cellulosic plants is 30-40%, compared with 20% for FAME, and financing costs are typically also higher (Williams, 2020).

There are two main risks that are liable to raise financing costs for sponsors of advanced biofuels. The first is technological risk: first-of-a-kind advanced biofuel projects tend to have high risk premiums. With difficulties securing long-term offtake agreements or feedstock supplies, project finance is typically out of reach. Instead, advanced biofuel developers often rely on unsecured loans with flexible repayment schedules or ones that can be converted to equity (IRENA, 2019). The second risk relates to feedstock availability: without a long-term offtake contract for a secure stream of waste or residue, investors may question the viability of a project. The possibility of a sustainable feedstock supply crunch also looms large over new projects (IEA, 2022).

Several countries that promote advanced biofuels offer financial support to manage these risks, such as grants, loan guarantees and tax incentives. These can have relatively large impact on early-stage projects: an IEA Bioenergy study found that reducing the financing rate from 10% to 8% and extending the financing term from 15 to 20 years would reduce overall production costs by up to 16% (IEA Bioenergy, 2019).

Clear, consistent and long-term biofuel support policies help reduce investor risk, and so lower financing costs, and are at the core of successful biofuel policies. To support advanced biofuels governments often include dedicated advanced biofuel targets, and additional incentives such as double counting towards regulated targets, limiting non-advanced feedstocks and rewarding greenhouse gas intensity improvements. Brazil's RenovaBio provides a framework for support to a wide range of biofuels, and ties the reward of tradeable decarbonisation credits to certified life-cycle assessments. Similarly, in the United States, the state-level Low-Carbon Fuel Standard in California and federal Inflation Reduction Act reward biofuel projects with lower greenhouse gas intensities, which often include advanced feedstocks.

There is also growing support for sustainable aviation fuels (SAFs), which are backed by environmental tax credits and a competitive grant programme under the US Inflation Reduction Act. In the European Union, the ReFuelEU Aviation directive sets minimum SAF blend-in shares, with sub-targets for synthetic fuels, through 2050. Bio jet made from food and feed feedstocks are not eligible under the directive. In 2022, following its announced Jet Zero pledge, the United Kingdom dedicated GBP 165 million to support SAF projects, with a plan to have at least five commercial SAF plants under construction by 2025.

2.6.1 Key recommendations to reduce the cost of capital

- **Set up clear, consistent and long-term demand policies.** A robust renewable fuel standard with clear definitions of sustainable feedstocks and third-party verification of life-cycle emissions can create stable market demand for advanced biofuels, providing assurance to investors and lenders. It is essential to ensure that robust waste management policies are in place that identify wastes and residues that can be used for advanced biofuel production, and provide timelines for implementation.
- **Reduce the risk of first-of-a-kind projects.** Early-stage projects often require additional capital and carry great risk. Governments can provide targeted tax credits or first loss guarantees that directly reduce the cost of capital for producers.
- **Strengthen international collaboration.** Mutual recognition of greenhouse gas intensity assessments of advanced biofuels or their feedstocks is essential to scale up international partnerships and biofuels trade, including use in international aviation and shipping. International collaboration on setting consistent life-cycle intensity standards and what processes can comply with international targets can help reduce risk, and so cost of capital.

2.7 Utility-scale hydro

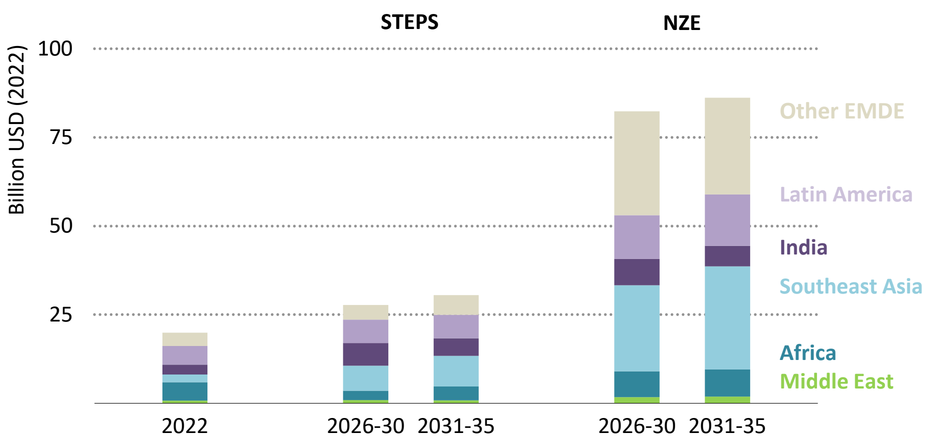
Investment outlook, sources of finance and sector development

Hydropower is the largest source of clean power globally today and is particularly prominent in EMDE, where it meets the majority of electricity demand in 28 countries (IEA, 2021a). There is still significant resource potential. For example, in Africa, only around 11% of hydropower's technical potential is currently utilised (International Hydropower Association, 2022). Investment in hydropower generation across EMDE has seen a gradual increase over the last five years, rising from under USD 20 billion in 2018 to nearly USD 25 billion in 2022 (Figure 2.14). However in some countries that have historically driven capacity expansion, such as Brazil, spending has slowed due to the limited number of economically viable sites available for greenfield projects as well as opposition to large projects from affected communities.

In low-emissions scenarios, hydropower is particularly valuable as a low-emissions source of flexibility and storage. In the NZE Scenario there is a fourfold increase in hydropower investment, driven by a dramatic rise in Southeast Asia and Eurasia, where hydropower plays an important role to replace the system services currently provided by thermal power plants. The vast majority of this is greenfield investment, although refurbishment and maintenance become more important with time, with the average lifespan of plants being 45-60 years before refurbishment becomes necessary.

