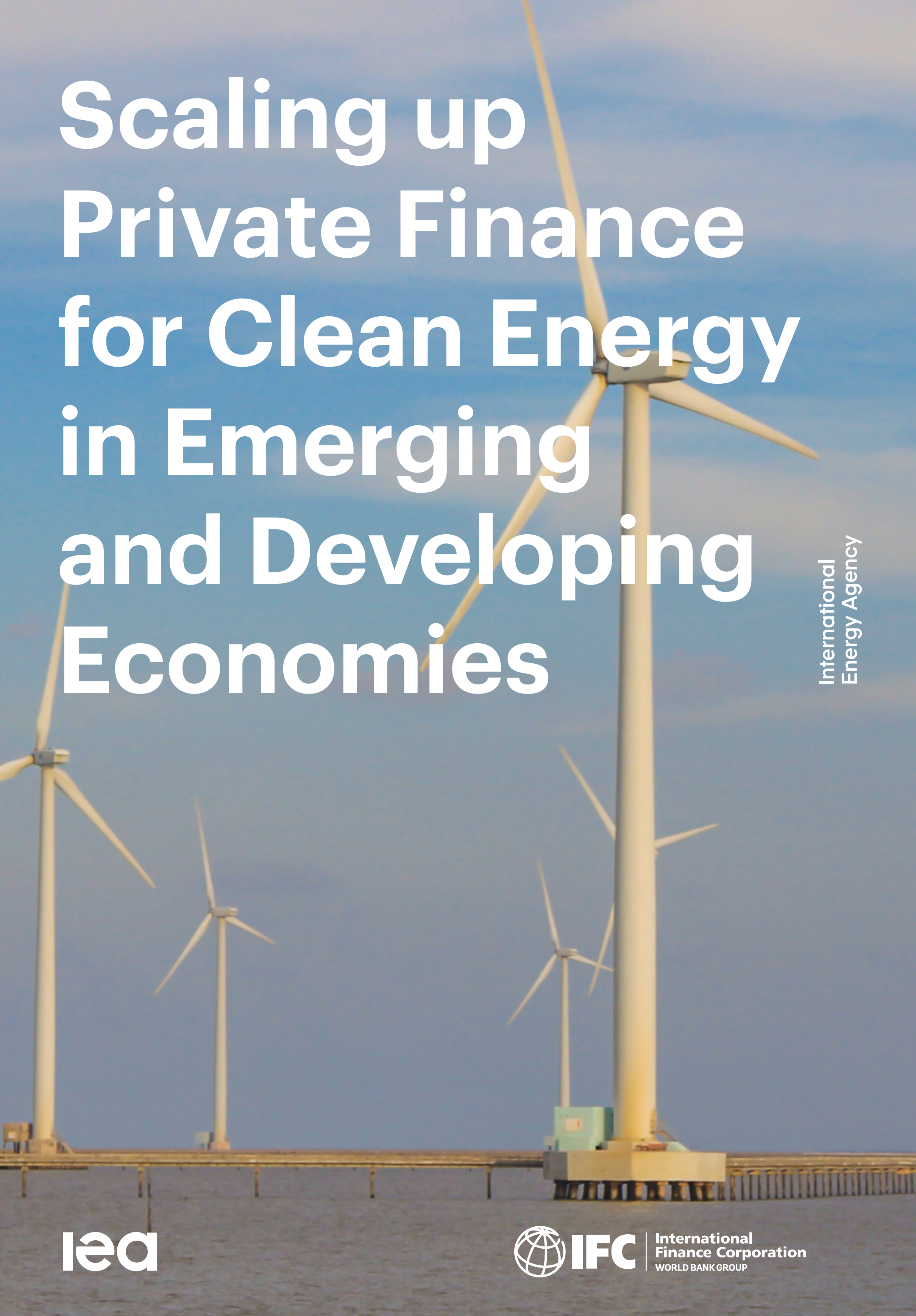
Scaling up Private Finance for Clean Energy in Emerging and Developing Economies



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A major build-out of clean energy and infrastructure is essential for emerging and developing economies to meet their growing demand for energy in a sustainable way. This is a huge opportunity for growth and employment, but too little clean energy investment is taking place in the vast majority of these economies, as they struggle with indebtedness, food and energy insecurity, high cost of capital, and increasingly visible effects of climate change.

Actions by all stakeholders – governments, high-income countries, development finance institutions and private investors – are needed to mobilise capital for rapid clean energy transitions while expanding access to electricity and clean cooking fuels. To support international efforts in this process, the IEA and the IFC have joined forces to quantify the investments required to build modern, clean energy systems and identify the policy actions and financial instruments that can deliver a major acceleration in private capital flows for the energy transition. This research also provides estimates of the quantity of concessional blended finance for the private sector that may be needed, supported by real-world case studies and insights.

Urgent action is needed, so we are pleased to be launching this report at the Paris Summit for a New Global Financing Pact, which aims to deliver concrete commitments and actions to scale up private finance for the clean energy transition. These actions must include steps to build a strong pipeline of investable projects, put in place the relevant financial instruments and regulatory policies to mobilise private investment, and make greater use of concessional finance to enable more clean energy projects.

The IEA and the IFC are committed to working with governments and the private sector to scale up climate finance, drawing on our knowledge and track record of mobilising capital in support of development outcomes. We are thankful to the joint IEA-IFC team that has produced this report and look forward to decision-makers globally coming together around the measures outlined in the report.

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How Emerging Market and Developing Economies (EMDEs) meet their rising energy needs will be pivotal to their and the world's energy and climate future. This country grouping covers a wide variety of low-income and middle-income economies, many of whom have severe deficits of reliable, affordable energy. All of the 775 million people that lack access to electricity and the 2.4 billion people that lack access to clean cooking fuels live in EMDEs. Cost-effective, clean technologies offer a compelling way forward and their use is growing, but, in most cases, energy demand is growing even faster. In a scenario based on today's policy settings, one-third of the rise in EMDE energy use over the next ten years would be met by fossil fuels. Much more needs to be done to ensure that all countries, and all parts of societies, benefit from clean energy technologies.

At present, some USD 770 billion is invested each year in clean energy in EMDEs, but most of this is in a handful of large economies. China accounts for two-thirds of this total and the top three countries – China, India and Brazil – for more than three-quarters. The concentration of investment is striking: China installed 100 GW of new solar PV capacity in 2022, adding, in a single year, ten times as much as the 11 GW of operating solar PV capacity in the whole of Africa. Growth in clean energy investment is a precondition not only for tackling climate change, but also to help reach a range of other sustainable development goals (SDGs), such as poverty reduction, health and education.

Quantifying clean energy investment needs

To meet rising energy needs in ways that align with the Paris Agreement, annual investment, public and private, in clean energy in EMDEs will need to more than triple from USD 770 billion in 2022 to USD 2.2-2.8 trillion per year by the early 2030s, remaining around these levels to 2050**.** If China is excluded, the increase is even steeper, amounting to as much as a seven-fold rise in annual investment from USD 260 billion to between USD 1.4-1.9 trillion. This surge in investment provides a powerful opportunity to underpin sustainable economic growth, create jobs and provide full energy access.

Investments in clean electrification, grid infrastructure and efficiency are the main components of the increase in spending. In scenarios that meet climate and sustainable development goals, by the early 2030s just over one-third of total EMDE clean energy investment goes into low-emissions generation, mainly to renewables. Another one-third is needed for improvements in efficiency and spending in end-use sectors, for example to boost efficient cooling and electric mobility. Just under one-quarter is needed for electricity grids and storage. Around 8% goes to low-emission fuels, such as biofuels, low-emission hydrogen, and carbon capture, utilisation and storage (CCUS). These investments build up a new clean energy system while aiding the adjustment of existing high-emitting sectors.

The cost of achieving universal access to electricity and clean cooking fuels by 2030 (SDG 7) is around USD 45 billion per year, less than 2% of overall spending on clean energy. The bulk of this is needed to expand access to electricity, via grid extensions, mini-grids, and stand-alone generation systems. Two-thirds of the electricity access investment is required in Africa. Some 60% of clean cooking investment, in biogases, LPG, electricity and modern bioenergy via clean cookstoves, is needed in Asia.

Table 1 ▹ Annual clean energy investments in EMDEs to align with sustainable development and climate goals (USD billion)

	Historical		Annual average required	
	2015	2022	2026-30	2031-35
Total EMDEs	538	773	1 784-2 222	2 219-2 805
By country / region				
China	287	511	730-853	850-947
Southeast Asia	28	30	171-185	208-244
India and Other Asia	76	82	321-348	418-467
Africa	26	32	160-203	207-265
Latin America	63	66	150-243	209-332
Middle East and Eurasia	57	52	233-390	303-550
Share by sector in NZE Scenario				
Low-emission power	33%	50%	41%	36%
Grids and storage	35%	21%	20%	23%
Low-emission fuels	1%	1%	7%	8%
Efficiency and end-use	31%	29%	32%	34%

Source: IEA. Notes: The range is derived from two IEA scenarios that meet energy-related SDGs but achieve a different pace of emissions reductions, aligned with the Paris Agreement. The higher bound comes from the Net Zero Emissions (NZE) by 2050 scenario, which reaches global NZE by 2050 and limits global warming to 1.5 degrees; the lower bound is from the Sustainable Development Scenario, which achieves global NZE in the 2060s. The sum of sector shares may not add up 100% due to rounding.

Both public and private investment need to increase to deliver clean energy at the scale required, but public resources alone will not suffice. In 2022 finance by public entities accounted for about half of EMDE clean energy spending, compared with less than 20% in advanced economies. We estimate that around 60% of the finance for EMDE clean energy investment (outside China) will need to come from the private sector: this requirement for private sector financing amounts to USD 0.9-1.1 trillion annually by the early 2030s, up from only USD 135 billion today.

Bringing in private capital at the scale and pace needed will require developing a much larger flow of clean energy projects that match investors' risk and return expectations. For the moment, the cost of capital for a typical utility-scale solar project can be two or three times higher in key emerging economies than in advanced economies or China, reflecting real and perceived risks at the country, sectoral and project levels. Tackling these risks and bringing down the cost of capital will require new and better ways of working between the public and private sectors.

Strategies to accelerate EMDE energy transitions have to be grounded in specific country starting points and circumstances. The low- and lower-middle-income countries, for instance, are home to more than 40% of the world's population but account for only 7% of global spending on clean energy. Some EMDE economies are highly dependent on coal; Indonesia, Mongolia, China, Viet Nam, India and South Africa stand out in this regard. Innovative strategies are needed to clear the way for cost-effective and cleaner options to enter the energy system and address the social dislocation associated with moving away from coal. Other EMDEs are major resource-owners, including oil and gas producers and exporters, and will need to transition away from high dependence on hydrocarbon revenues. Yet others stand to benefit from the clean energy transition, as they are rich in the critical metals and minerals that it demands.

The current international context presents additional complexities for the clean energy transition in EMDEs. New policies in Europe, the United States and other advanced economies are attracting significant new investments in clean energy, spurring technology learning and innovation but making it more challenging for EMDEs to compete for private capital. Rising global interest rates add to EMDE government debt burdens and also raise investors' required returns for clean energy projects. The commitment by advanced economies to mobilise USD 100 billion per year in finance for climate mitigation and adaptation in EMDEs was due to have been met in 2020, but is likely to be met only in 2023.

Scaling up private finance for the clean energy transition

Coordinated action on four fronts is needed to mobilise private finance in the scale and timeframe required. (i) EMDE governments will need to create the enabling environment for private investment and strengthen the institutions that are responsible for energy sector operation and governance; (ii) Significantly larger quantities of concessional finance will be needed to mitigate country and project risks, enhance credit quality, and improve financing terms to attract private investors to many clean energy projects; (iii) New green financing instruments and platforms, such as green bonds, sustainability-linked loans, project aggregation platforms, and voluntary carbon markets will need to be enhanced/redesigned to attract international investment capital at scale in support of credible and robust transition plans; and (iv) Deeper capital markets and financial systems in EMDEs will be necessary to scale domestic private investment in clean energy.

The key role of concessional finance

Concessional finance must be significantly scaled up and used strategically to mobilise the largest possible amounts of private capital in support of EMDE development and climate goals. Concessional funds (guarantees, senior or subordinated debt or equity, performance-based incentives, interest rate or swap cost buydowns, viability gap funding or other investment grants) are not a substitute for needed policy action or institutional reforms, but when used judiciously can mobilise private capital for clean energy projects that otherwise would not be financed. This includes projects: that involve newer technologies that have yet to scale and are not yet cost-competitive in many markets, such as battery storage, offshore wind, renewable-powered desalination, or low-emission hydrogen; that are in frontier markets with higher levels of country and political risk; or that involve macroeconomic risks, such as foreign exchange risk, that raises the cost of the project.

To enable the amount of private finance required for the energy transition in EMDEs outside China (USD 0.9-1.1 trillion annually), we estimate that some USD 80-100 billion of concessional finance per year will be needed by the early 2030s. These figures are estimated considering the varied shares of public and private financing in different geographies and sectors, the specific types of clean energy technologies that may require concessional finance to be viable, and variations in the amount of concessional finance needed to attract private finance in different types of projects and country contexts. These figures exclude China.

Table 2 ▷ Estimated need for concessional finance in blended finance structures in the NZE Scenario (USD billion)

	Annual average required	
	2026-30	2031-35
Total EMDEs (without China)	**83**	**101**
By country / region		
Southeast Asia	7	9
India and other Asia	16	20
Africa	37	46
Latin America	13	15
Middle East and Eurasia	10	11
By sector		
Low-emission power, grids and storage	44	53
Low-emission fuels	10	12
Efficiency and end-use	29	36

Notes: These figures cover only the concessional finance that mobilises private capital. They do not cover other potential needs for concessional funding, e.g., to SOEs that rely on public financing.

Source: IFC estimates based on IEA NZE Scenario investment requirements.

New financing instruments

Financing instruments such as green, social, sustainable and sustainability-linked (GSSS) bonds have the potential to mobilize private capital at scale by attracting institutional investors that do not typically invest in individual projects. Today there is more than USD 2.5 trillion in ESG-related investment funds, but almost none of that capital flows to EMDEs. GSSS bonds offer one opportunity to attract some of that capital, but issuances remain heavily concentrated in advanced economies. In 2022, USD 136 billion of GSSS bonds were issued by EMDEs, with more than half of those issued in China. Growing this market will require robust third-party certification and monitoring, standardised industry guidelines, harmonised taxonomies, cost-effective regulation, and better instrument design.

Project aggregation platforms and securitisation vehicles can overcome the asymmetry between the relatively small size of most energy transition projects in EMDEs and the

relatively large minimum investment size that major institutional investors require. These platforms, such as the Managed Co-Lending Portfolio Program (MCPP) One Planet, aggregate large numbers of smaller projects and may use concessional finance to mitigate some of the credit risk. The result is a standardised, investment-grade, multi-asset portfolio that can attract the largest institutional investors. However, regulatory provisions in advanced economies affecting some institutional investors, such as public pensions and insurance companies, limit investments and/or portfolio exposure to EMDEs.

Voluntary carbon markets have the potential to attract private capital, including from corporations, to the EMDE energy transition, but need strong oversight to grow from today's low base. Carbon credits linked to real, verifiable emissions reductions and removals could be a valuable revenue stream for EMDEs. These have the potential to attract not only financial investors, but also to mobilise capital from large companies seeking to offset the portion of their corporate emissions that cannot immediately be eliminated. But much work still needs to be done on standards and monitoring, reporting, and verification processes. Moreover, companies must commit to and embark upon credible emissions reductions plans to avoid the perception that carbon credits merely enable them to continue polluting.

Better data is also essential to enable private investors to assess the true risks associated with EMDE investments. Poor information feeds high risk perceptions that push up the cost of capital in EMDEs. One step to improve this situation is through the database of the Global Emerging Markets Risk Database (GEMs) consortium, started in 2009. It pools credit information between multilateral development banks (MDBs) and development finance institutions (DFIs) to provide aggregate risk statistics. Efforts are currently underway to expand access to these data to other investors. Country efforts to improve data and its availability will be important in attracting investors.