Hydropower projects are both capital-intensive and highly site-specific. Many aspects are individually designed for a particular project, unlike in solar or wind investments that rely more on standardised inputs. In addition, many of the precise geotechnical conditions are hard to predict, often resulting in costly delays. Given the high upfront costs and risks, financing is generally conditional on power purchase guarantees or long-term contracts. A further challenge is that there tends to be a mismatch between financial and economic value of hydropower projects, with some beneficial uses of the dam, such as support for flood management or irrigation, not resulting in revenue streams for the project. In some cases, important energy-related services such as the provision of flexibility to the power system are also not adequately remunerated.

Figure 2.14 ▷ Investment in hydropower in EMDE in STEPS and the NZE Scenario, 2022-2035



Large-scale hydropower projects increase fourfold under the NZE Scenario, demonstrating their value for flexibility and storage

This strong economic benefit but challenging financing environment is one of the primary reasons the public sector dominates hydropower developments. Some 70% of all hydropower capacity globally installed between 2000 and 2020 were publicly owned and operated. In EMDE, these projects are often funded by large loans from multilateral development banks secured against the sovereign balance sheet. China also plays a very significant role in hydropower financing, generally via loans from export credit agencies that are tied to the use of Chinese state-owned contractors. Between 2021 and 2030, the IEA estimates that over half of all new hydropower projects in sub-Saharan Africa, Southeast Asia and Latin America are set to be either built, financed, partially financed or owned by Chinese firms (IEA, 2021a).

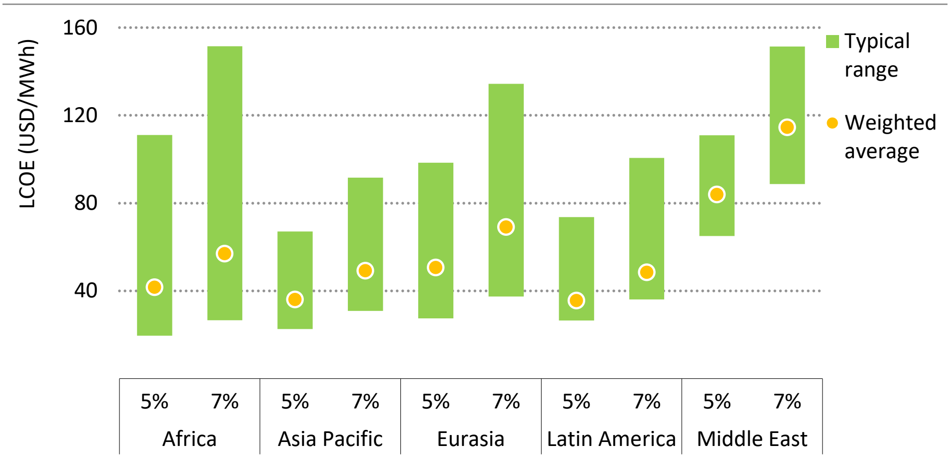
Given the financing landscape, some of the most significant risks influencing the cost of capital for hydropower projects are:

- **Environmental and social risks:** concern that these risks will trigger permitting delays and additional costs.
- **Revenue risk:** less predictable weather patterns and business models that fail to monetise the multiple uses of dams can reduce revenues.
- **Off-taker risk:** As with other sectors, hydropower financing costs can be driven up by concerns over the reliability of the off-taker.

Key factors influencing financing costs

The importance of bilateral finance from China, which is generally provided at attractive rates, and the challenges in identifying viable hydropower projects mean that financing costs are not necessarily the primary obstacle to growth of the sector. That said, given the high upfront costs to develop hydropower plants, the cost of capital can have a major impact on the LCOE. Analysis from the IEA Hydropower Special Market Report found that an increase in the WACC of just 1 percentage point can result in 7-14% higher generation costs (Figure 2.15).

Figure 2.15 ▹ Average LCOE of greenfield hydropower plants (>10 MW) at 5% and 7% WACC



High upfront costs for hydropower facilities mean the WACC has a significant impact on generation costs, with a 1% increase in WACC resulting in an up to 14% increase in LCOE

Note: MWh = megawatt-hours; LCOE = Levelized cost of electricity; WACC = weighted average cost of capital.
Source: (IEA, 2021a)

One of the major steps to reduce financing costs, as well as to increase interest in hydropower investments, is to improve the policy environment for this sector. Today, fewer than 30 countries have policies directly targeting hydropower. These policies can support the complex pre-development and construction phases, with clear permitting processes to keep delays to a minimum.

The use of public-private partnerships (PPPs) to fund hydropower has grown in recent years and is likely to play a key role in order to meet the ambitious growth of the sector under the NZE Scenario. These PPPs tend to include a mix of government, DFIs and donors, and private corporations, and generally require long-term contract clauses to mitigate high off-taker risk and other risks such as low rainfall limiting power production. While PPP financing structures can involve lengthy preparation, the blended use of concessional and commercial capital results in cheaper capital without adding excessive fiscal pressure to the host government.

2.7.1 Key recommendations to reduce the cost of capital

Many of the obstacles to future hydropower development are in the pre-development stage, with long permitting times and regular delays in construction presenting some of the major challenges to investment. Under the NZE Scenario, with greenfield hydropower capacity ramping up, the identification of attractive sites is also set to become a key barrier. There are multiple steps governments can take to create a more attractive investment environment for hydropower projects:

- **Improve long-term planning for hydropower projects, including site mapping with environmental data**. Governments can include hydropower targets directly within long-term energy strategy and integrated resource planning. Where possible, targets can also be accompanied by efforts to identify viable sites for future projects, including where private partners are sought. Site identification is likely to be most beneficial if accompanied by publicly available, up-to-date environmental data. In countries where these data are unavailable, DFIs and donors can support studies to collect and publish this information.
- **Create robust, streamlined environmental and social processes and standards, alongside clear monitoring procedures.** Governments can support investment by ensuring a clear process on obtaining environmental and social impact assessments, as well as laying out standardised environmental monitoring and community support and relocation procedures. These should be in line with global standards such as the Hydropower Sustainability Guidelines on Good International Industry Practice and the Hydropower Sustainability Assessment Protocol, both from the International Hydropower Association. DFIs and donors can support these efforts through technical assistance and capacity-building grants.
- **Ensure that business models reflect the multiple benefits of hydropower facilities**. Currently business models for hydropower facilities often do not adequately reflect dams' multiple uses within their revenue expectations. Governments can seek to create business models that value additional services such as irrigation, water supply or flood control. Local governments can also work with local communities in proposed sites for future dams to help them take advantage of future developments.

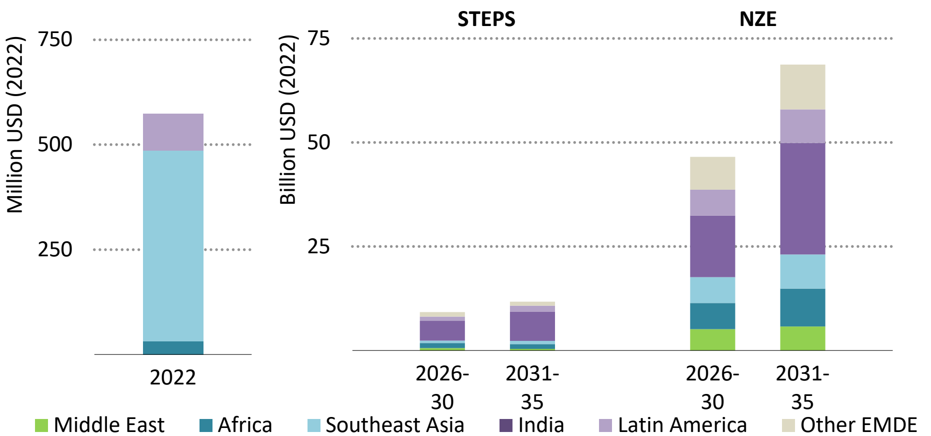
2.8 Battery storage

Investment outlook, sources of finance and sector development

Worldwide investments in battery storage have been going from strength to strength, but spending in EMDE is lagging behind. In the past five years, global investments in utility-scale batteries jumped sevenfold to USD 14 billion in 2022 and are expected to double again in 2023. However, the lion's share of this spending has been in advanced economies and in China: of the USD 14 billion invested in 2022, only USD 600 million (less than 5% of the total) was spent on batteries in EMDE.

Battery storage is a particularly important technology to ensure reliable electricity supply in EMDE that have significant renewables potential and the prospect of rapid growth in electricity demand. In the NZE Scenario, investments in battery storage increase by a factor of 120 in EMDE by 2031-2035 (Figure 2.16). About 40% of this spending occurs in India, with Africa, Southeast Asia, and Latin America and the Caribbean the other main markets.

Figure 2.16 ▷ Investment in utility-scale batteries in EMDE in the STEPS and the NZE, 2022-2035



Spending in utility-scale batteries in EMDE increases by a factor of 120 in the NZE, especially in regions with fast electricity demand growth and need for flexibility

Utility-scale battery systems have distinct use cases that can provide meaningful revenue streams for project developers and battery storage operators:

- **Energy arbitrage**: storage of electricity at times when it is abundant for sale at higher prices, mostly in countries with existing wholesale power markets.
- **Frequency regulation**: provision of immediate power supply to maintain grid balance and prevent frequency fluctuations.

- **Resource adequacy**: meeting of peak load demand.
- **Power reserve**: maintenance of electricity output during unexpected outages.

These use cases are further strengthened when utility-scale battery storage is integrated with solar PV and wind power projects because it allows charging of the batteries during times of excess supply, better aligns solar and wind power generation with system demand, reduces curtailment, and improves the quality and reliability of the services that projects can offer the power system.

As with other sectors, financing conditions for battery storage are influenced by country-specific risks such as debt management or currency fluctuations and by two sector-specific risks:

- **Regulatory risk**: battery storage systems do not always have equal access to the power market, and a strategy for remunerating flexibility services might be missing.
- **Off-taker risk**: delayed payments by or under recoveries from distribution companies for provided energy storage services.

Key factors influencing financing costs

While sharing many similarities with solar PV and wind power projects, the WACC for battery storage is often higher. This is due to the relatively innovative nature of battery storage systems and the fact that battery storage must be able to leverage several of the mentioned revenue streams at the same time. This amplifies the regulatory and off-taker risks prevalent in the sector.

Financing costs for battery storage in EMDE can be significantly higher than in advanced economies due to deficiencies in the policy and regulatory environment. Investors require strategic clarity from policy makers on the role of batteries. Detailed regulations that outline how battery storage operators will be remunerated for providing services such as frequency regulation and meeting of peak load demand, as well as their participation in power markets, are critical if battery storage is to be able to leverage the multiple potential revenue streams and become a profitable investment.

India is an example of an EMDE effectively addressing regulatory risks: the implementation of the General Network Access and other regulations in 2022 allowed battery storage systems the equal participation in the power market along with other energy sources and clarified the permissible use cases for battery storage. Strategic direction was provided by the Ministry of Power's announcement that more than 40 GW of battery storage capacity would be required by 2030 as well as the Government's Green Energy Corridor policy, which made battery systems a key element of India's future transmissions network. These ambitions are further supported by India's production-linked incentive scheme, which aims at the development of a domestic battery storage manufacturing industry.

"Round-the-clock" renewable energy auctions that combine battery storage with solar or wind power projects are becoming more and more common. While not being a substitute for adequate overall system planning and renewables integration, these are effective in lowering the cost of capital because they allow battery storage operators to charge the batteries with renewable electricity at times of excess production – thereby improving the project financials – while lowering the risk of curtailment for the involved solar or wind power projects. In fact, the IEA's Cost of Capital Observatory finds that the cost of capital for a battery storage project tends to be at the same level as a solar PV project if both are bundled. As a result of these reforms, India has jump-started investment in the battery storage market with 2.5 GW in utility-scale battery storage expected to be installed in 2023 – after seeing no additions in 2022 – and investment spending expected to grow strongly.