Deepening local capital markets and financial systems

Deeper local capital markets and financial systems are necessary to scale up domestic private investment in the clean energy transition. In some EMDEs, such as China and India, domestic capital -- rather than foreign capital -- has been the major source of private capital for the clean energy transition thus far. Developing domestic bond, equity, and derivatives markets (e.g., currency swaps) can enable domestic funding of climate projects. Project-related revenue streams from energy transition projects in EMDEs are typically denominated in local currency. International investors who bring foreign currency therefore create foreign exchange risk for either themselves or for EMDE borrowers. Whilst swaps are needed to hedge currency risk, this can be expensive and a range of options may be needed to defray the costs of foreign currency hedging, including use of concessional finance.

Credible transition planning

Financing for clean energy projects will not flow without credible climate transition commitments and planning by governments: a point of departure is country commitment to ambitious Paris-aligned goals, converted into clean energy transition plans and targets. This vision for the energy sector, including universal access to modern energy where this remains to be achieved, needs to be consistent with energy sector reform and planning so that it provides meaningful signals to private markets. A regional perspective can reduce costs, especially in the power sector where cross-border trade creates a wider balancing market for renewable-rich systems.

Integrated planning, policy and regulatory reform, and capacity building can turn high-level commitments into a pipeline of bankable clean energy projects. Strong pricing signals are crucial: a price on carbon, or regulatory and policy measures with equivalent effect, are needed to help steer investment decisions towards cleaner and more efficient technologies. Among issues deterring investors are subsidies that tilt the playing field against clean energy investments, unpredictable procurement practices, lengthy procedures for licensing and unclear land rights; arbitrary or weak contract enforcement; restrictions on private or foreign ownership; and poor creditworthiness of counterparties. Support for capacity and institution-building is vital to improve energy sector governance and to enhance clean energy knowledge and relevant skills.

Good policies provide the signal to investors

With the right policy environment, the cost-competitiveness and maturity of renewable technologies for electricity generation mark them out as a major opportunity for scaling up private sector investment. For utility-scale renewables, the key success factors have included competitive auctions for new capacity, combined with long-term power purchase agreements (PPAs) with a creditworthy off-taker and reliable land and grid access. Removing barriers to corporate PPAs, through which companies contract directly with renewable power producers, is another way to unlock strong incentives for privately driven investments. Public financial support can be justified to develop confidence in new markets or to mitigate specific risks, for example, guarantees that limit the risk of non-payment. In coal-dependent power systems, innovative financing mechanisms with international backing that refit, repurpose or retire existing coal plants create room for the beneficial expansion of low-emissions generation. Mini-grids or distributed generation such as residential rooftop solar are likewise a channel for private investment.

Investments in clean energy generation are dependent on the timely expansion of grids, alongside energy storage and other options to allow for the integration of variable renewables. In many EMDEs, weak electricity infrastructure results in unreliable access for users and is a major risk for investors. More than 90% of investments in EMDE grids are the responsibility of SOEs, many of which are facing severe financial strains and lack access to capital. Private sector participation in electrical grids is limited in most cases to the distribution sector, although private sector financing for energy storage projects is on the rise. Early network investment planning, public support and public-private partnerships, and measures to strengthen the operational and financial performance of utilities can ensure that grid infrastructure becomes an enabler, rather than a bottleneck, for expanding renewables.

Low-emissions fuels are important in the clean energy transition, especially in sectors where direct electrification is not feasible or cost-effective. There is burgeoning investor interest in low-emission hydrogen, especially for production via electrolysis in countries with low-cost solar or wind potential. Commercial viability is in its early stages and, for the moment, supply-side initiatives in Africa, Latin America, and the Middle East are not matched by a comparable level of commitments from buyers, putting a premium on secure offtake arrangements to underpin investments. Sustainable biofuels and CCUS are the other main investment avenues. Policy incentives and mandates in Brazil, China, India, and Indonesia have underpinned a strong rise in EMDE biofuels production, encompassing both liquid biofuels and biogases.

Investment in more efficient and electrified technologies in buildings, transportation and industry is a crucial component of energy transitions. Almost 70% of EMDEs have set specific targets for deploying electric vehicles. Regulatory policies such as building codes, minimum energy performance standards (MEPS), fuel efficiency and quality standards, alongside non-regulatory policies such as labels and information campaigns, and financial incentives are important to enable sustainable choices by consumers. Efficient cooling needs to be a particular focus, given rising global temperatures and the huge scope for increased cooling demand as EMDE incomes rise. Many of the investments in this area are relatively small and bespoke; standardisation and aggregation are important to bring in private capital.

Clean energy supply chains, including batteries, solar panels and wind turbines, represent a growing opportunity for private sector investors in EMDEs. While most countries rely on imports, China manufactures three-quarters of the world's batteries and solar PV modules and has an exceptionally strong position in processing and refining of critical minerals. Other major EMDE markets for clean energy, such as India, are now providing incentives for domestic clean energy manufacturing. Countries in Africa, Latin America, and Southeast Asia are leading resource holders of battery metals, copper and rare earth minerals, and are seeking ways to move beyond primary production.

A call to action

A redoubled effort is needed to put EMDEs on a pathway to higher clean energy investment and full participation in what the Independent High-Level Expert Group on Climate Finance rightly called the "growth story of the 21st century: sustainable, resilient and inclusive". The urgency of tackling climate change demands it, but it is far from the only reason to move faster. Other benefits include improved air quality and sharp reductions in pollution-related healthcare costs and premature deaths. This report's analysis highlights why private initiative is an essential part of the solution – but the report is also clear-eyed on what it takes for private investors to commit capital. Sound regulations and public policies, strengthened institutions and greatly expanded international support are the keys to unlock private financing for clean energy in EMDEs at scale.

Scaling up clean energy in EMDEs

Setting the scene

S U M M A R Y

- The case for building tomorrow's energy systems around clean technologies is compelling, enabling Paris Agreement emission targets and energy access goals to be met while underpinning sustainable economic growth and job creation. Although high-income economies account for the majority of past emissions, without sufficient focus on the transformation of their energy systems EMDEs will continue to account for the largest source of future emissions growth.
- Currently, about 775 million people in EMDEs still lack access to electricity and 2.4 billion people lack access to clean cooking fuels. With EMDEs leading population growth in the coming decades, the need for economic growth to generate enough quality jobs will result in further demands for energy.
- Promoting policies to facilitate the energy transition through the diffusion and adoption of clean energy technologies can spur productivity, increase standards of living and boost resilience to climate change-related shocks.
- The pace of innovation in clean energy technologies is promising, with much of the sector seeing significant increases in capacity and declines in cost. However, much of this push has taken place in advanced economies and China, and more recently other large emerging economies. This leaves many other developing economies still struggling with accessibility and high costs of capital.
- A large scale-up of clean energy deployment across all EMDEs will require an increase in all sources of finance: public and private, domestic and international, concessional and non-concessional. In 2022 finance from public entities accounted for about half of EMDE energy spending, compared with less than 20% in advanced economies. Public institutions will remain prominent in areas like electricity networks and low-emission fuels, and will need to take the lead in ensuring access to electricity and clean cooking fuels. However, EMDE fiscal space is constrained by slowing global growth, rising borrowing costs and higher indebtedness, necessitating a major scale-up in private finance to support a broad and rapid rise in clean energy investment.
- The mobilisation of private finance on a scale consistent with the achievement of SDGs and net zero goals requires new regulations and policies, including additional concessional finance to mitigate risk at the country, sector and project level, and to enhance returns where investors are not able to capture the full social return.
- In addition to sound regulations and policies, policy predictability and commitment to an announced transition path are critical to increase private finance. Advancing policies, including regulation, finance and other incentives, can help mitigate political and other risks.

1.1. Introduction

The world's energy and climate future, more than ever, is dependent on decisions made in emerging market and developing economies (EMDEs). Reliable, affordable and modern energy in these economies could enable productive industries, well-functioning cities and efficient infrastructure to underpin economic development, as well as support better health and education outcomes. However, if economic growth in EMDEs is carbon-intensive, as historically witnessed among advanced economies, then greenhouse gas (GHG) emissions would be locked in for longer, leading to unavoidably severe impacts from climate change. Although high-income economies account for most of the stock of emissions, without sufficient focus on the transformation of their energy systems EMDEs would account for the largest source of future emissions growth.

Accelerated investment in clean energy technologies and infrastructure could lead to greater prosperity and job creation without an associated steep rise in GHG emissions. Prospects to move along this pathway ultimately depend on mobilising investment in EMDEs – the rationale for this report, conducted jointly by the International Energy Agency (IEA) and the International Finance Corporation (IFC). This initiative seeks to bring together the respective strengths of the two organisations and shed light on the critical issue of what it will take to scale up clean energy investment in EMDEs, in particular from the private sector.

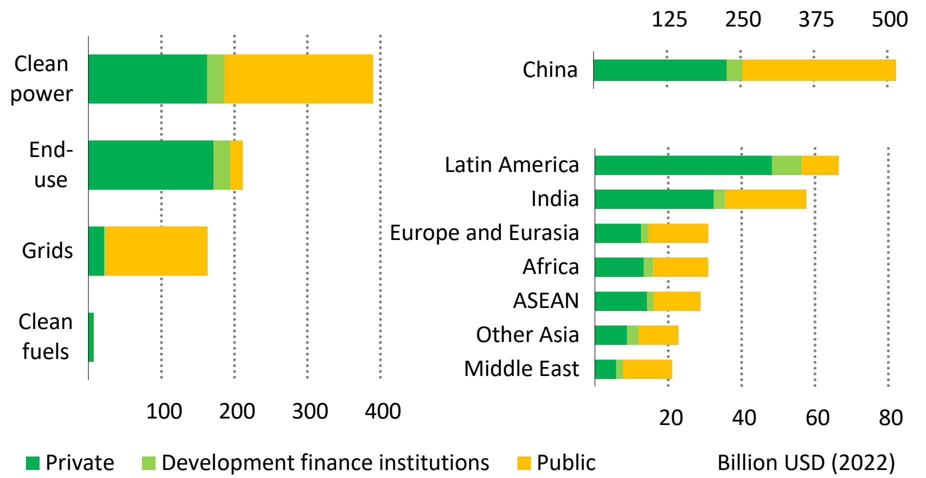
Why the focus on the private sector? Unlike in advanced economies, clean energy investment in most EMDEs is currently heavily dependent on public entities, largely by state-owned enterprises (SOEs). In 2022 finance by public entities accounted for about half of EMDE clean energy spending, compared with less than 20% in advanced economies (Figure 1.1).[1] SOEs are likely to remain significant in areas like electricity networks, where they currently account for more than three-quarters of EMDE capital expenditure, or in low-emission fuels, especially where large national oil companies are important forces behind energy transition investment. Public institutions will also need to take the lead in vital areas such as ensuring access to electricity and clean cooking fuels.

However, EMDEs are not in a position to rely on scarce national public funds to support a broad scale-up in clean investment in full. If all of the investment required to get on track with energy-related Sustainable Development Goals (SDGs) and the Paris Agreement were to come from the EMDE public purse, this would mean devoting well over 10% of aggregate EMDE tax and non-tax revenue to clean energy investment this decade, and considerably higher for many low-income countries. This is much too high a share to be reasonable, given that governments have to allocate scarce resources across a wide range of priorities. Clean energy projects are only one part of the picture, even when it comes to the response to climate change; there are major needs in areas like adaptation and resilience, land use and afforestation, and sustainable agriculture. In addition, today's environment is particularly

[1] The methodology for the IEA's investment analysis is available in the *World Energy Investment 2022: Methodology Annex* (IEA, 2022).

challenging for many EMDEs, as rising borrowing costs, higher fuel import bills and growing indebtedness further limit the fiscal capacity to support capital-intensive clean energy projects.

Figure 1.1 ▷ Clean energy finance in EMDEs by public and private sources in 2022



Around half of clean energy investment in EMDEs is financed by public entities, but a scale-up will require a much greater role for the private sector

There is a strong case for developed economies to deepen their engagement with EMDEs on access to international finance, on a bilateral and multilateral basis, especially given their historical responsibility for the bulk of emissions. This will be essential to catalyse the necessary investment in critical areas and to support longer-term reform processes. A starting point is the commitment made by developed countries at successive United Nations Climate Change Conferences (or Conferences of the Parties) to mobilise USD 100 billion per year in climate finance, a figure which covers bilateral and multilateral public climate finance, as well as climate-related export credits and private finance mobilised by the public climate funds. This commitment was made for 2020 but is now likely to be met only in 2023, three years past the target date. Moreover, the success of this public funding in mobilising private finance has been "lower than anticipated, with most mobilised in middle-income countries with relatively conducive enabling environments and low-risk profiles" (OECD, 2022a).

The delivery of this commitment remains essential to avoid further erosion of trust among EMDEs, but the USD 100 billion figure should not be understood as a measure of the required level of international support. As the report of the Independent High-Level Expert Group on Climate Finance noted, this figure was "negotiated, not deduced from analyses of what is necessary for a purpose" (Songwe, Stern and Bhattacharya, 2022). Our own analysis suggests that the need for external financing of clean energy investment in EMDEs is considerably higher, in the order of USD 500 billion to USD 700 billion per year, from both public and private sources, by the early 2030s.

The international aspect is a vital part of the solution, but must be considered in the context of a central message of this report: all sources of finance for clean energy will need to expand significantly if EMDEs are to reach energy-related SDGs as well as align with the Paris Agreement ambition to limit global temperature rise to 1.5°C above pre-industrial levels. These sources include public and private, domestic and international, concessional and non-concessional. Each of them has particular characteristics that, in different blends and combinations, can be an appropriate match for projects across different parts of the energy sector and different country circumstances.

The current status of private sector investment in clean energy in EMDEs varies widely by country, but some parts of the clean energy economy in EMDEs are already seeing significant private sector financing. Investment in clean sources of electricity generation is the best example. SOEs dominate certain segments, such as hydropower, nuclear and industrial plants (given the dominance of China), but the majority of low-emission power assets – for example in wind and solar PV – have been developed by private entities. Technology risk in these areas is relatively low and this means that where supportive policies are in place, these projects can be an attractive option for private investors.

The task is to broaden and accelerate this private sector involvement. An increasing number of private entities are seeking to contribute to addressing climate change, as witnessed by the breadth of participation in coalitions like the Glasgow Financial Alliance for Net Zero (GFANZ). To unlock greater private sector investment, there will need to be complementary public policy reform, the balancing of risk and return, and the judicious use of expanded public funding including from advanced economies. Such public funding can improve the feasibility of clean energy investments and bring in larger volumes of private capital, especially in sectors and countries that are perceived as higher risk. As such, public interventions need to de-risk projects as well as directly finance them, and to invest in complementary infrastructure such as electricity grids and storage, in order to prepare and structure a flow of viable and bankable projects that can attract finance (or co-finance) from the private sector.

1.1.1. Scope and structure of the report

This report covers the investment and financing requirements for clean energy in EMDEs. The time horizon considered in this analysis is the period to 2035. Each of these aspects requires clarification and definition.

By **clean energy** we mean a range of efficient, low- or zero-emission technologies and necessary infrastructure that can put countries on a path consistent with reaching the energy-related SDGs and longer-term decarbonisation objectives, such as net zero emissions by 2050. We group these elements into three categories:

- Low-emission power, which includes renewables and nuclear, as well as the required associated electricity grids and storage.
- Low-emission fuels, mainly sustainable biofuels, low-emission hydrogen, and CCUS and related infrastructure.
- Energy efficiency improvements and decarbonisation of end-use sectors, such as transport, industry, and buildings.

The projected investments include those that are needed to ensure universal access to electricity and clean cooking fuels.

The numbers put forward for clean energy investment do not, however, cover all energy-related capital expenditure. Substantial additional investments in fossil fuels, in EMDEs and in other countries, play a part in the supply and unabated use of fossil fuels; they are not the subject of this report, but are an important part of the broader energy picture. Scenarios that meet climate goals see steady reductions in fossil fuel investment, but some continued spending is needed in all the scenarios that we examine in this report (Box 1.1). The extent of this requirement depends on how quickly clean energy investment scales up. Some fossil fuel infrastructure, notably in the case of natural gas, supports the scale-up of wind and solar PV generation by providing a valuable source of flexibility for power system operation.

This report explores the clean energy investment needed to align EMDEs to pathways consistent with long-term sustainable development and Paris Agreement targets. The report does not address other investments that form part of the broader response to climate change, such as spending on adaptation and resilience, loss and damage, sustainable agriculture, afforestation and conservation, and biodiversity.

Not all the clean energy investments included in this report immediately deliver zero-emission energy or energy services. The analysis considers investments in infrastructure and technologies that have a supporting role to play in decarbonisation, such as enabling infrastructure (e.g. grids) that are essential for reliable and secure electricity systems and can be used for all generation technologies. The emissions associated with investment in electrified end uses, such as electric mobility, depend on the eventual decarbonisation of power generation. Some investments in efficiency, for example more fuel-efficient trucks or more efficient industrial processes, provide emission reductions but do not bring them down to zero. Nonetheless, they are critical in the pathway to greater efficiency and lower emissions. Adequate financial channels need to be available to support a wide range of clean investments across all parts of the energy sector. Those energy technologies that do not play a direct or supporting role in decarbonisation are excluded from the analysis. Additionally, while the early retirement of coal-fired power generation plants does contribute to decarbonisation, it is not included in the quantitative analysis of this report.

Box 1.1 ▹ Scenarios used in this report

Three scenarios are referenced in this report:

- 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 2.5°C in 2100.
- The **Sustainable Development Scenario (SDS)** achieves key energy-related UN SDGs, but reaches global net zero emissions in the 2060s (with many countries and regions reaching net zero much earlier). This scenario is aligned with the Paris Agreement objective of "holding the increase in the global average temperature to well below 2°C.
- 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. Like the SDS, it also meets the key UN SDGs related to universal energy access, alongside major improvements in air quality.

The SDS and the NZE Scenario are normative scenarios that show the pathways to reach specific outcomes. Between the two, the NZE Scenario represents the safer pathway to ensuring the Paris Agreement goals are met.

This report focuses on **emerging market and developing economies** in Africa, Europe, Latin America and the Caribbean, the Middle East, and Asia (together referred to in this report as EMDEs). This largely coincides with the countries that are not members of the Organisation for Economic Co-operation and Development (OECD); however, for the purposes of this report the EMDE grouping includes four OECD member countries: Chile, Colombia, Costa Rica and Mexico.[2]

The material in this report is structured as follows:

Chapter 1 sets the scene, discusses the developmental, macroeconomic and technological context, outlines the scope of the report, and provides an organisational framework for the analysis that follows.

[2] A previous report by the IEA on Financing Clean Energy Transitions in Emerging and Developing Economies (IEA, 2021) did not include the People's Republic of China (hereafter, "China") in the EMDE grouping, as the dynamics of energy investment in China are quite distinctive, but China is included in the EMDE aggregate in this report.

Chapter 2 assesses the current clean energy investment landscape in EMDEs and then quantifies the investment and finance needed to 2035 to reach energy-related SDGs and get on track for climate targets. The analysis includes an assessment of the future split between public and private financing.

Chapter 3 considers the key bottlenecks and market failures limiting private capital mobilisation for the energy transition in EMDEs. It surveys the various risk factors that face private investors and considers the types of policies and regulation that can reduce these risks and enhance returns for investors in EMDEs, with case studies that illustrate good policy practice.

Chapter 4 examines the measures and financial instruments that can enlarge the pool of private funding for clean energy projects in EMDEs. It provides estimates of concessional finance that will be required to crowd in private funding for clean energy, considers where and how concessional funding can be most effective, the potential for local currency financing, and some innovative options including green, blue, social, sustainability, and sustainability-linked bonds, carbon markets, and syndication platforms.

1.2. EMDE clean energy transitions in context

EMDEs span a wide range of country circumstances and levels of development and substantial variations in economic performance (Table 1.1). They include major suppliers and consumers of energy, countries where the majority of investment is already in clean energy (e.g. China, India and Brazil) and others where for every dollar of energy expenditure, less than 20 cents is spent on clean energy investment. The diversity of country contexts means that EMDEs have a range of different possible pathways, speeds and technology choices as they continue to develop their energy systems and integrate ever-larger amounts of low-emission technology. The focus of this report is on identifying the most effective ways to scale up private sector clean energy finance in these markets and how to frame the issues, taking into account the specific opportunities and barriers to energy investment in EMDEs.

1.2.1. Development context

The three decades prior to the Covid-19 pandemic were marked by significant improvements across a range of EMDE development outcomes. The global poverty rate, measured by the share of the population living below the World Bank's extreme poverty line, had dropped from 38% in 1990 to 8.5% by 2019, reflecting a reduction from more than 2 billion to about 660 million people (World Bank, 2023). Average life expectancy has increased from 46 years in 1950 to 71 years in 2021. Average years of schooling have significantly improved in many countries; for example, in India they jumped from about 3 years in 1990 to 6.4 years in 2017.

Table 1.1 ▷ Key economic and energy indicators for selected EMDEs

	Population	Urban population	Access to clean cooking	GDP per capita	CO_2 emissions	Energy demand per capita	Electricity consumption per capita	Share of renewables in power mix	Energy Investment	Clean energy investment
	2021	**2021**	**2021**	**2021**	**2020**	**2020**	**2020**	**2020**	**2021**	**2021**
	million	*%*	*%*	*USD/capita, PPP*	*Million tonnes*	*GJ/capita*	*kWh/capita*	*%*	*% of GDP*	*% of total energy*
Argentina	46	92	100	23 650	149	68	2 814	26	1.8	26
Bangladesh	167	39	23	6 494	84	11	498	2	3.1	68
Brazil	214	87	96	16 031	389	56	2 541	84	3.5	65
Chile	20	88	100	28 685	84	82	4 151	49	1.9	67
China	1 412	63	81	19 338	10 081	104	5 262	28	3.6	67
Colombia	50	82	92	16 819	73	34	1 506	66	1.9	67
Egypt	104	43	100	12 706	188	36	1 544	12	2.8	34
India	1 391	35	64	7 242	2 075	26	928	21	2.6	57
Indonesia	275	57	82	13 027	532	36	980	19	1.8	38
Kazakhstan	19	58	92	28 685	204	147	5 513	11	6.1	25
Kenya	55	28	18	5 211	16	22	166	94	2.4	48
Mexico	128	81	85	20 277	351	58	2 218	20	1.5	42
Morocco	37	64	98	8 853	62	24	908	18	2.8	34
Mozambique	32	38	5	1 348	6	15	392	84	2.4	48
Nigeria	211	53	14	5 408	88	32	134	24	2.4	48
Russia	144	75	86	32 863	1 552	220	6 838	20	4.4	22
Saudi Arabia	35	85	100	48 711	484	276	10 311	0.2	5.7	15
Senegal	17	49	24	3 840	8	12	322	12	2.4	48
South Africa	60	68	87	14 624	388	88	3 538	5	1.7	63
Thailand	70	52	84	18 761	243	80	2 770	17	2.5	45
Viet Nam	98	38	65	11 676	294	42	2 321	35	2.5	45

Note: PPP = purchasing power parity. Source: IEA calculations; World Bank (2022).

Yet most EMDEs have been struggling to reach robust and sustained levels of long-term economic growth or graduate towards high-income status. The improvements observed in recent decades have been uneven across countries and within them, with only a few examples of countries that shifted their income status from low and middle to high income. Some of the significant improvements in global development indicators were driven by the achievements of a few large economies. Discussions around middle-income traps and the policies needed to facilitate the path towards economic development are the subject of an active debate among policy makers and global development institutions.[3]

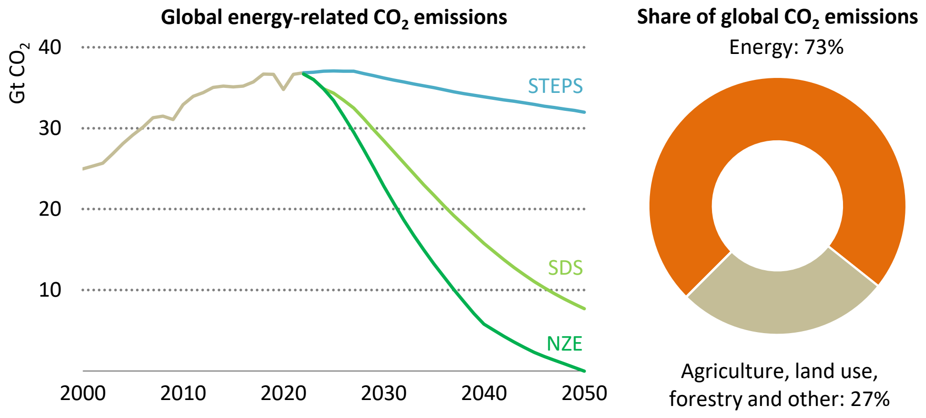
The need for major gains remains, with a large incidence of poverty in regions that will be driving demographic changes and the increasing demand for energy. Despite significant improvements in global poverty reduction prior to the Covid-19 pandemic, the share of the population living below the poverty line in Africa and South Asia is still far from the SDG of eradicating poverty in all its forms by 2030. The socio-economic impact of the Covid-19 pandemic has been felt particularly acutely among EMDEs. Several indicators, including energy access, nutrition, poverty and indebtedness, have shown a marked deterioration following the pandemic and made the SDGs even more challenging to reach. In several cases, historic improvements were wiped out due to the twin impacts of the pandemic and the energy crisis.

EMDEs now have development path opportunities in a new context where climate change is at the centre of economic decisions. Despite its relevance, this topic was absent from most of the policy decisions and actions to enhance long-term economic growth in previous decades. This scenario has changed, driven by increasing evidence that the rise in temperature is an important threat to global prosperity and convergence in the positions of key global actors – from the scientific community to governments and the private sector. The average global temperature is set to continue rising to 2050, even in a scenario that reaches net zero emissions by 2050, as concentrations of CO_2 in the atmosphere continue to rise until such time as any residual emissions are balanced by removals from the atmosphere.

Currently, almost three-quarters of global CO_2 emissions are from the production and use of energy, and energy-related CO_2 emissions reached a new high in 2022 at 36.8 billion tonnes (Gt) (Figure 1.2). Around 40% of this comes from fuels used in power generation, followed by emissions from industry (25%), transport (21%) and buildings (8%). EMDEs account for around two-thirds of today's energy-related CO_2 emissions, and China alone for around one-third. If China is excluded, then average per-capita emissions in EMDEs are under one-third of the level in advanced economies.

[3] This will be the central topic of the World Bank's forthcoming 2024 World Development Report, focusing on economic growth in middle-income countries.

Figure 1.2 ▷ Global energy-related CO_2 emissions by scenario and share of energy in total emissions



IEA. CC BY 4.0.

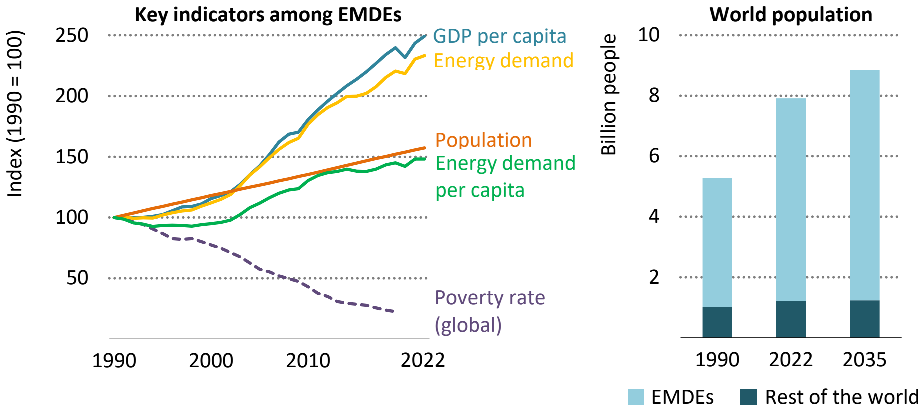
Achieving net zero emissions and the stabilisation of the global average temperature will require a huge acceleration in the pace of clean energy deployment

Sources: IEA; Ritchie, Roser and Rosado (2020).

With EMDEs leading population growth in the coming decades, the need for economic growth to generate sufficient quality jobs will result in further demands for energy (Figure 1.3). Currently, about 775 million people in EMDEs still lack access to electricity and 2.4 billion people lack access to clean cooking fuels. Moreover, some regions with a lower incidence of poverty or population growth, such as the Latin America and the Caribbean and East Asia, still face large challenges with inequality and the need to reach higher and inclusive economic growth. These challenges reinforce the need for major build-out of clean energy infrastructure to meet the rising demand for energy services in a sustainable way. However, almost all the increase in clean energy investment to date has been in advanced economies and China (see Chapter 2), underscoring the need for faster clean energy transitions in EMDEs beyond China.

Clean energy transitions are ready to form a key pillar of sustainable long-term growth. In addition to lowering GHG emissions, the accelerated deployment of clean energy and energy efficiency technologies and policies contributes to facilitating universal access to energy, boosting productivity growth and creating new jobs, while promoting a circular economy that minimises waste and helps improve material efficiency and the reduction of air pollutants.

Figure 1.3 ▷ Select development indicators for EMDEs, 1990-2022, and global population projections, 1990-2035



Higher incomes and a growing population – especially in Africa and South and Southeast Asia – are set to bring rapid increases in demand for energy services

Note: Poverty rate here refers to the share of the global population living under USD 2.15 per day.
Sources: IEA; poverty data from World Bank.

Many EMDE economies are also particularly vulnerable to climate change, especially those that rely largely on agriculture as the main sector driving economic growth and absorbing large numbers of workers. Evidence across countries suggest that droughts and extreme heat during the period 1964-2007 significantly reduced national cereal production by around 10% (Lesk, Rowhani and Ramankutty, 2016). Without additional action on adaptation, each degree Celsius increase in global mean temperature would, on average, reduce global yields of wheat by 6%, rice by over 3%, maize by over 7%, and soybeans by over 3% (Zhao, Liu and Piao, 2017).

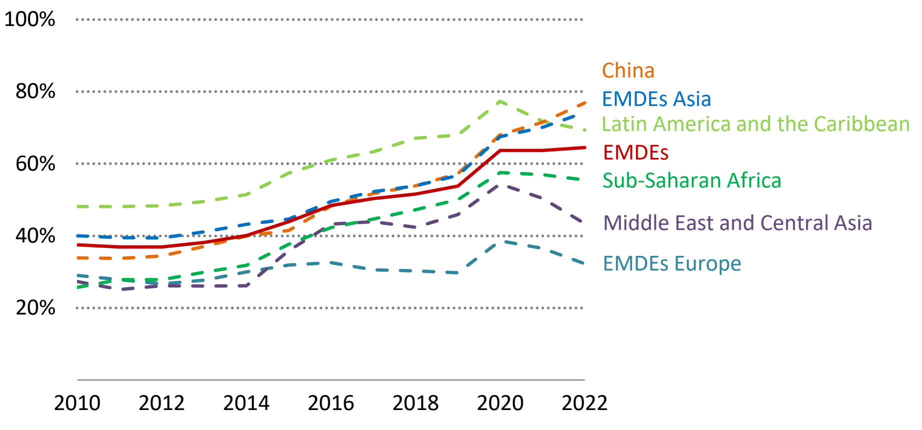
1.2.2. Macroeconomic context

After the pandemic-related decline in 2020, global economic activity rebounded strongly in 2021, reflecting the relaxation of lockdowns, gradual recovery of international trade and substantial fiscal stimulus in most countries. This recovery was, however, disrupted in early 2022 by the repercussions of Russia's invasion of Ukraine, including further damage to international trade and financial linkages, sharp increases and greater volatility in food and energy prices, and heightened risk and uncertainty. Higher prices for fossil fuels played a key role in accelerating inflation, which had already risen during the 2021 recovery with the upswing in demand amid ongoing disruptions to supply chains and the exit of significant numbers of labour force participants.

Inflation pressures were given further impetus by surging prices for food and fertilisers, following the spikes in the global price of oil and natural gas as well as supply disruption caused by Russia's invasion of Ukraine. As a result, the worldwide tightening of monetary policy needed to re-anchor inflation, conditioned by the actions of the US Federal Reserve Board, has had to be stronger than many had expected. This led, by early 2023, to (i) a sizeable correction of global equity markets, (ii) reduced bond issuance, especially by lower-rated issuers, amid expectations of renewed recession in advanced economies, including the United States and Europe, and (iii) a further slowdown in global GDP growth. Among EMDEs, slower growth has been accompanied in many instances by reduced inflows of private foreign capital, which has weakened exchange rates, boosted inflation, and reinforced the need for tighter monetary policy and higher interest rates.