Off-taker risk for batteries relates to the payment to battery operators for the energy storage services they provide. In countries without wholesale power markets, this risk is often elevated because utility-scale battery storage operators are unable to realise their single largest revenue driver – energy arbitrage, or the charging of the batteries when electricity prices are low and the injection of stored electricity into the grid when prices are high. Moreover, for other storage services provided, operators are dependent on being quickly and predictably remunerated for the services they provide to the grid. However, as laid out in section 2.2, in many countries these are often transmission companies in poor financial state, which can be mitigated through creditworthy intermediaries or other risk mitigation mechanisms such as guarantees from development finance institutions.

An interesting example where concessional funding helped overcome regulatory and off-taker risks is a project in South Africa that will see the decommissioning of an ageing coal-fired power station with 220 MW of solar PV and wind power combined with 150 MW battery storage. Despite load-shedding and South Africa's public energy utility Eskom facing financial difficulties, as well as a weak regulatory environment for battery storage, a consortium led by the World Bank was able to structure a USD 500 million package – including some highly concessional financing – for the battery storage portion. The combination of variable renewables with battery storage aims to support adequacy of power supply and grid stability, and the concessional funding is estimated to lead to USD 80 million in debt servicing costs for Eskom. This illustrates the significance of blending concessional finance from DFIs in reducing the overall financing cost.

2.8.1 *Key recommendations to reduce the cost of capital*

Reducing the cost of capital for utility-scale battery storage in EMDE means a focus on three priority areas:

- **Establish a clear and stable regulatory framework** that defines the role of utility-scale battery storage, allows its equal participation in the power market, and defines the permissible use cases to ensure planning security and transparent revenue expectations for battery storage investors and operators. This also involves clarifying the role of battery storage in a country's clean energy transition, electricity mix and transmission system as well as capacity targets. In addition, and where feasible, this can also require the reform of the power market to establish wholesale markets which can be a significant revenue driver for battery storage projects – especially the greater the penetration of variable renewables and the need for short- and medium-term flexibility.

- **Develop the market through well-designed and regular procurement programmes, with concessional finance where required.** Implementing competitive capacity auctions that provide capacity payments at a fixed rate can significantly improve the financial viability of battery storage projects and lower their financing costs. In nascent markets, such capacity payments could be financed with concessional debt which would be reduced towards market-based rates with greater deployment. Such auctions would be especially impactful if combined with solar PV or wind power projects as they can further improve the financials of battery storage projects while reducing the curtailment risk of variable renewables projects.
- **Expand off-taker guarantee and credit enhancement mechanisms** by offering state or international guarantees or establishing creditworthy intermediates to reduce the risk of no or late payment for energy storage services. Covering non-payment delays is particularly important for battery storage operators given their reliance on multiple revenue streams and provision of system services for which the key benefactor – and therefore off-taker – would be in most cases state-owned transmission and distribution companies in poor financial state.

Box 2.3 ▷ Case studies that explore how EMDE have addressed risks to scale up clean energy investment

Measures to reduce the cost of capital are highly country- and technology-specific. A broad range of solutions is therefore necessary to support the overall goal of lowering the cost of capital for clean energy projects across EMDE. Across the diverse set of EMDE covered in this report, a series of success stories exist that can provide guidance for future measures. We explored eight examples in detail for this report. They are included in full in the 'Cost of Capital Observatory' on the IEA website available here: iea.org/reports/cost-of-capital-observatory.

The case studies include:

- **Developing a country-specific investment proposition in Senegal:** many international investors have limited exposure to African countries due to the high risk perceptions associated with the region as a whole. Senegal has been successful at attracting comparatively more investment into its energy sector and at a lower cost than in many of its regional peers. In part this is due to lower political and macroeconomic risks, including in relation to currency volatility thanks to the local currency's peg to the euro. But the country has also taken steps to improve the attractiveness of the energy sector, notably via programmes such as the International Finance Corporation-led Scaling Solar initiative.
- **Steps to reduce off-taker risk for renewables in India:** the cost of capital for utility-scale solar is 50% higher in India than in the European Union, despite the country's

strong regulatory framework and the introduction of "reverse auctions." Off-taker risk is one of the key drivers, primarily due to non-payment risks from state owned DISCOMs. To reduce this risk, the government introduced a late payment charge on DISCOMs, and at both the state and federal level, measures have also been introduced to support debt restructuring and improved revenue collection at DISCOMs.

- **Strong regulatory framework and tariff system for grids in Brazil:** Brazil has succeeded in attracting significant private capital to its grid network thanks to a robust regulatory framework that has proven to be both sustainable and adaptable. The system allows for the use of both concessions and IPT projects. Importantly, the regulation includes a predictable and reliable remuneration system that is cost-reflective, and hence reduces revenue risks for investors.
- **Attracting more private capital to grids in Indonesia:** grid investments in Indonesia are dominated by the state utility PLN and financed by DFIs, but a diversification of financing sources will be necessary to meet ambitious energy transition targets. While there have been some successes, notably via novel financing approaches such as a results-based lending scheme, private sector investors are still deterred by the lack of robust technical regulations, uncertain project development and limited transparency around tariffs.
- **Tender programmes for battery storage in South Africa:** the South African government has developed two tender programmes to expand the use of battery storage in the country. The programmes target both utility-scale battery and hybrid projects and allow for competitive bidding, primarily from the private sector. While these steps are helping to lower the cost of capital for utility-scale battery projects, the poor financial health of the state utility Eskom and constraints on available grid capacity continue to pose major hurdles for hybrid projects.
- **Innovative banking products for green buildings in Colombia:** Colombia introduced green building codes in 2015 but, as elsewhere in EMDE, high upfront costs still acted as a brake on development. Since the introduction of the codes, multilateral development banks have worked with banks in the country to devise innovative products to provide lower-cost loans. Notably, these include the use of green bonds where proceeds were used to lend to developers of green buildings at lower-than-commercial rates and the development of green mortgages.
- **Procurement support for e-buses for public transport in India:** under the National Electric Bus Program in India, the government set ambitious targets to expand the use of e-buses in public transport. A bulk procurement model was adopted to reduce upfront costs, as well as the introduction of a pay-as-you-go leasing model. These steps have helped reduce the upfront purchasing costs, but further steps can be taken to widen adoption of the scheme.