Against this background, inflation appeared to have peaked in most countries by late 2022 and may fall toward monetary authorities' target levels by later in 2023. There are important exceptions, however, in countries where fiscal imbalances and inadequate monetary policy responses are leading inflation to continue rising toward 100% or more. Overall, the headwinds confronting growth are well known. Factors that cushioned economic activity during the pandemic and early recovery have diminished, including large-scale fiscal stimulus, access to cheap credit, and new and expanded financial support from international financial institutions and multilateral development banks. Most countries face limits to fiscal support, owing to accumulated government debt as high interest rates and tightening credit conditions undermine consumption and investment, and slowing growth in partner countries weakens export prospects (Figure 1.4). Despite important innovations in recent years, competition has increased for a constrained pool of multilateral funding.

Figure 1.4 ▹ General government debt in EMDEs as a percentage of GDP



High and rising levels of government debt, especially in Asia, constrain the possibilities for governments to finance clean energy investments

The June 2023 edition of the World Bank Group report *Global Economic Prospects* projects global GDP growth to decline from 3.1% in 2022 to 2.1-2.4% in 2023-2024. Outlooks for individual economies vary widely, however. Growth in Asia is expected to rebound strongly, while growth in Africa may remain around 2022 levels (with widely diverging performance within the region). Growth in Latin America and the Caribbean, the Middle East and Central Asia, and Europe is not expected to pick up. In all regions, full recovery of the ground lost during the pandemic is not likely to happen soon. By the end of 2024 real GDP in EMDEs would be about 6% lower than the levels projected before the pandemic. This provides a difficult context for moving forward with clean energy transitions.

Downside risks to the outlook include the possibility of a renewed upturn and greater volatility in food and energy prices, the persistence of elevated inflation leading to longer-than-expected tightening of global financial conditions, a broadening of financial sector stresses already experienced in many advanced economies, and the potential consequences of growing geopolitical fragmentation. Moreover, the combination of low growth, elevated debt levels and high interest rates has intensified debt distress across a growing number of EMDEs. Roughly a quarter of EMDEs are now at high risk of debt distress, and over half of low-income countries are at high risk of, or already experiencing, debt distress. Such a macroeconomic backdrop increases the complexity of achieving energy- and climate-related SDGs as well as longer-term decarbonisation targets among EMDEs.

1.2.3. Technological context

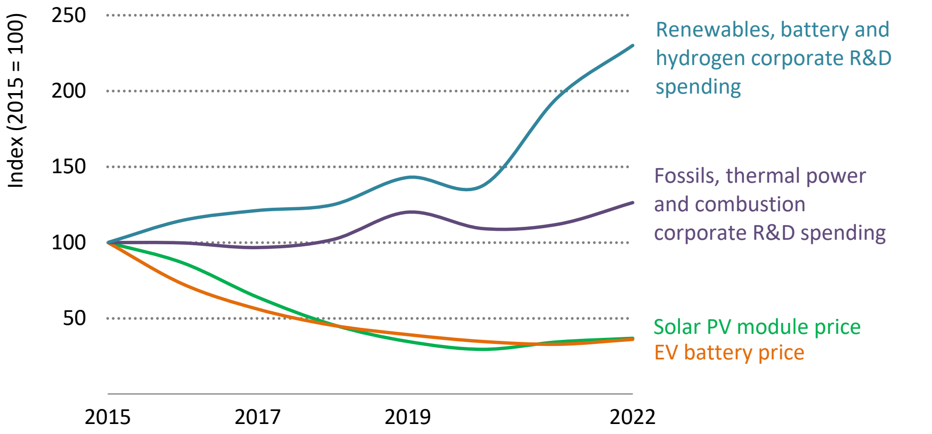
Technology plays a key role in enabling energy transitions. By providing alternatives to traditional fossil fuels in the form of more sustainable and renewable sources of energy that deliver more reliability, greater efficiency and lower costs, technological progress is essential to offering affordable and sustainable solutions for energy transitions across EMDEs.

Innovation and diffusion are the two main channels through which technological change drives energy transitions. These channels are complementary, but they entail different challenges and have diverse implications in the context of EMDEs. A portfolio of policies for innovation can generally be thought of as having both supply-side technology push elements that reduce the cost of knowledge creation in advance of commercialisation, and demand-side market pull elements that enhance net revenue from sales after commercialisation, spurred by market competition.

Innovation usually requires an ecosystem with a complex set of complementary factors, including knowledge and human and physical capital, combined with enabling institutions and a supportive policy environment; many of these complementary capabilities are more widely available in advanced economies. Innovation in EMDEs often involves the adaptation to local contexts of technologies initially developed in advanced economies or in larger emerging economies such as China. Diffusion of technologies typically occurs through international trade, foreign direct investment or technology licensing channels; additional mechanisms include patent buyouts, compulsory licensing, patent pools and open-source approaches. Diffusion involves both large-scale adoption enabled by national or corporate programmes, and a more decentralised process involving individual decisions of adoption by firms and households.

The pace of innovation in clean energy technologies is promising. The number of priority patent applications in the past 20 years, split by technological field and invention year, indicates that the speed of clean energy technology innovation has been increasing faster than other technologies on average (OECD, 2022b). Furthermore, corporate R&D spending by clean energy technology companies (including renewables, hydrogen, battery and energy storage companies) has been growing faster than R&D spending by fossil fuel companies, illustrating a growing interest in and potential pipeline of innovative clean energy technologies in the marketplace (Figure 1.5).

Figure 1.5 ▻ Global corporate R&D spending and clean energy technology prices



Growing R&D spending globally on renewables and batteries – along with economies of scale from manufacturing and improved supply chains – have contributed to falling costs

In recent years, some clean energy technologies have seen significant increases in capacity and declines in costs. For example, prices for solar PV modules and EV batteries dropped by over half between 2015 and 2022, making them much more affordable. However, much of the push that enabled technological advances and economies of scale in clean energy has taken place in advanced economies and China. For many EMDEs, fossil fuel technologies continue to remain relatively more accessible and affordable in several sectors.

Many households in EMDEs still do not have access to electricity and a large number of firms do not have reliable sources of energy without significant disruption. This reflects the challenges of translating energy-related innovation into technologies that are widely adopted by firms and households. Evidence from EMDEs, including Kenya and Pakistan, show that more than 75% of enterprises face electricity outages in these countries (World Bank, 2022).

A global effort to facilitate the diffusion, adoption and intensive use of clean energy technologies is needed to overcome the incentives still favouring the use of fossil fuel-linked technologies and speed up energy transitions across EMDEs. Fossil fuel-related technologies have benefited from well over a century of innovation and diffusion, with well-established supply chains globally. As the dominant sources of energy supply in the world, fossil fuel technologies are mainstream and available “off the shelf” for consumers to purchase where they need them. Additional energy transition policies and other forms of support are needed to facilitate the diffusion of clean energy technologies in ways that are consistent with improving the prospects of economic prosperity in EMDEs. This should also include the generation and diffusion of technologies to transform the minerals and metals critical to clean energy production.

Promoting policies to facilitate energy transitions should also provide the opportunity to address the large technological divide across firms and households. Enterprises in EMDEs are, on average, far from the technological frontier. Evidence from firms across 22 EMDEs shows that both credit constraints and weak green enterprise management practices hold back corporate investment in clean energy technologies that are embodied in new machinery, equipment and vehicles (De Haas, et al., 2023). These assets are not only more environmentally efficient, but they can also boost overall productivity. Moreover, green enterprise management practices are strongly correlated with the adoption of more sophisticated digital and other sector-specific technologies, which in turn enable these more capable firms to be more resilient in the face of economic shocks (Cirera, Comin and Cruz, 2022). Therefore, improving private capital mobilisation and the enabling environment to facilitate the diffusion and adoption of green technologies, including green management practices among firms, can also stimulate the adoption of other technologies, spur business productivity and generate greater resilience to climate-related shocks.

1.3. Organising framework

Addressing climate change requires broadly two types of actions: mitigation of GHG emissions; and adaptation to minimise damage resulting from climate change and extreme weather events. Every country needs to address both issues with priority action according to their circumstances. While both have substantial financing needs, the focus of this report is on mitigation of energy-related emissions – clean energy transitions.

Recognising the challenges that EMDEs are likely to face in mobilising private finance for their clean energy transitions, this section introduces the principles that determine where and how public interventions can help ensure the mobilisation of sufficient private finance. It categorises the overall investment picture that is further elaborated in Chapter 2. It discusses what types of additional regulatory and policy measures are required to address variations in country-, sector- and project-specific risks, as well in the private returns on clean energy projects relative to fossil fuel production and use, as a precondition for the private bankability of projects. This sets the stage for the discussion of regulations and policies in Chapter 3. Finally, it differentiates between resources provided via policies to support projects directly (Chapter 3) and concessional resources to lower the cost of finance and to crowd-in additional private finance (Chapter 4). It highlights the need for additional measures both to mitigate risk and to enhance returns to ensure sufficient private finance for the energy transitions in EMDEs.

Three dimensions of energy transitions

Public interventions are needed to create the incentives for additional private finance in EMDEs to differing degrees across all aspects of energy transitions. These aspects can be grouped into three: on the supply side, the power and fuels transitions; and on the demand side, the end-use transition.

The power transition involves accelerating the ongoing shift to low-emission electricity produced by renewables and nuclear power. Specifically, renewables means investment in solar PV, wind (onshore and offshore), hydro, geothermal, bioenergy and other renewable technologies. The power transition also includes investment in strengthening and restructuring the underlying electricity grid networks (transmission and distribution). Given the intermittency of some renewable sources such as solar and wind, investment in a range of sources of flexibility in power market operation is essential, including robust grids, dispatchable generation, storage (including batteries) and demand response.

The fuels transition relates to the phasing down of fossil fuels, namely coal, oil, natural gas and their derivatives, and the scaling up of low-emission fuels, such as low-emission hydrogen (including hydrogen produced via electrolysis, using renewables), modern liquid and gaseous biofuels, and synthetic fuels. It also includes investment in carbon capture, utilisation and storage (CCUS).[4]

The end-use transition includes shifts in the energy used by all enterprises and households, with a focus on decarbonisation investments for three major end users of fuels: industrial production; transport; and buildings. It includes investments in energy efficiency and savings, with the introduction of economic incentives for a full circular economy that minimises waste in energy and materials use. The overall package also includes investment in access to electricity and clean cooking for all excluded people.

There are important commonalities and interdependencies between the transitions as they affect private investment. All three transitions require investment in substantial

[4] CCUS is an umbrella term for a set of related technologies that can help to avoid greenhouse gas emissions. Includes: the separation or capture of CO_2 before it can be emitted by industrial processes or power plants, or directly from the atmosphere; the transport of CO_2 by pipeline or other means; the conversion of captured CO_2 into saleable products; and the storage of CO_2 in geological or mineral repositories for long-term isolation from the atmosphere.

restructuring of existing production methods and business models, such as the transition away from fossil fuel production assets and the construction of charging infrastructure for EV batteries. They also create the risk of significant stranded assets and sunk costs, in the form of the conversion or retirement of production capacity before the end of its useful life and the associated impact on local workforces and communities. Across all three transitions, there will be interdependent shifts in the production, transport, trade and consumption of energy and energy-consuming goods and services. Investment in renewable power projects will become more attractive in countries currently using coal-fired plants as these plants are retired, but investment in the scaling up of renewables will be required before the phasing down of coal plants. Similarly, investment in low-emission hydrogen production requires demand from steel and other industrial users, while demand in turn is predicated on a market with available supply.

Principles for creating demand for private finance

Demand for private finance in EMDEs is a derived demand. It is derived from the volume of projects that meet attractive risk-adjusted returns relative to other global bankable projects. Currently the main constraint to financing is not the supply of private finance, but the absence of projects at a scale that is necessary for the transitions to be realised. The main reason for the absence of enough projects, in turn, is the absence of a robust policy and regulatory framework, including the needed flow of concessional resources, to close the gap between private and social returns and thereby improve relative risk-adjusted returns.

An effective policy and regulatory framework is required to address those variations in country-specific costs and risks that are particularly acute in EMDEs. These are risks that raise the cost of capital in EMDEs relative to advanced countries (particularly relevant for high-CAPEX/low-OPEX projects that characterise many renewable projects), a cost that cannot be compensated for by higher, though still uncertain returns, and cannot be controlled by the project investor. They include:

- Macroeconomic risks and political instability of the host country.
- Underdeveloped markets, such as financial markets, which reduce the ability to manage financial risks such as foreign exchange risk.
- Policy risks, regulatory shortfalls and corruption, including renewable generation offtake risk.
- Higher costs of doing business due to poor infrastructure, reduced human capital, the overall business environment and investors' lack of experience in many EMDE markets.

There are also significant variations in costs and risks that are specific to projects across the three transitions and need to be addressed by effective policies and regulations. They include:

- The technology utilised and uncertainties regarding technological evolution.

- The importance of sunk costs (already incurred and irrecoverable) in the overall cost structure and the risk of stranded assets (that are retired to be replaced with cleaner facilities).
- The expected market size and profits, and uncertainties regarding their evolution.
- The resilience of clean energy supply chains, in particular the availability of inputs such as critical minerals and their ease of exploitation.

In addition to measures to mitigate country-, sector- and project-specific risks and costs, additional regulations and policies, including concessional resources, may in many instances be needed to enhance private returns on clean energy projects relative to fossil fuel production and use, and relative to clean energy projects in advanced countries. In choosing which projects to support, policy makers should use the social rate of return on investment as the appropriate benchmark. It accounts for externalities including all environmental and social co-benefits associated with the abatement of GHGs, other market failures, and other transaction costs that lead to divergences between private and social net benefits.

A stable climate is a public good endangered by GHG emissions, which act as a negative externality. The first-best policy solution to raise clean energy returns relative to fossil fuel production is a global carbon tax, together with technology policies and compensation payments for sunk costs and social adjustment costs (including to support relocation and retraining of workers and income assistance to those unable to adjust). However, a global solution such as a carbon tax is very difficult to implement due to information-related market failures and other transaction (especially bargaining) costs, including between current and future generations, and between people in different regions, both within and across countries (Blanchard, Gollier and Tirole, 2022). For those countries where a carbon tax is not feasible and private investors are not able to capture the full social benefit of their investments, additional return-enhancement measures are needed.

Revenue-enhancing measures are intended to substitute for the relative prices and the ensuing allocation of resources that would be achieved under a carbon tax, reflecting all environmental and social co-benefits. They are needed to support the additional pipeline of projects and complementary investments that require these higher relative returns. Limited returns are indeed listed as the leading barrier to private investment in decarbonisation in Bain's latest annual energy transition survey of more than 600 senior energy and natural resource executives, significantly ahead of lack of policy and regulatory support, lack of technology, slow permitting and legal processes, supply chain constraints and any supply-side shortfall of capital (Dougans, et al., 2023). The environmental and social co-benefits from clean energy technology adoption that should be reflected in higher returns include a range of positive impacts passed on to customers. The efficient cooling systems powered by clean energy, for example, could help reduce food waste, deliver fresher food from rural to urban markets, distribute vaccines, and make work and at-home study more pleasant and effective.

Some important clean energy projects require the involvement of more than one country to be viable and the most cost-effective.[5] The bankability of private sector investments in these international projects poses additional challenges and requires additional support beyond the mitigation of country-, sector- and project-specific risks and the enhancement of returns at the country level. Multi-country investments typically require multi-country governance of information flows, co-ordination, and regulation to ensure joint accountability and enforceability and thereby to ensure bankability and attract private capital.

Finally, in addition to sound regulations and policies, policy predictability and commitment to an announced transition path are critical to increase private finance. The more predictable government regulations and policies are, the lower the risks for any investor. Political instability, corruption and conflict further increase risks. More broadly, better quality governance generally goes along with lower risk for private investors. Investors benefit from "visibility" of subnational, national and international programmes. These may include announced programmes on the procurement of new renewable generation capacity with enforceable targets, including auction dates, portfolio standards (obligations on distribution companies to buy an increasing share of low-emission electricity over time) and supporting regulatory reforms to lower offtaker payment risk. Political stability and good governance can also help secure environmental and social co-benefits, including energy access and inclusion for vulnerable groups and well-distributed positive outcomes across all stakeholders.

Projects with varying levels of complexity

Within the energy transitions, private finance in the end supports specific projects, which can be differentiated by the complexity of the challenges they pose to make them bankable. The complexity facing specific projects can be thought of as varying along a continuum across at least three dimensions:

- The extent to which the main technology is either established or fast maturing (e.g. solar PV and wind) versus emerging (e.g. low emissions hydrogen and CCUS).
- The extent to which, other than direct project costs, there are no associated restructuring costs or that these costs are easily recuperable in available secondary markets versus high sunk costs (e.g. non-depreciated assets with high irretrievable value that do not have valuable alternative uses, such as coal mines in the presence of bans on future energy-related use of coal).
- The extent to which policy, regulation, governance and social adjustment challenges have been addressed and other public goods are in place versus significant unresolved co-ordination, information or public goods barriers to be addressed as a precondition to the project's viability.

[5] These include renewable generation projects as well as interconnections where supply is in a different country from the main sources of demand. A famous example is the Itaipu hydroelectric plant located at the border between Brazil and Paraguay, with power production beginning in 1984. In 2018 it supplied 15% of Brazil's and 90% of Paraguay's energy consumption.

Some projects will be more complex along some of these dimensions and less complex among others, differentially affecting the bankability of the project. Less complex projects are more tractable and more straightforward candidates for private finance. They are often more easily replicable and scalable solutions that include investment in existing competitive renewable energy technologies – where costs have been driven down dramatically in the last decade – to accelerate the power transition. Investment in renewable power also benefits from established markets and proven solutions on the end-user side, for instance complementary investment in networks of EV charging stations or a battery leasing and swapping model to reduce the upfront EV costs. They also include power transmission and distribution projects in countries with receptive business environments on the power side, as well as the decarbonisation of buildings on the end-use side.

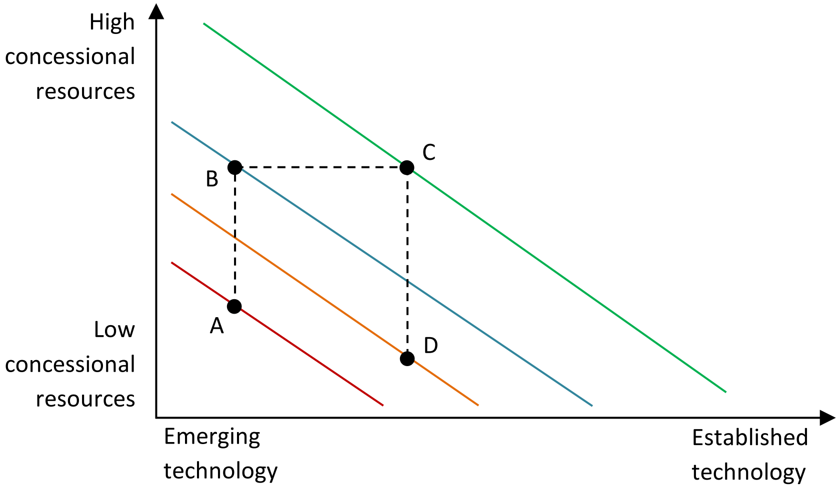
More complex projects involve more challenges, typically with a range of public-supported actions required to make the associated private investments bankable. They typically include high sunk costs and the need to address prior contractual commitments between high-carbon fuel producers and users. They include the problem of stranded costs in power in localities and countries with a heavy dependence on coal, such as those associated with existing coal mines and processing facilities, the phasing out of which is more complex than expanding renewable generation capacity. They are also more demanding from a technological standpoint. They may require massive restructuring on the end-user side (e.g. steel and cement producers) to substitute low-carbon for fossil fuels. In addition, they may be complicated by the need to incorporate adjustments based on local stakeholder/community involvement.

While many projects require both equity and debt finance, they need different mixes of financing sources and instruments. More complex projects involving heavy sunk costs and social adjustment costs, including but not limited to major write-offs from power plant retirements or restructuring on the end-user side, will often require more public subsidies, equity and concessional finance.

Concessional funding

When considering which projects should have priority for concessional funding and how much may be required to crowd-in private finance, factors to consider include the relative importance of country-, sector- and project-specific risks and costs, and the project's return (including all environmental and social co-benefits relative to other investments). The "concessionality" gradient illustrates these trade-offs in a simplified manner (Figure 1.6). The vertical y-axis represents the degree of "concessionality" needed to crowd in private investment in a particular energy transition project. Concessional resources here refer to resources that are extended at below-market terms. They may include domestic and global public or philanthropic funds extended on below-market terms both directly as project finance and indirectly by using concessional capital to catalyse investment in the project (e.g. through the use of a guarantee or a grant for project preparation). The latter, discussed in greater detail in Chapter 4, are termed "blended finance" when they mobilise multiples of additional private capital.

Figure 1.6 ▻ The concessionality gradient



The need for concessional resources is determined by specific risk and cost factors, including the maturity of the relevant technology

The horizontal x-axis represents the state of the technology used in the project – how established it is. Newer, untested and explorative technologies such as novel forms of low-emission hydrogen and CCUS are closer to the y-axis. These have greater risk of failing to achieve sufficient cost reductions that would allow them to scale and be competitive with other available technological options; accordingly, expected returns are lower, all other things being equal. Concessional resources, by reducing the loss the investor might incur and/or enhancing the return, can make them attractive enough to invest in.

Given the global urgency to meet climate targets and the lack of access to technologies, especially in countries with relatively low intellectual property rights protections, concessional resources can also facilitate the transfer of specific technologies between innovators and adopters. Market forces alone are likely to be insufficient to provide the necessary technologies that are critical for the transition to net zero emissions to countries and regions. For more established technologies the extent of concession required is lower, such as investment in solar panels, represented further to the right on the technology axis. Even with established technologies, some degree of concessional resource may be needed given market characteristics and the extent of externalities, other market failures, and other transaction costs that lead to divergences between private and social net benefits.

The relationship between expected returns and technology is one of several relationships that determine the need for concessional resources. In the figure, point A represents the degree of concessional resources needed for a particular technology. In countries where other risks are higher, the returns required for investment are higher (external-to-project risks such as macroeconomic stability or currency depreciation risk that cannot be adequately hedged, or project risks such as higher-than-expected stranded costs). In these cases, the degree of concession offered to investors may need to be greater for the same technology, represented by point B. In the case where the technology is more established but other costs are higher (e.g. risks associated with retiring assets related to fossil fuel production and use), the degree of concession required might be at point C, the lower risks associated with the more established technology being balanced by other higher risks or costs. Conversely, the more that countries directly support energy transition investment through a carbon tax or equivalent measure, the lower the need for additional concessional resources to incentivise private investors, resulting in a position like point D on the concessionality gradient.

Besides the trade-offs between different types of risk and their implications for the need of concessional resources, the figure highlights the key role of innovation. Just as many renewable technologies have moved from emerging to mature, thereby reducing the concessional resource required to support projects with these technologies, innovations that bring down the cost of new and emerging technologies will similarly reduce the amount of concessional resources required to support the clean energy transition, all else being equal.

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Clean energy investment in EMDEs

Today's trends, tomorrow's needs

SUMMARY

- In 2022 around USD 770 billion was invested in clean energy across EMDEs. Although this amount is set to rise in 2023, the geographical distribution of this spending is very uneven: China accounts for two-thirds of clean energy investment in EMDEs, and the top three countries (China, India and Brazil) for more than three-quarters. Outside China, spending on clean energy in EMDEs in recent years has been essentially flat at around USD 260 billion per year, a worrying trend.
- The largest share of clean energy investment in EMDEs is in power generation, reflecting the maturity of many clean generation technologies. Solar PV is the only technology that has seen consistent increases in investment spending. Financing costs play a major role in determining the LCOE in key emerging markets, constituting around half of the LCOE for utility-scale solar PV projects. Only China exhibited a lower overall share of financing costs, closer to that in advanced economies.
- Low and lower-middle income countries, home to more than 40% of the global population, accounted for only 7% of global clean energy spending in 2022. One area where shortfalls in investment and infrastructure in EMDEs are particularly visible is energy access. These countries include all of the 775 million people that lack access to electricity and the 2.4 billion people that lack access to clean cooking fuels.
- Clean energy investment in EMDEs needs to grow from USD 770 billion in 2022 to USD 2.2-2.8 trillion by the early 2030s in order to meet growing demand in a sustainable way, to reach energy-related UN Sustainable Development Goals and to get on track for the outcomes targeted in the Paris Agreement. Achieving universal energy access by 2030 would take less than 3% of the overall investment amount.
- This more than threefold increase in clean energy investment goes well beyond a reallocation of existing investment from fossil fuels to clean technologies. It means attracting new sources of funding to the energy sector. For the moment, with few exceptions, this surge in investment is not yet visible. Without it, EMDEs will not be in a position to meet rising demand for energy services in a sustainable way, prolonging reliance on fossil fuels and leading to consistently high global emissions.
- Over the next ten years, more than one-third of the clean energy investment required by the early 2030s goes into low-emission generation; another one-third is needed for improvement in efficiency and other end-use spending, including electric mobility; just under a quarter is needed for electricity grids and storage; and around 8% for clean fuels. In climate-driven scenarios, we estimate that the private sector will need to finance about 60% of the clean energy spend in EMDEs.

2.1. Introduction

The prospects for secure progress to reach the energy-related Sustainable Development Goals (SDGs) and the objectives of the Paris Agreement ultimately come down to investment. The purpose of this chapter is to explore the state of play for clean energy investment across EMDEs and then to quantify what will be required over the period to 2035, in different countries and regions, to get on track. We examine the opportunities and pitfalls facing investors, notably the wide variations in the cost of capital. We highlight the areas that are moving more quickly, as well as those that are lagging behind, and the sources of future investment and finance that will be required. As spending shifts to generally more capital-intensive technologies, the role of financing becomes even more critical for the feasibility and affordability of the transition, especially at a time of rising debt and interest rates.

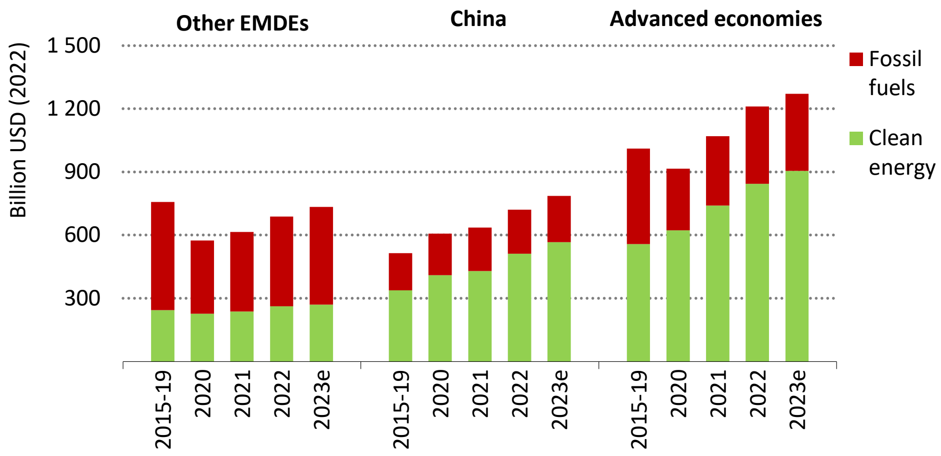
The expansion and transformation of the power sector to boost the efficient use of clean electricity – and ensure universal energy access – is a key pillar of sustainable development. This is reflected in the rising share of final energy consumption that is met by electricity in climate-driven scenarios. The expanding role of electricity across a wide range of end uses also requires a major increase in spending on grids and storage to meet growing demand, integrate renewables and modernise power systems. Some EMDEs have a lot of carbon-intensive electricity generation, notably countries in Asia that have relatively young coal-fired fleets, which under normal circumstances might have long operating lifetimes ahead of them. Reducing reliance on these polluting assets while maintaining affordable, reliable electricity supply is a key policy and financing challenge.

Clean energy investment requirements go well beyond electricity. Investments that target more efficient buildings, equipment, appliances and vehicles are essential to relieve strains on the supply side and on consumer bills. Moreover, many EMDEs are urbanising and industrialising at a rapid pace. This means rapidly increasing demand for energy-intensive goods such as cement, steel and chemicals, as well as for heavy-duty transport and shipping. Traditionally, this process has been deeply intertwined with the use of fossil fuels, but achieving deep reductions in global emissions means finding a lower-emissions pathway. Clean electrification cannot take on all these tasks directly, opening up roles for investment in low-emission fuels in future EMDE pathways. Competitive costs also open up the possibility for some EMDEs to produce low-emission fuels for export, as Brazil does already for biofuels and as other countries may do in the future for low-emission hydrogen.

2.2. The clean energy investment landscape in EMDEs

The role of EMDEs in global energy investment is growing but the trends are very uneven, both in the geographical distribution of spending and in the consistency of these capital flows with SDGs. The diversity of EMDEs in their economic development, natural resource endowments and energy policy frameworks drives a wide range of energy investment trajectories. China has an outsized role in all capital flows, particularly for clean energy investment: it accounts on its own for two-thirds of clean energy investment in EMDEs, and the top three countries (China, India and Brazil) for more than three-quarters. By contrast the whole of sub-Saharan Africa – excluding South Africa – accounts for just 3% of EMDE energy investment, and only 2% of clean energy spending.

Figure 2.1 ▷ EMDEs in global energy investment, 2015-2022, 2023e



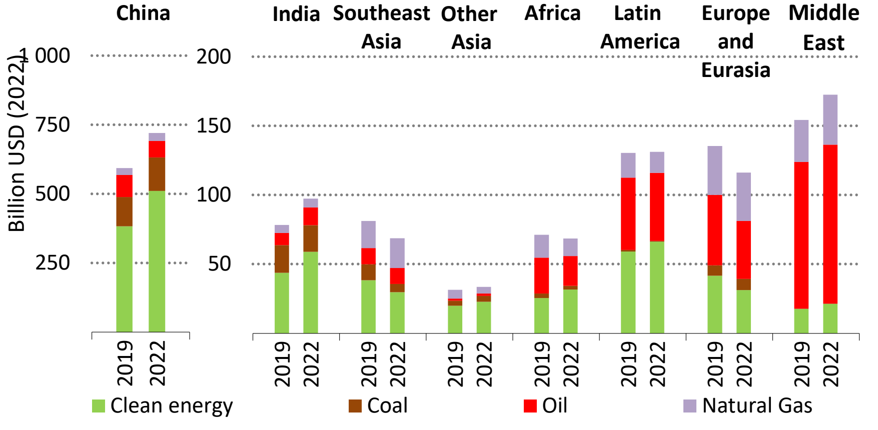
Growth in clean energy investment in recent years has been concentrated in advanced economies and China, but future increases in energy demand will come from other EMDEs

Outside China, spending on clean energy in EMDEs in recent years has been relatively flat at around USD 260 billion per year, a worrying trend (Figure 2.1). Falling technology costs mean that these funds can be consistent with gradual increases in deployment year-on-year, but this trend is a long way from what will be needed to meet rising demand for energy services in a sustainable way. Clean energy investment has been increasing in China and advanced economies; in practice, the increase seen in spending on clean energy investment in these economies since 2019 is bigger than the total spending in all EMDEs without China. Early signs from 2023 underscore these diverging trends between regions, creating a clear risk of new dividing lines in global energy and climate affairs.

The risks are particularly apparent in low-income countries, many of which have been hit hard first by Covid-19 and then by rising indebtedness as borrowing became more expensive. Affordability is a key concern, especially in countries that still have a large share of their population lacking access to electricity or reliant on the traditional use of biomass for cooking. Despite high renewable potential in many cases, notably in Africa and across parts of South Asia, investment in many low and lower-middle income countries is hindered in practice by barriers such as higher financing costs, high debt burdens of electric utilities, the absence of clean energy deployment strategies, and challenges related to land acquisition, enabling infrastructure and the creditworthiness of offtakers (see Chapter 3).