- **Refinancing hydropower projects to reduce end-user tariffs in Uganda:** one of the largest power plants in Uganda, Bujagali dam, was refinanced in 2018, marking one of the first arrangements of its kind in sub-Saharan Africa. The refinancing resulted in significantly reduced financing costs associated with the project by delaying debt repayments, resulting in a meaningful tariff reduction. The project also serves as a good example for how to leverage operational assets to bring in more private capital.

Definitions

This annex provides general information on terminology used throughout this report including: units and general conversion factors; definitions of fuels, processes and sectors; regional and country groupings; and abbreviations and acronyms.

Units and measurements

GW	gigawatt
km	kilometre
mboe/d	million barrels of oil per day
MW	megawatt
MWh	megawatt-hour
TWh	terawatt-hour
Wp	watt peak

Definitions

Aviation: This transport mode includes both domestic and international flights and their use of aviation fuels. Domestic aviation covers flights that depart and land in the same country; flights for military purposes are included. International aviation includes flights that land in a country other than the departure location.

Battery storage: Energy storage technology that uses reversible chemical reactions to absorb and release electricity on demand.

Bioenergy: Energy content in solid, liquid and gaseous products derived from biomass feedstocks and biogas. It includes solid bioenergy, liquid biofuels and biogases. Excludes hydrogen produced from bioenergy, including via electricity from a biomass-fired plant, as well as synthetic fuels made with CO_2 feedstock from a biomass source.

Biogas: A mixture of methane, CO_2 and small quantities of other gases produced by anaerobic digestion of organic matter in an oxygen-free environment.

Biogases: Include both biogas and biomethane.

Biogasoline: Includes all liquid biofuels (advanced and conventional) used to replace gasoline.

Bio jet kerosene: Kerosene substitute produced from biomass. It includes conversion routes such as hydroprocessed esters and fatty acids (HEFA) and biomass gasification with Fischer-Tropsch. It excludes synthetic kerosene produced from biogenic carbon dioxide.

Buildings: The buildings sector includes energy used in residential and services buildings. Services buildings include commercial and institutional buildings and other non-specified buildings. Building energy use includes space heating and cooling, water heating, lighting, appliances, and cooking equipment.

Carbon capture, utilisation and storage (CCUS)**:** The process of capturing carbon dioxide emissions from fuel combustion, industrial processes or directly from the atmosphere. Captured CO_2 emissions can be stored in underground geological formations, onshore or offshore, or used as an input or feedstock in manufacturing.

Carbon dioxide (CO_2)**:** A gas consisting of one part carbon and two parts oxygen. It is an important greenhouse (heat-trapping) gas.

Chemical feedstock: Energy vectors used as raw materials to produce chemical products. Examples are crude oil-based ethane or naphtha to produce ethylene in steam crackers.

Clean cooking systems: Cooking solutions that release less harmful pollutants and are more efficient and environmentally sustainable than traditional cooking options that make use of solid biomass (such as a three-stone fire), coal or kerosene. This refers to improved cookstoves, biogas/biodigester systems, electric stoves, liquefied petroleum gas, natural gas or ethanol stoves.

Clean energy: In *power*, clean energy includes: renewable energy sources; nuclear power; fossil fuels fitted with CCUS; hydrogen and ammonia; battery storage; and electricity grids. In *efficiency*, clean energy includes energy efficiency in buildings, industry and transport, excluding aviation bunkers and domestic navigation. In *end-use applications*, clean energy includes: direct use of renewables; electric vehicles; electrification in buildings, industry and international marine transport; CCUS in industry; and direct air capture. In *fuel supply*, clean energy includes low-emissions fuels and measures to reduce the emissions intensity of fossil fuel production.

Coal: Includes both primary coal, i.e., lignite, coking and steam coal, and derived fuels, e.g., patent fuel, brown-coal briquettes, coke-oven coke, gas coke, gas works gas, coke-oven gas, blast furnace gas and oxygen steel furnace gas. Peat is also included.

Cost of capital: The expected financial return, or the minimum required rate of return, to justify an investment in a company or a project.

Conventional liquid biofuels: Fuels produced from food crop feedstocks. Commonly referred to as first-generation biofuels and include sugar cane ethanol, starch-based ethanol, fatty acid methyl ester (FAME), straight vegetable oil, and hydrotreated vegetable oil produced from palm, rapeseed or soybean oil.

Direct air capture (DAC)**:** A type of CCUS that captures CO_2 directly from the atmosphere using liquid solvents or solid sorbents. It is generally coupled with permanent storage of the CO_2 in deep geological formations or its use in the production of fuels, chemicals, building materials or other products. When coupled with permanent geological CO_2 storage, DAC is a carbon removal technology.

Electric vehicles (EVs)**:** Electric vehicles comprise battery electric vehicles and plug-in hybrid vehicles.

Electricity demand: Defined as total gross electricity generation less own use generation, plus net trade (imports less exports), less transmission and distribution losses.

Electricity generation: Defined as the total amount of electricity generated by power only or co-generation plants including generation required for own use. This is also referred to as gross generation.

End-use sectors: Include industry, transport, buildings and other, i.e. agriculture and other non-energy use.

Energy sector greenhouse gas emissions: Energy-related and industrial process CO_2 emissions plus fugitive and vented methane and nitrous dioxide emissions from the energy and industry sectors.