Fossil fuels account for the largest share of energy investment in many EMDEs, with the notable exceptions of China and India (Figure 2.2). EMDEs include many of the world's largest hydrocarbon resource owners, and account for well over half of global investment in fossil fuel supply. In some hydrocarbon-rich countries and regions, notably in the Middle East and Eurasia spending on oil and gas dwarves that on clean energy (although these countries are large net exporters to the rest of the world). Major fuel producers and exporters saw their revenues surge in 2022. Net income among EMDE fossil fuel producers in 2022 was USD 2.9 trillion, almost double the average of USD 1.4 billion seen for the years 2017-2021. These revenues open up important avenues for large oil and gas producers to diversify their economies and energy systems via a much-needed boost to transition-related spending.

Figure 2.2 ▹ Energy investment in EMDEs, 2019 and 2022



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Trends vary widely across EMDEs, but with the notable exception of China, investment in clean energy is typically well below that in fossil fuel supply

Policy measures taken by governments are a key determinant of how much capital is committed to the energy sector, and where and how it is invested. The energy crisis has prompted new initiatives aimed at advancing clean energy deployment and addressing existing and emerging energy security risks. Some of the most prominent have been in advanced economies, with the Inflation Reduction Act in the United States, the Fit for 55 package and the Green Industrial Plan in the European Union, and the GX Green Transformation programme in Japan. China has also stepped-up policy support for a range of clean energy technologies and there are examples too in other EMDEs, including:

- India's launch of a Green Energy Corridor programme to evacuate power from renewable-rich states to India's power demand centres. Phase II of the scheme, with a project cost of USD 1.5 billion, was initiated in January 2022. In January 2023 India also initiated the National Green Hydrogen Mission, with earmarked government funding of USD 2.4 billion and a target to mobilise almost USD 100 billion in investment to develop green hydrogen production capacity of 5 million tonnes per annum by 2030.

- The conclusion of Just Energy Transition Partnerships (JETPs) with Indonesia, South Africa and Viet Nam, offering a new model for international support for national efforts to scale up renewables, reduce reliance on coal and other polluting fuels, and manage the social implications of change.
- A revamped procurement framework for renewable power in Cambodia, using competitive auctions and blended finance packages to boost market development, reduce revenue risks and lower financing costs. As part of the auction, the Cambodian single-buyer utility provides 20-year power purchase contracts, complemented by a loan from the Asian Development Bank (blended finance) to fund grid infrastructure.
- A tender programme from Chile's Economic Development Agency in 2021, worth up to USD 50 million, to develop green hydrogen projects that are to install 10 MW (or more) of capacity and commence commercial operation by the end of 2025.
- The United Arab Emirates becoming in 2021 the first of the major Gulf oil and gas producers to commit to net zero emissions by 2050, including a 30% share for renewables plus nuclear by 2030.
- Two new transmission auctions in Brazil that would amount to approximately USD 10 billion in new investment, a similar amount to that of the entire 2018-2022 period. The first transmission auction, announced in March 2023, was for the construction and maintenance of nearly 5 000 km of transmission lines to support further wind and solar deployment.
- Kenya introducing net metering regulations for distributed PV capacity, after passing enabling legislation in 2019. The regulations allow electricity consumers with on-site generation (no more than 1 MW) to sell excess power to the national grid.

As discussed in Chapter 3, the implementation of many more such policy initiatives will be needed across EMDEs for a sustained rise in clean energy investment, notably from the private sector. This needs to be accompanied by strengthened institutions and governance, as well as efforts to deepen the pool of available funding for clean energy projects; this is the theme taken up in Chapter 4. Without strong institutions, supportive policy frameworks and additional sources of funding to support clean energy transitions, most EMDEs will continue to lag behind the rest of the world, with the risks especially visible in low to lower-middle income countries (Box 2.1).

The opportunities are huge, but some EMDEs will have more challenging transition pathways than others. Our analysis suggests three categories that require particular attention:

- Least developed countries (LDCs). Most private finance has gone in practice to middle-income countries with relatively low risk profiles. The poorest and most vulnerable countries often face severe shortfalls in energy supply and large populations without access. They also face significant barriers to securing finance for clean energy projects, not only from the private sector, but also from multilateral climate funds that should be easier to access but where complex procedures are often a major problem.

- Countries with existing carbon-intensive energy systems, notably those dependent on coal. There is a clear economic case to deploy cost-effective clean energy technologies like renewables, but political and contractual roadblocks can hinder the entry of cleaner options to the energy system, alongside deep links to jobs and development in coal-producing regions. For these reasons, transitions are likely to be challenging in countries where existing coal dependency is high: Indonesia, Mongolia, China, Viet Nam, India and South Africa stand out, which is why some of these countries are the focus for JETPs and for innovative transition finance strategies.
- Large oil and gas resource owners, producers and exporters. These countries are confronted by a very different set of opportunities and constraints, due to their high dependence on oil and gas revenues to support economic structures and development models. These revenues have been high during the energy crisis, creating an opening to pursue diversification of economies and energy systems. Many of today's oil and gas producers have resources and expertise that can find a place in a changing energy system. However, in the absence of meaningful change, transitions could also be deeply destabilising once oil and gas revenues fall back.

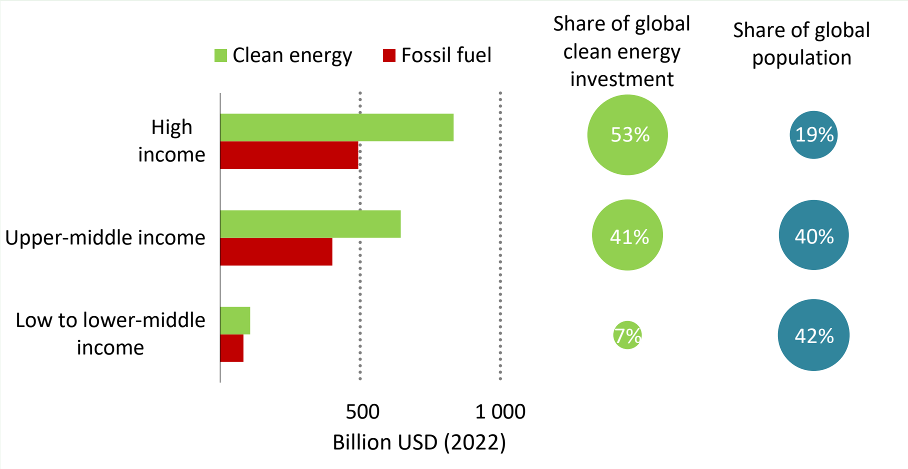
Box 2.1 ▻ Country income levels and energy investment

The EMDE group of over 150 countries is highly diverse. It ranges from very large, fast-growing emerging market economies with middle to upper income levels, to developing economies with low access to clean and affordable energy, through to small island states that are especially vulnerable to the impacts of climate change. For this report, our analysis has, where possible, looked at a disaggregation of EMDEs by region.

One other often-used approach is to classify EMDEs according to income groups (as defined by the World Bank). This approach highlights close correlations between income level and energy investment; over 90% of global energy investment in 2022 was in high and upper-middle income countries (Figure 2.3).

The disparity between the distribution of the global population and spending on clean energy is particularly striking. Low and lower-middle income countries, home to more than 40% of the global population, accounted for only 7% of global clean energy spending in 2022. Among this group, clean energy investment has increased in recent years, and so has fossil fuels. But there is much more to be done to allow for the expansion of infrastructure in ways that meet the urgent need for affordable, modern and sustainable energy.

Figure 2.3 ▷ **Energy investment and population by region, classified by current income level**



Low and lower-middle income countries' share of global fossil fuel and clean energy spending is far below the amount implied by their share of the global population

2.2.1. Clean energy investment in EMDEs by sector

In 2022 around USD 770 billion was invested in clean energy across EMDEs. The largest share is in power generation, reflecting the maturity of these technologies (Table 2.1). Substantial variations exist across the different sources of low-emission power. Solar PV is the only source on a consistently rising trend, while annual investment in wind power is more volatile (and heavily influenced in practice by policy developments in China).

Annual investment in low-emission dispatchable generation, with the exception of nuclear power, has fallen back, while spending on grid infrastructure in recent years has also been below the average seen prior to the Covid-19 pandemic. These are worrying trends not just for energy transitions, but also for the security of electricity supply: robust transmission and distribution networks are vital to meet rising demand, ensure the efficient integration of renewables into the grid and to maintain system stability. Increased spending on EVs, notably in China, has been the main factor pushing up overall investment in the end-use sectors, including energy efficiency. Investment in low-emission fuels is only around 1% of the EMDE total, primarily for the moment in biofuels.

One area where shortfalls in investment and infrastructure in EMDEs is particularly visible is energy access. EMDEs include all of the 775 million people that lack access to electricity and the 2.4 billion people that lack access to clean cooking fuels; bringing modern energy to all is a precondition for progress on many other SDGs, including those concerning poverty reduction, health, education and sustainable cities.

Table 2.1 ▷ Selected indicators of clean energy investment spending in EMDEs, 2018-2022

(Billion USD 2022)	2018	2019	2020	2021	2022
Clean energy	**587**	**628**	**636**	**667**	**773**
Low-emission power	229	289	321	328	383
Renewable power	212	269	299	304	356
Solar PV	80	93	108	141	181
Wind	66	105	117	91	111
Hydro	51	55	59	59	51
Bioenergy	14	15	14	11	10
Geothermal and other renewables	1	1	1	2	2
Nuclear and other clean energy	17	19	22	23	27
Grids and storage	**175**	**152**	**141**	**142**	**160**
Transmission	69	54	53	53	60
Distribution	105	96	86	86	92
Battery storage	1	1	2	3	8
Low-emission fuels and CCUS	**3**	**3**	**3**	**4**	**8**
Energy efficiency and end use	**181**	**185**	**172**	**193**	**221**
Energy efficiency	94	103	94	96	97
Transport	54	54	39	42	47
Buildings	23	33	37	36	32
Industry	18	16	19	18	18
End use	86	82	78	97	125
EVs	8	10	11	30	57

Notes: Energy efficiency and end use include spending on energy efficiency, renewables for end use and electrification in the buildings, transport (including EVs) and industrial sectors; low-emission fuels include modern liquid and gaseous bioenergy, low-carbon hydrogen, and hydrogen-based fuels that do not emit any CO_2 from fossil fuels directly when used and also emit very little when being produced; CCUS = carbon capture, utilisation and storage.

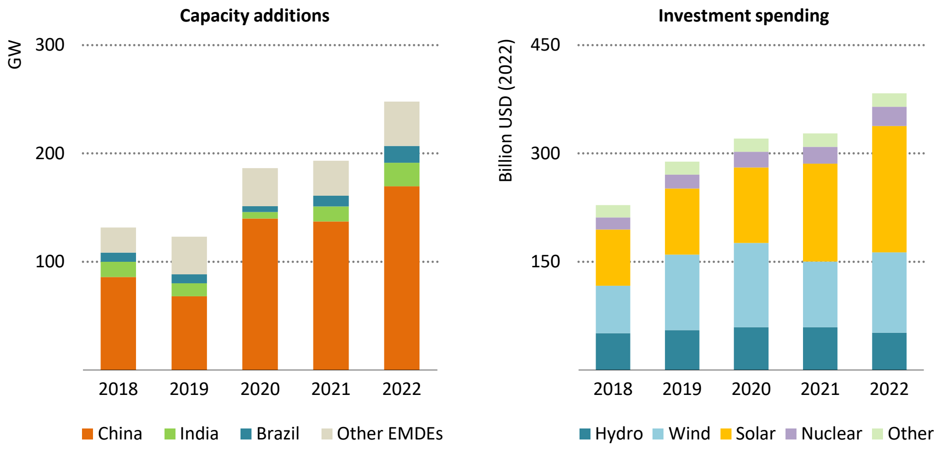
Prior to the Covid-19 pandemic considerable progress had been made on energy access. In EMDEs the share of the population with access to clean energy for cooking increased from 48% in 2010 to 63% in 2019. In the same period, access to electricity among EMDEs increased from 75% to 88%. India has demonstrated the potential of strong government-led initiatives, which have managed to provide electricity to 400 million additional people since 2010 – achieving universal access to electricity in 2021 – and reduce the number of people without access to clean cooking by 300 million.

However, the Covid-19 pandemic and the global energy crisis have set progress back. The number of people around the world without access to electricity is likely to have risen by about 20 million in 2022, while 100 million could have been forced back to using traditional fuels for cooking (IEA, 2022a). To prevent a further worsening of the situation, EMDE governments spent more than USD 100 billion in total during the energy crisis to limit the impact of higher fuel prices on household budgets and to promote structural changes in energy consumption (IEA, 2023a). This included programmes ranging from support for the installation of solar home systems in Nigeria to an increased subsidy for LPG cooking cylinders in India.

Low-emission power

Investment in low-emission generation has been relatively strong in recent years on the back of high capital expenditure in China, followed at some distance by India and Brazil (Figure 2.4). In 2022 almost 250 GW of clean power capacity was added across EMDEs – China alone installed 170 GW, while India and Brazil added 22 GW and 16 GW respectively. Given the size of its power market, China plays an outsized role in the absolute numbers for capacity additions, but other EMDEs have experienced annual growth rates above 10% in recent years, pushed by supportive policies and the cost competitiveness of clean power generation sources.

Figure 2.4 ⊳ Clean power capacity additions and investment in EMDEs, 2018-2022



Annual clean power capacity additions have almost doubled since 2018, with investment focused on solar and wind power

Enabled by cost reductions in recent years, renewables – especially solar and wind power – have been the driving force behind the increase in clean power installations in EMDEs. In

2022, out of the USD 380 billion invested in clean power in EMDEs, USD 137 billion was spent on solar PV and USD 110 billion on wind power. Almost 60% of the 136 GW of capacity additions in solar were utility-scale plants, with the rest being distributed solar PV and a small amount of concentrated solar capacity. As for wind power, 2022 saw 66 GW of onshore wind power additions and 9 GW of offshore power plants, even though some projects in Asia experienced construction delays.

Around 30 GW of hydropower – both large hydropower and pumped-storage hydro – entered operation in 2022 in EMDEs, but this technology is seeing a decline in overall investment spending as the remaining pipeline of hydro projects is relatively weak. However, nuclear experienced a strong year, with 10 GW of the worldwide 15 GW going online in EMDEs – mainly in China and India. About USD 27 billion was spent on new nuclear power plants in EMDEs in 2022.

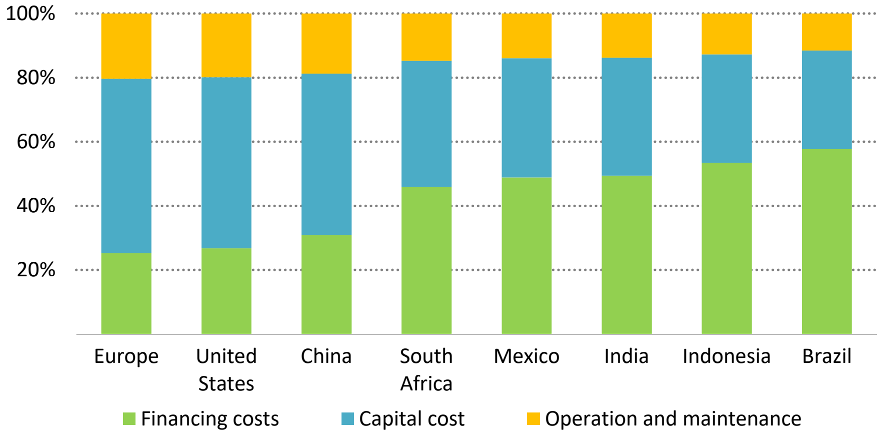
Our analysis of final investment decisions (FIDs) that lead to future capital expenditure and capacity additions shows a steady increase in clean power approvals across many EMDEs. FIDs for utility-scale renewables tripled in India. A similar jump was also observed in South Africa as it grapples with a severe energy crisis and formulates its investment plan for its JETP. In Indonesia, another JETP country, no new coal FIDs were awarded. Despite these positive trends, investment in utility-scale renewables in many EMDEs (especially lower income countries) is hindered by a range of risks that push up the cost of capital and hence the financing costs of a project.

SPOTLIGHT

Why is the cost of capital for a renewable power project higher in many EMDEs?

The cost of capital is a pivotal indicator for energy transitions, as many clean energy projects are characterised by relatively high upfront investment, offset by lower operating costs over their lifetime. Financing costs can be a very high share of overall costs for clean energy projects in EMDEs. Our analysis of utility-scale solar PV projects reaching FID in 2021 suggests that financing costs constituted about half of the overall levelised cost of electricity (LCOE) in most of the key emerging markets (Figure 2.5). Only China exhibited a lower overall share of financing costs, closer to that in advanced economies.