Ethanol: Refers to bioethanol only. Ethanol is produced from fermenting any biomass high in carbohydrates. Currently ethanol is made from starches and sugars, but second-generation technologies will allow it to be made from cellulose and hemicellulose, the fibrous material that makes up the bulk of most plant matter.

Fossil fuels: Include coal, natural gas and oil.

Heat (end use)**:** Can be obtained from the combustion of fossil or renewable fuels, direct geothermal or solar heat systems, exothermic chemical processes, and electricity (through resistance heating or heat pumps which can extract it from ambient air and liquids). This category refers to the wide range of end uses, including space and water heating and cooking in buildings, desalination and process applications in industry. It does not include cooling applications.

Heat (supply)**:** Obtained from the combustion of fuels, nuclear reactors, large-scale heat pumps, geothermal or solar resources. It may be used for heating or cooling, or converted into mechanical energy for transport or electricity generation. Commercial heat sold is reported under total final consumption with the fuel inputs allocated under power generation.

Hydrogen: Hydrogen is used in the energy system as an energy carrier or as an industrial raw material, or is combined with other inputs to produce hydrogen-based fuels. Unless otherwise stated, hydrogen in this report refers to low-emissions hydrogen.

Hydrogen-based fuels: See low-emissions hydrogen-based fuels.

Hydropower: Refers to the electricity produced in hydropower projects, with the assumption of 100% efficiency. It excludes output from pumped storage and marine (tide and wave) plants.

Industry: The sector includes fuel used within the manufacturing and construction industries. Key industry branches include iron and steel, chemical and petrochemical, cement, aluminium, and pulp and paper. Use by industries for the transformation of energy into another form or for the production of fuels is excluded and reported separately under other energy sector. There is an exception for fuel transformation in blast furnaces and coke ovens, which are reported within iron and steel. Consumption of fuels for the transport of goods is reported as part of the transport sector, while consumption by off-road vehicles is reported under industry.

Investment: Investment is the capital expenditure in energy supply, infrastructure, end use and efficiency. Fuel supply investment includes the production, transformation and transport of oil, gas, coal and low-emissions fuels. *Power sector* investment includes new construction and refurbishment of generation, electricity grids (transmission, distribution and public electric vehicle chargers), and battery storage. *Energy efficiency* investment includes efficiency improvements in buildings, industry and transport. *Other end use* investment includes the purchase of equipment for the direct use of renewables, electric vehicles, electrification in buildings, industry and international marine transport, equipment for the use of low-emissions fuels, and CCUS in industry and direct air capture. Data and projections reflect spending over the lifetime of projects and are presented in real terms in year-2022 US dollars converted at market exchange rates unless otherwise stated. Total investment reported for a year reflects the amount spent in that year.

Levelised cost of electricity (LCOE): 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. It does not include network integration or other indirect costs.

Low-emissions fuels: Include modern bioenergy, low-emissions hydrogen and low-emissions hydrogen-based fuels.

Low-emissions hydrogen: Hydrogen that is produced from water using electricity generated by renewables or nuclear, from fossil fuels with minimal associated methane emissions and processed in facilities equipped to avoid CO_2 emissions, e.g. via CCUS with a high capture rate, or derived from bioenergy. In this report, total demand for low-emissions hydrogen is larger than total final consumption of hydrogen because it additionally includes hydrogen inputs to make low-emissions hydrogen-based fuels, biofuels production, power generation, oil refining, and hydrogen produced and consumed on-site in industry.

Low-emissions hydrogen-based liquid fuels: A subset of low-emissions hydrogen-based fuels that includes only ammonia, methanol and synthetic liquid hydrocarbons, such as synthetic kerosene.

Mini-grids: Small electric grid systems, not connected to main electricity networks, linking a number of households and/or other consumers.

Modern gaseous bioenergy: See biogases.

Modern liquid bioenergy: Includes biogasoline, biodiesel, bio jet kerosene and other liquid biofuels.

Natural gas: Includes gas occurring in deposits, whether liquefied or gaseous, consisting mainly of methane. It includes both non-associated gas originating from fields producing hydrocarbons only in gaseous form, and associated gas produced in association with crude oil production as well as methane recovered from coal mines (colliery gas). Natural gas liquids, manufactured gas (produced from municipal or industrial waste, or sewage) and quantities vented or flared are not included. Gas data in cubic metres are expressed on a gross calorific value basis and are measured at 15° C and at 760 millimetres of mercury (Standard Conditions). Gas data expressed in exajoules are on a net calorific basis. The difference between the net and the gross calorific value is the latent heat of vaporisation of the water vapour produced during combustion of the fuel (for gas the net calorific value is 10% lower than the gross calorific value).

Off-grid systems: Mini-grids and stand-alone systems for individual households or groups of consumers not connected to a main grid.

Offshore wind: Refers to electricity produced by wind turbines that are installed in open water, usually in the ocean.

Oil: Includes both conventional and unconventional oil production. Petroleum products include refinery gas, ethane, liquid petroleum gas, aviation gasoline, motor gasoline, jet fuels, kerosene, gas/diesel oil, heavy fuel oil, naphtha, white spirits, lubricants, bitumen, paraffin, waxes and petroleum coke.

Other energy sector: Covers the use of energy by transformation industries and the energy losses in converting primary energy into a form that can be used in the final consuming sectors. It includes losses in low-emissions hydrogen and hydrogen-based fuels production, bioenergy processing, gas works, petroleum refineries, coal and gas transformation, and liquefaction. It also includes energy own use in coal mines, in oil and gas extraction, and in electricity and heat production. Transfers and statistical differences are also included in this category. Fuel transformation in blast furnaces and coke ovens are not accounted for in the other energy sector category.

Other industry: A category of industry branches that includes construction, food processing, machinery, mining, textiles, transport equipment, wood processing and remaining industry. It is sometimes referred to as non-energy-intensive industry.