Figure 2.5 ▷ Composition of LCOE for a utility-scale solar PV plant with FID secured in 2021



Financing costs for a new renewable power project are around half of total levelised costs in many emerging markets, higher than in advanced economies and China

Notes: Investment Capital cost refers to the specific expenses incurred in the acquisition and construction of an asset, including capital assets; financing costs refer to the expenses associated with raising funds (interest on debt, financial institution or lender fees, etc.).

The cost of capital is a benchmark for the pricing of money and reflects the minimum rate of return required upon investing in a project or company. It reflects investors' (equity providers) and financiers' (debt providers) perceptions of risk, with higher risks being reflected in a higher cost of capital. For example, if two solar PV projects are identical in all respects except that one has a power purchase agreement with a less creditworthy utility, the increased risk of non-payment in that case would be reflected in more expensive debt financing.

Estimating the cost of capital in EMDEs can be difficult. Financial market data are a key source of information for the pricing of debt and equity in advanced economies, but these markets are typically less well developed in EMDEs. Information on default rates and other risks is also generally poor. This is a major drawback for investors, as inadequate assumptions around the cost of capital can lead to the mispricing of risk and misallocation of capital to different markets and sectors.

To promote transparency on these issues, the IEA teamed up with partners to launch a Cost of Capital Observatory in 2022, (IEA, 2023b) with a strong focus on EMDEs. Data collected for solar PV projects in Brazil, India, Indonesia, Mexico and South Africa (for projects reaching FID in 2019 and 2021) show a cost of capital ranging from 8.5% to

13.5%, with lower levels in India and higher levels in Brazil, and a slight increase in 2021 in some countries. These values are two to three times higher than the average cost of capital in advanced economies and China.

These differences are driven by higher currency and country risk (reflected in higher sovereign bond rates), as well as higher energy-specific and liquidity risks, especially the risk of non-payment by the offtaker, the ease of obtaining the required project permits, the ability of the transmission grid to evacuate power, the clarity of domestic power sector regulations, and the risk of investing in relatively more illiquid assets.

A more granular understanding of the risks that push up the cost of capital provides useful insights for EMDE policy makers looking to accelerate capital flows to clean energy projects. This is particularly important in today's global macroeconomic context of higher inflation and interest rates, which affect the relative attractiveness of renewable investment as well as investment in EMDEs more generally.

Bringing down the cost of capital would make a huge difference to the overall cost of energy transitions. IEA estimates show that lowering the cost of capital by 2 percentage points relative to our baseline assumption would reduce the total clean energy investment bill (including financing costs)[6] to reach net zero emissions in EMDEs by a cumulative USD 2 trillion over the period to 2035.

Grids and storage

In 2022 expenditure on grid and storage infrastructure in EDMEs amounted to some USD 160 billion. China has been investing heavily in expanding and modernising its grid, including investment in ultra-high-voltage transmission projects. China is also investing heavily in different energy storage technologies, and is targeting 100 GW in battery storage capacity by 2030. India is also making significant investment in its electricity grid (almost USD 18 billion in 2022), with a focus on increasing capacity and improving its infrastructure to facilitate the integration of renewable energy sources. In 2022 the approval of the Green Energy Corridor Phase II marked a major milestone, with a budget of around USD 1.5 billion allocated to capacity additions for lines and substations and interregional transmission. Batteries are well suited to help meet the short-run flexibility needs of India's power system, and there are several programmes to scale up domestic manufacturing and deployment. Over USD 2 billion was allocated in 2022 under the Production Linked Incentive (PLI) Scheme and the National Programme on Advanced Chemistry Cell Battery Storage (NPACC).

Despite this, EMDEs still encounter major challenges obtaining finance for infrastructure development as they continue to grapple with implementing policy and regulatory reforms that drive a more favourable investment environment. This holds true in particular in many African countries where developing sustainable business models for attracting private

[6] Financing costs are not included in the capital expenditure numbers provided in this report.

investors remains difficult. Over half of sub-Saharan Africa's utilities are currently unable to cover their operating costs due to high network losses, underpricing and poor revenue collection mechanisms. Network losses averaged 15% across the continent in 2020 – almost twice the global average of 8%. There are some positive signs as demonstrated by South Africa's investment in grids, which increased by a third in 2022 to reach USD 290 million. However, the situation in South Africa remains difficult: while NERSA – South Africa's national energy regulator – recently approved a tariff increase of 18% that should ease the financial strain on Eskom, there is a delicate balance between covering costs and maintaining user affordability, with the attendant risks of increased non-payment.

Low-emission fuels

The main current component of spending on low-emission fuels is the capital spent on supplying biofuels, but this also includes any investments in low-emission hydrogen, CCUS and – in the future – synthetic fuels. Amounts are small for the moment, but this is a dynamic area as EMDEs include some of the leading players in today's biofuels output and many countries have announced plans for low-emission hydrogen and CCUS as well.

In 2022 investment in liquid biofuels – predominantly biodiesel and ethanol – almost doubled in EMDEs to reach USD 6.6 billion. Around two-thirds of this growth was in biodiesel where Brazil, a major producer, is scaling up capacity to meet higher blending requirements. Robust growth was also recorded in Southeast Asian countries, notably Indonesia and Thailand, which have large quantities of sustainable feedstocks and policies in place to promote their development. Biofuels already make up 7% of road transport fuels in Southeast Asia, a share that is 50% higher than the global average.

EMDEs are leading anticipated growth in global biofuels production, with Brazil, India and Indonesia at the fore. The main near-term constraint relates to cost pressure due to high energy and fertiliser prices. The incentives to produce biogases from organic waste, by contrast, have been enhanced by today's high natural gas prices. In 2022 biofuel prices climbed to record levels due to high energy and fertiliser costs, as well as export losses from Ukraine and weather-related supply disruptions. While the situation is improving, biofuel prices remain elevated, which could slow production expansion.

EMDE oil and gas producers, particularly in the Middle East, are building low-emission fuels into their investment strategies. Saudi Arabia's NEOM Green Hydrogen Project (NGHP) is set to be the world's largest utility-scale green hydrogen facility (USD 8.5 billion) if completed as planned in 2026. Elsewhere, the production, use and export of hydrogen and hydrogen-rich fuels such as green ammonia are being integrated into plans for various industrial hubs, such as the Pecém Industrial and Port Complex in Brazil and the Suez Canal Economic Zone in Egypt. Countries in Africa and Latin America are actively scoping out the possibilities for hydrogen production and export, although the IEA's project tracking underscores that the number of projects aiming to supply international markets is for the moment significantly higher than those seeking to import (IEA, 2022b).

Energy efficiency and end use

About USD 600 billion is spent on average each year on energy efficiency and end-use investments around the world. Over half of this spending occurs in advanced economies, almost a third in China and only 10% in other EMDEs. The main drivers of efficiency investment in the buildings, transport and industrial sectors are a combination of price incentives and the stringency of regulatory measures; together they push spending on more efficient vehicles, construction, appliances (notably for cooling) and new industrial equipment. In end-use sectors, spending reflects the state of play on EV sales and the roll-out of charging infrastructure, as well as the direct use of renewables like solar thermal and bioenergy in industry and buildings.

For the moment, outside China, these drivers are not strong in most EMDEs. Taking the buildings sector as an example, investment in energy efficiency has slowly decreased reaching USD 32 billion in 2022. This is a missed opportunity, given the high level of new construction and growing urban populations. Weak energy efficiency provisions in building codes and inadequate energy performance standards for materials and appliances hinder efficiency investment in the buildings sector. As of 2021, 85% of EMDEs did not have a specific energy efficiency mandate in their building codes. The exceptions provide a compelling case for the benefits; India, for example, has gradually introduced energy performance standards and building codes and has seen efficiency-related investment rise by nearly three-quarters since 2014. India has also demonstrated how bulk procurement policies can quickly develop the market for clean cooling and efficient lighting solutions.

In the transport sector, many EMDE governments are aiming to improve vehicle efficiency and shift towards electric forms of transport. Almost 70% of EMDEs have targets for deploying EVs, investment in which nearly doubled in 2022 to USD 57 billion. However, again outside China, most of these targets are at relatively early stages of implementation. More than half of all electric cars on the road worldwide are in China and the share of electric cars in China’s domestic car market is approaching 30%. The other leading EV markets among EMDEs are also showing rapid growth, albeit from a very low base: the share of electric cars in total sales rose to 3% in Thailand in 2022, and to 1.5% in India and Indonesia. Electric two- and three-wheelers are gaining ground more quickly: over half of India’s three-wheeler registrations in 2022 were electric (IEA, 2023c), and the electric bus fleet is also growing rapidly, notably in Latin America. Investment in clean energy manufacturing and in supplies of battery metals and other critical minerals is also increasingly a part of EMDE strategies (Box 2.2).

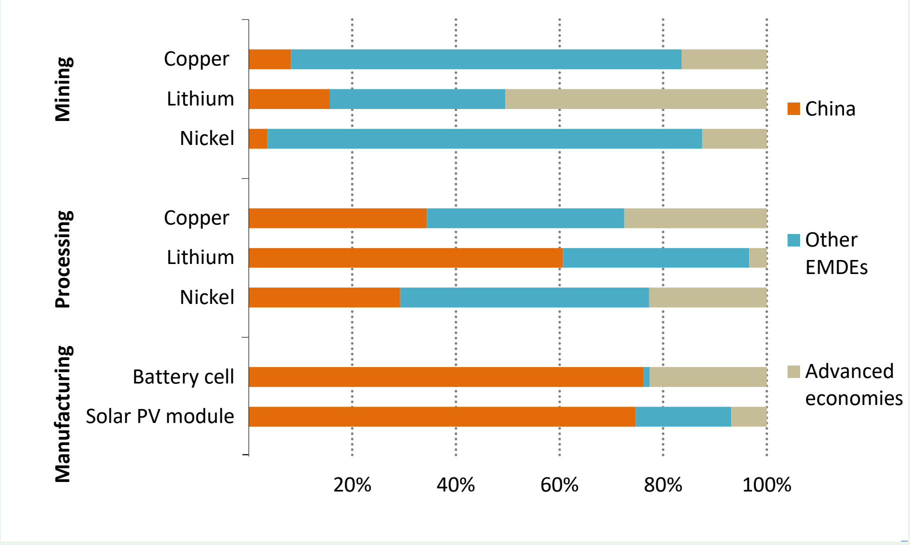
Box 2.2 ⊳ Investment in clean energy supply chains

As transitions accelerate, governments around the world are looking to establish footholds in the new clean energy economy as a way to promote industrial growth and employment. Many of the opportunities and risks for EMDEs are already coming into view. EMDEs have many of the minerals and metals required for a clean energy economy.

With rising demand for energy services, they will also require a massive scale-up in deployment of a range of clean technologies if the world is to get on track for its energy security and climate goals. But they are also vulnerable to the consequences of inadequate access to technology and high degrees of concentration in clean energy value chains.

2

Figure 2.6 ▷ Selected critical mineral production and clean energy manufacturing, 2021



China has a dominant share globally in critical mineral processing and clean energy technology manufacturing

Source: IEA analysis based on S&P Global, (2022a), S&P Global, (2022b), S&P Global, (2022c), WMBS, (2022), InfoLink, (2022) and Benchmark Mineral Intelligence, (2022).

Critical minerals are a case in point. EMDEs have major resources and are among the leading producers of cobalt, nickel, lithium, copper and rare earth elements (Figure 2.6). Transitions will open up major new opportunities for producers to scale up supply. But there are uncertainties over how quickly demand will scale up and (S&P Global, 2022c) over how much value is available in the midstream segments of critical mineral processing and refining, where China has an extremely strong position.

2.3. Scaling up clean energy investment to 2035

In IEA scenarios clean energy investment in EMDEs needs to grow from USD 770 billion in 2022 to between USD 2.2 trillion and USD 2.8 trillion by the early 2030s in order to meet growing demand in a sustainable way, to achieve energy-related UN SDGs and to get on track with the targets in the Paris Agreement (Table 2.2). This more than tripling in clean energy investment goes well beyond a reallocation of existing investment from fossil fuels to clean technologies. It means attracting new sources of funding for the energy sector. Large increases in clean energy investment are needed across the board, but the increases are particularly striking in many countries and regions outside China. While China "only" requires a doubling of current clean energy investment over the next ten years, other EMDEs typically need to see a six- or sevenfold increase. This is an enormous challenge as well as a huge opportunity to bring economies and energy systems onto a more sustainable path.

Table 2.2 ▻ Annual clean energy investment in EMDEs to 2035 to align with sustainable development and climate goals

	Historical		Annual average required	
(Billion USD 2022)	2015	2022	2026-2030	2031-2035
Total EMDEs	538	773	1 784-2 222	2 219-2 805
By country/region				
China	287	511	730-853	850-947
India	55	59	253-263	325-355
Southeast Asia	28	30	171-185	208-244
Other Asia	21	23	68-85	93-112
Africa	26	32	160-203	207-265
Latin America	63	66	150-243	209-332
Europe and Eurasia	33	31	111-188	127-232
Middle East	24	21	122-202	176-318

Notes: The projections are from two IEA scenarios that meet energy-related SDGs but achieve a different pace of emissions reduction, aligned with the aims of the Paris Agreement; the higher bound comes from the Net Zero Emissions by 2050 (NZE) Scenario, which reaches global net zero emissions by 2050 and limits global warming to 1.5°C; the lower bound is from the Sustainable Development Scenario (SDS), which achieves global net zero emissions in the 2060s and a well-below 2°C stabilisation in global average temperatures; the table shows annual investment in 2015 and 2022 and average annual investment during 2026-2030 and 2031-2035.

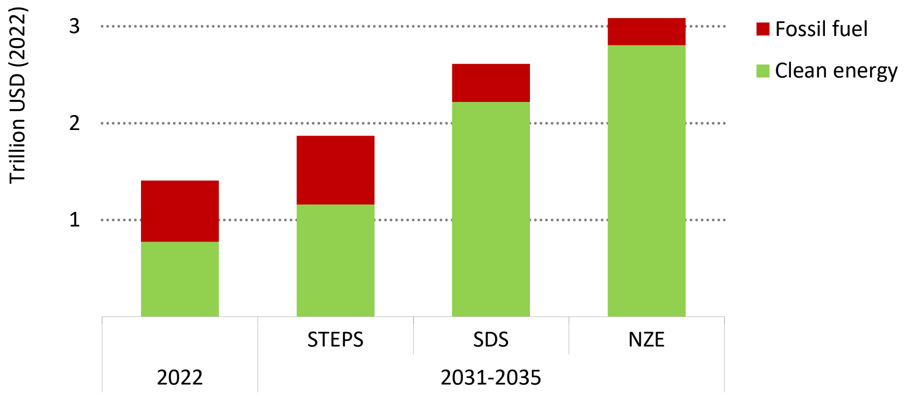
Given their underlying economic and demographic dynamics, higher investment will be needed in EMDEs in any future scenario to meet future demand for energy services. Another measure of the need for "additional" investment is to consider the requirements of normative scenarios versus a baseline set of future projections, and also using total energy investment, i.e., including fossil fuels. The baseline scenario that we use here is the IEA Stated Policies Scenario (STEPS), which explores a future for the energy system derived from today's policy settings, and which does not automatically assume that goals like the SDGs or net zero commitments are met. Normative scenarios, such as the IEA Net Zero Emissions by 2050

(NZE) Scenario, start from the achievement of a defined goal in the future (e.g., SDGs and reaching global net zero emissions in 2050) and explore the changes in the energy system that are required to meet this goal (Box 2.3).

In the STEPS, total annual energy investment in EMDEs (including investment in fossil fuels and clean energy) rises from USD 1.4 trillion in 2022 to USD 1.9 trillion by the early 2030s. Compared with this scenario, the investment required in EMDEs by the early 2030s to reach the SDGs and climate goals ranges from USD 2.6 trillion per year to more than USD 3 trillion per year in the NZE Scenario. The additional annual investment spending by the early 2030s relative to the baseline scenario is therefore USD 743 billion to USD 1.2 trillion.