Passenger car: A road motor vehicle, other than a moped or a motorcycle, intended to transport passengers. It includes vans designed and used primarily to transport passengers. Excluded are light commercial vehicles, motor coaches, urban buses and mini-buses/mini-coaches.

Power generation: Refers to electricity generation and heat production from all sources of electricity, including electricity-only power plants, heat plants, and co-generation plants. Both main activity producer plants and small plants that produce fuel for their own use (auto-producers) are included.

Renewables: Include bioenergy, geothermal, hydropower, solar photovoltaics (PV), concentrating solar power (CSP), wind and marine (tide and wave) energy for electricity and heat generation.

Residential: Energy used by households including space heating and cooling, water heating, lighting, appliances, electronic devices and cooking.

Road transport: Includes all road vehicle types (passenger cars, two-/three-wheelers, light commercial vehicles, buses, and medium and heavy freight trucks).

Shipping/navigation: This transport mode includes both domestic and international navigation and their use of marine fuels. Domestic navigation covers the transport of goods or people on inland waterways and for national sea voyages (starts and ends in the same country without any intermediate foreign port). International navigation includes quantities of fuels delivered to merchant ships (including passenger ships) of any nationality for consumption during international voyages transporting goods or passengers.

Solar: Includes both solar PV and CSP.

Solar home systems (SHS)**:** Small-scale photovoltaic and battery stand-alone systems, i.e. with capacity higher than 10 watt peak (Wp) supplying electricity for single households or small businesses. They are most often used off-grid, but also where grid supply is not reliable. Access to electricity in the IEA definition considers SHS from 25 Wp in rural areas and 50 Wp in urban areas. It excludes smaller solar lighting systems, e.g. solar lanterns of less than 11 Wp.

Solar photovoltaics (PV)**:** Electricity produced from solar PV cells including utility-scale and small-scale installations.

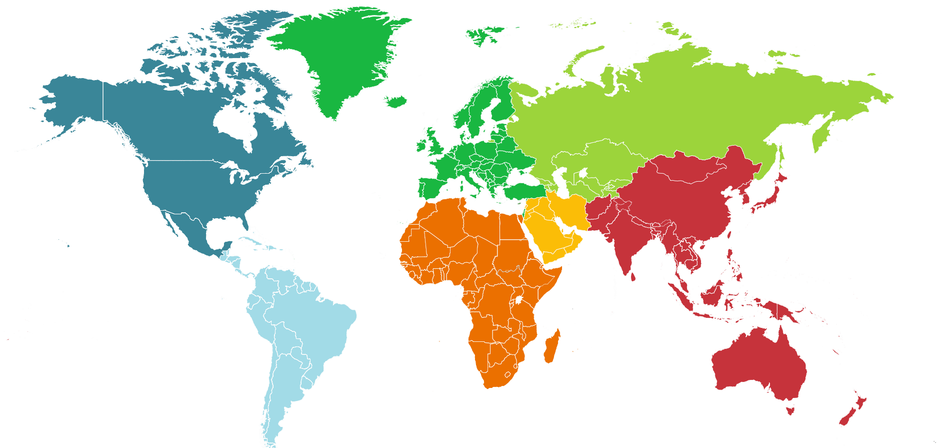
Stand-alone systems: Small-scale autonomous electricity supply for households or small businesses. They are generally used off-grid, but also where grid supply is not reliable. Stand-alone systems include SHS, small wind or hydro generators, and diesel or gasoline generators. The difference compared with mini-grids is in scale and that stand-alone systems do not have a distribution network serving multiple customers.

Transport: Fuels and electricity used in the transport of goods or people within the national territory irrespective of the economic sector within which the activity occurs. This includes: fuel and electricity delivered to vehicles using public roads or for use in rail vehicles; fuel delivered to vessels for domestic navigation; fuel delivered to aircraft for domestic aviation; and energy consumed in the delivery of fuels through pipelines. Fuel delivered to international marine and aviation bunkers is presented only at the world level and is excluded from the transport sector at a domestic level.

Unabated fossil fuel use: Consumption of fossil fuels in facilities without CCUS.

Regional and country groupings

Main country groupings



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Africa: North Africa and sub-Saharan Africa regional groupings.

Asia Pacific: Southeast Asia regional grouping and Australia, Bangladesh, the People's Republic of China (China), Democratic People's Republic of Korea (North Korea), India, Japan, Korea, Mongolia, Nepal, New Zealand, Pakistan, Sri Lanka, Chinese Taipei, and other Asia Pacific countries and territories.[3]

Caspian: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

Central and South America: Argentina, Plurinational State of Bolivia (Bolivia), Bolivarian Republic of Venezuela (Venezuela), Brazil, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, and other Central and South American countries and territories.[4]

China: Includes (the People's Republic of) China and Hong Kong, China.

Developing Asia: Asia Pacific regional grouping excluding Australia, Japan, Korea and New Zealand.

Developing Europe: Albania, Belarus, Bosnia and Herzegovina, Gibraltar, Republic of Kosovo, North Macedonia, Republic of Moldova, Montenegro, Serbia and Ukraine.

Emerging market and developing economies (EMDE): Africa, Developing Europe, Eurasia, Latin America, the Middle East, and South and Southeast Asia. For the purposes of this report, the EMDE grouping includes four member countries of the Organisation for Economic Co-operation and Development (OECD): Chile, Colombia, Costa Rica and Mexico.

Eurasia: Caspian regional grouping and the Russian Federation (Russia).

Europe: European Union regional grouping and Albania, Belarus, Bosnia and Herzegovina, Gibraltar, Iceland, Israel,[5] Kosovo, Montenegro, North Macedonia, Norway, Republic of Moldova, Serbia, Switzerland, Türkiye, Ukraine and United Kingdom.

European Union: Austria, Belgium, Bulgaria, Croatia, Cyprus,[4,5] Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, the Slovak Republic, Slovenia, Spain and Sweden.

Eurozone: Austria, Belgium, Croatia, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia and Spain.

IEA (International Energy Agency)**:** OECD regional grouping excluding Chile, Colombia, Costa Rica, Iceland, Israel, Latvia and Slovenia.

Latin America and the Caribbean: Central and South America regional grouping and Mexico.

Least developed countries: Countries that fall into a triple criteria of income, human asset index, and economic and environmental vulnerability index according to the United Nations. Africa: Angola, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, South Sudan, Sudan, Togo, Uganda, United Republic of Tanzania, and Zambia. Asia: Afghanistan, Bangladesh, Cambodia, Lao People's Democratic Republic (Lao PDR), Myanmar, Nepal, Timor-Leste and Yemen. Caribbean: Haiti. Pacific: Kiribati, Solomon Islands and Tuvalu

Middle East: Bahrain, Islamic Republic of Iran (Iran), Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic (Syria), United Arab Emirates and Yemen.

Non-OECD: All other countries not included in the OECD regional grouping.

North Africa: Algeria, Egypt, Libya, Morocco and Tunisia.

North America: Canada, Mexico and the United States.

OECD (Organisation for Economic Co-operation and Development)**:** Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Türkiye, the United Kingdom and the United States.

Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam. These countries are all members of the Association of Southeast Asian Nations (ASEAN).

Sub-Saharan Africa: Angola, Benin, Botswana, Cameroon, Côte d'Ivoire, Democratic Republic of the Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Kingdom of Eswatini, Madagascar, Mauritius, Mozambique, Namibia, Niger, Nigeria, Republic of the Congo (Congo), Rwanda, Senegal, South Africa, South Sudan, Sudan, United Republic of Tanzania (Tanzania), Togo, Uganda, Zambia, Zimbabwe, and other African countries and territories.[6]

Country notes

[1] Note by Republic of Türkiye: The information in this document with reference to "Cyprus" relates to the southern part of the island. There is no single authority representing both Turkish and Greek Cypriot people on the island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".

[2] Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

[3] Individual data are not available and are estimated in aggregate for: Afghanistan; Bhutan; Cook Islands; Fiji; French Polynesia; Kiribati; Macau, China; Maldives; New Caledonia; Palau; Papua New Guinea; Samoa; Solomon Islands; Timor-Leste; Tonga and Vanuatu.

[4] Individual data are not available and are estimated in aggregate for: Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, Bonaire, Sint Eustatius and Saba, British Virgin Islands, Cayman Islands, Dominica, Falkland Islands (Malvinas), Grenada, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and Grenadines, Saint Maarten (Dutch part), Turks and Caicos Islands.

[5] The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD and/or the IEA is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

[6] Individual data are not available and are estimated in aggregate for: Burkina Faso, Burundi, Cabo Verde, Central African Republic, Chad, Comoros, Djibouti, Gambia, Guinea, Guinea-Bissau, Lesotho, Liberia, Malawi, Mali, Mauritania, Sao Tome and Principe, Seychelles, Sierra Leone, and Somalia.

Abbreviations and acronyms

ANEEL	Agencia Nacional de Energia Eléctrica (Brazilian national electric energy agency)
APS	Announced Pledges Scenario
AT&C	aggregate technical and commercial
BNDES	Brazilian Development Bank
CCUS	carbon capture, utilisation and storage
CESL	Convergence Energy Services Limited
CO_2	carbon dioxide
CSP	concentrating solar power
DAC	direct air capture

DFI	development finance institutions
DISCOM	distribution company
EDGE	Excellence in Design for Greater Efficiencies
EMDE	emerging market and developing economies
EV	electric vehicle
FAME	fatty acid and methyl ester
GDP	gross domestic product
HEFA	hydroprocessed esters and fatty acids
IEA	International Energy Agency
IFC	International Finance Corporation
INR	Indian rupee
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producer
IPT	independent power transmission
JETP	Just Energy Transition Partnership
LCOE	levelised cost of electricity
LEED	Leadership in Energy and Environmental Design
LPG	liquefied petroleum gas
MIGA	Multilateral Investment Guarantee Agency
MME	Ministry of Mines and Energy (Brazil)
NZE	Net Zero Emissions by 2050 (Scenario)
OECD	Organisation for Economic Co-operation and Development
PLN	Perusahaan Listrik Negara
PPA	power purchase agreement
PPP	public-private partnership
PV	photovoltaics
SAF	sustainable aviation fuel
SDG	Sustainable Development Goals (United Nations)
SECI	Solar Energy Corporation of India
SHS	solar home system
SMEs	small and medium enterprises
SOE	state-owned enterprise
STEPS	Stated Policies Scenario
TCX	The Currency Exchange Fund
UN	United Nations
US	United States
WACC	weighted average cost of capital

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Chapter 1: Unlocking clean energy investment

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Reducing the Cost of Capital

World Energy Investment Special Report

Investment in emerging and developing economies (EMDEs outside China) needs to increase more than sixfold by the early 2030s to get on track to limit global temperature rise to 1.5°C. A high cost of capital in these countries makes it much more difficult to attract investment. With growing international attention to this issue, the International Energy Agency (IEA) was tasked by the Paris Summit on a New Global Financing Pact in June 2023 to make recommendations on how to bring down the cost of capital for clean energy investment in EMDEs.

This report builds on previous IEA analysis and on new survey data collected for the IEA's Cost of Capital Observatory project. The cost of capital is particularly important for clean energy projects which typically have high upfront costs during development. In EMDEs, the cost of capital is far higher relative to advanced economies and China due to real and perceived risks. Country-related risks such as currency fluctuations or the rule of law, and sector- and project-related risks including revenue flows, regulatory uncertainty and access to the grids are among the main concerns for investors. Reducing these risks will be key to lowering the cost of capital and in turn unlocking clean energy investment in the parts of the world that most need it.

This special report provides detailed insights into the risk factors that affect financing costs across different clean energy sectors in EMDEs and provides recommendations of what can be done to address them.