This additional investment results in major savings in annual fossil fuel expenditure, which in the early 2030s is reduced by some USD 400 billion due to lower demand and prices. This generates lower climate-related risk over time, and much more immediate improvements in environmental and health outcomes via better air quality in major cities and in rural households, sharply reducing pollution-related premature deaths.

Figure 2.7 ▷ Total energy investment in EMDEs by scenario

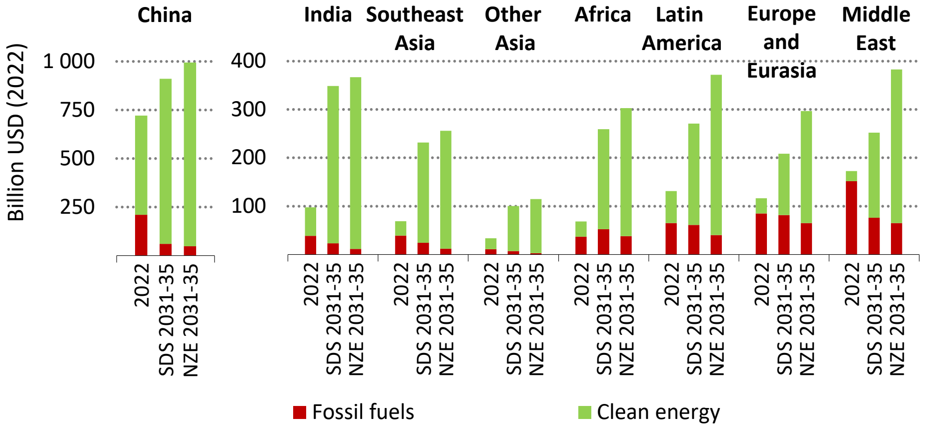


Investment rises in all future scenarios: an extra USD 743 billion to USD 1.2 trillion is needed by the early 2030s to get on track for SDGs and climate goals, bringing multiple benefits

Note: Annual investment in 2022 and average annual investment between 2031-2035.

Over the past five years, around half of the energy investment in EMDEs excluding China has been in fossil fuels, with a higher proportion in the Middle East, North Africa and sub-Saharan Africa, where they accounted for three-quarters of capital expenditure. As a cleaner and more efficient energy system is built in scenarios that meet sustainable development and climate goals, so the requirement for investment in fossil fuel supply diminishes. But the increase in clean energy investment is much larger than the decline in fossil fuel spending; a simple reallocation of existing investment flows is not sufficient to secure a more sustainable future. The energy sector needs to attract additional sources of capital. As it does so, the proportion of total investment going to clean energy rises fast. That around half of investment in EMDEs already goes towards clean energy is thanks in large measure to China. By the early 2030s in the NZE Scenario around 90% of a much larger total goes to clean energy investment. USD 9 is spent on clean energy for each USD 1 spent on fossil fuel supply (Figure 2.8).

Figure 2.8 ▹ EMDE total energy investment in the NZE and the SDS Scenarios



Higher levels of investment in the NZE Scenario and SDS are accompanied by an increased allocation of capital to clean energy in all regions

Note: Annual investment in 2022 and average annual investment between 2031 and 2035.

Box 2.3 ▹ How do IEA clean energy investment numbers compare with other sources?

The USD 2.6 trillion in clean energy spending in EMDEs in 2030 in the NZE Scenario is part of a larger USD 4.5 trillion envelope of global clean energy investment, also taking into account investment in advanced economies. This latter number has been widely quoted, including in the concluding document of COP27, the Sharm el-Sheikh Implementation Plan.

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 IPCC Sixth Assessment Report (AR6) 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".

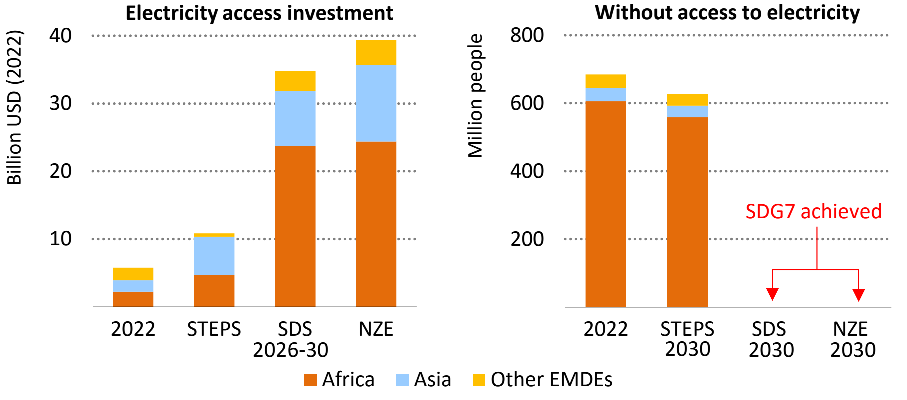
There are a few important considerations to have in mind when comparing energy-related investment projections:

- **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 (Songwe, et al., Finance for climate action: Scaling up investment for climate and development, 2022) concluded that EMDEs excluding China will need to spend around USD 2.4 trillion per year by 2030 to get on track for these goals, whereas the figures in Table 2.2 of this report (once China is excluded) are USD 1.2-1.6 trillion. However, the higher number also allows for investment in adaptation and resilience, mechanisms to deal with loss and damage, and investment in sustainable agriculture and restoring the damage human activity has done to natural capital and biodiversity. 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 EVs is included.

2.3.1. Ensuring universal energy access

To achieve SDG7 by 2030, 110 million people each year need to gain access to electricity and 320 million each year to clean cooking facilities. In the STEPS the world is off track to meet SDG7 so a considerable additional effort is required. Achieving universal access to modern energy by 2030 would require around USD 42 billion to USD 46 billion in annual investment between 2026 and 2030, with electricity access accounting for USD 35 billion to USD 39 billion and clean cooking for around USD 7 billion per year (Figure 2.9). This is less than 2% of the annual clean energy investment required in EMDEs between 2026 and 2030 to achieve the NZE Scenario (and 1% of global clean energy investment during this period).

Figure 2.9 ⊳ Electricity access investment and number of people without access to electricity[7]



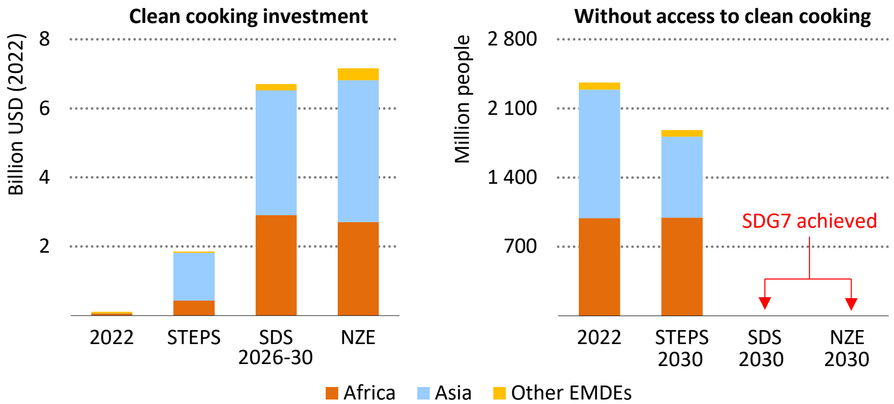
Annual investment in electricity access needs to more than triple compared with the STEPS to 2030, allowing an additional 660 million people to gain access by 2030, largely in Africa

Note: Annual investment in 2022 and average annual investment between 2026 and 2030.

In the NZE Scenario around 45% of the people gaining access to electricity do so by being connected to the grid; a further 30% and 25% respectively are connected through mini-grids and stand-alone generation systems, often powered by solar PV and other low-carbon power sources. Consequently, annual average investment in transmission, distribution and battery storage between 2026 and 2030 reaches USD 20 billion, with low-emission power seeing USD 19 billion annually. Some two-thirds of the electricity access investment is required in Africa, to connect the 600 million people there that remain without access. These are not typically investments that can attract private sector financing, although there are opportunities to encourage innovative business models that provide electricity on a pay-as-you-go basis (often solar PV systems that customers pay for using mobile payment systems), or to overbuild captive generation for mining projects or other industrial facilities near underserved communities, so as to contribute to local electrification and development.

[7] The IEA and the World Bank maintain two separate databases on access to electricity based respectively on supply (from energy companies) and demand (from surveys/censuses) data. Besides the use of different sources, the main differences between both databases stem from the definitions used. The IEA excludes Off-grid solar systems smaller than 10 watt-peak from its access calculations. For more information, see the IEA's Guidebook for Improved Electricity Access Statistics (IEA, 2023d).

Figure 2.10 ▷ Clean cooking investment and people without access to clean cooking



Clean cooking investment will need to grow nearly fourfold over the levels in the STEPS; investment in the NZE Scenario is weighted more towards electricity and biogas than LPG

Note: Annual investment in 2022 and average annual investment between 2026 and 2030.

As for access to clean cooking, around 1.1 billion people gain access through low-carbon fuels such as biogas and modern bioenergy in the NZE Scenario, for example using biomass in modern cooking stoves, followed by LPG and electric cooking (Figure 2.10). In Asia strong policy support helps the adoption of LPG cooking, while the use of modern bioenergy is more prevalent in Africa – a solution that is also increasingly pushed by financial flows from international and voluntary carbon markets. Given the high number of people lacking access to clean cooking in Asia, USD 4 billion per year is invested in this region between 2026 and 2030 – in particular, in India and China, followed by other Asian and Southeast Asian countries – with Africa seeing clean cooking investment of almost USD 3 billion per year. The vast majority of investments are in clean cooking facilities run with fuels such as biogas (especially in Asia), LPG and electricity.

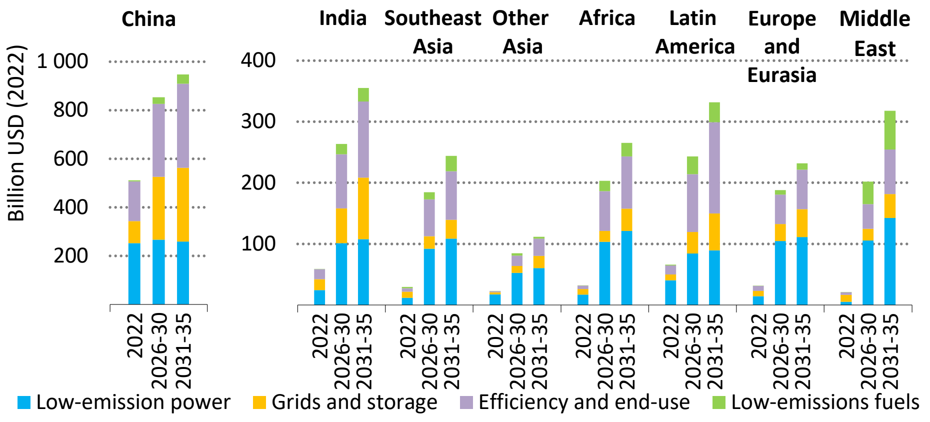
Closing the access gap is not only a supply or infrastructure issue, but also an affordability challenge as most of the people yet to gain access to modern energy are living in poverty. In the short term, upfront and energy costs need to be subsidised for the most vulnerable households. But medium- and long-term planning should incorporate demand stimulation measures both at the household level and for productive uses. These include facilitating appliance ownership and combining energy planning with planning for other sectors such as agriculture and infrastructure, for example for transport. Such combined planning can catalyse the economic development of areas that have notable access gaps, increase energy demand and make it more profitable for energy companies to invest into energy access projects as well as less risky for private capital.

Co-ordinated and targeted national policies will be key to achieving universal access to electricity and clean cooking, as will the provision of international support. In the context of the UN Energy Compacts, governments and the private sector have so far committed more than USD 650 billion to achieve SDG7 by 2030. On top of this, international organisations, catalytic partnerships and others have committed an additional USD 1.5 trillion. If all these commitments are respected, then large government programmes undertaken by utilities and dedicated agencies will need to play an important role in scaling up the number of projects – especially those that can receive international support and are attractive to private investors. This could involve making projects VAT-free or underwriting them with financial guarantees from domestic or international financial institutions. Establishing projects that reduce CO_2 emissions in a clear and verifiable manner could also attract private capital through the utilisation of international and voluntary carbon markets.

2.3.2. Investment needs by sector

Over the next ten years, clean electrification and efficiency are the watchwords for most of the projected increase in spending: just over one-third of total clean energy investment by the early 2030s goes into low-emission generation; another one-third is needed for improvements in efficiency and other end-use spending (including electric mobility); just under a quarter is needed for electricity grids and storage; and around 8% for clean fuels (Figure 2.11). Achieving this increase will not be simple; the policy settings, strategies, and funding levels – both domestic and international – are not yet in place. But enhanced action by all stakeholders can make this increase possible and bring multiple benefits.

Figure 2.11 ▻ Clean energy investment by sector in EMDEs in the NZE Scenario



Clean electrification and efficiency are the key watchwords for the transformation of the energy system over the next ten years in EMDEs

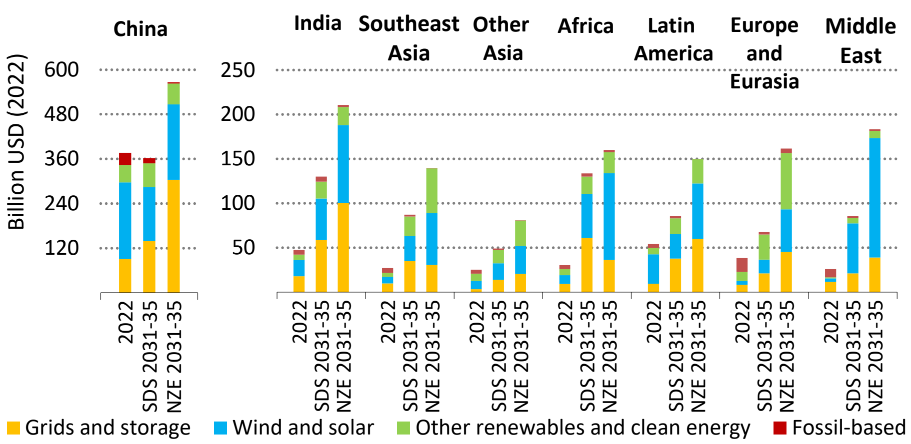
Note: Annual investment in clean energy in 2022 and average annual investment between 2026 and 2030 and 2031 and 2035 in the NZE Scenario.

Low-emission power

Meeting climate goals requires the dramatic expansion of low-emission power over the next decade, enabling a reduction in emissions from coal and other polluting sources of power while also meeting rising electricity demand. In the NZE Scenario power systems worldwide reach net zero emissions by 2040 (this happens in advanced economies in 2035). The SDS sees a slightly slower pace of change, but the electricity sector is in the vanguard of change in all scenarios that meet climate goals. Renewable power needs to account for about 85% of the generation capacity added over the next decade in EMDEs (Figure 2.12).

Demand for electricity in EMDEs grows on average by 5% annually to 2035 in climate-driven scenarios, more than twice the rate of advanced economies, and around 1.7 times the level of economic growth. Overall, an average of 680 GW of renewables (almost 90% of which are wind and solar) and almost 20 GW of nuclear power (more than half of which are in China) are added each year in EMDEs in the NZE Scenario to 2035. Installed renewable capacity increases more than fivefold to 2035, and annual investment rises from USD 360 billion in 2022 to more than USD 900 billion by the early 2030s.

Figure 2.12 ▷ Investment in power generation by country and sector in the SDS and NZE Scenario



New investment in fossil fuel-based generation has been faltering in recent years; wind and solar account for the largest share of new power in the NZE Scenario

Note: Annual investment in clean energy in 2022 and average annual investment between 2031 and 2035 in the NZE Scenario and the SDS.

Although solar PV and wind lead the way, the addition of hydropower and other dispatchable low-emission capacity is critical to provide reliable operation of the power system. Nuclear power also increases quite rapidly, notably in China, India and parts of the Middle East. Investment in carbon capture remains relatively minor in the power sector, but by 2030 it starts to play a role in bringing down emissions from existing coal-fired power, as does co-firing coal-fired plants with low-emission fuels such as biomass and ammonia.

Investment in distributed solar PV increase by a factor of 10 annually by 2035 in sub-Saharan Africa and doubles in India. While investment levels remain well below those for utility-scale solar PV, distributed solar plays a distinct role in enhancing electricity service, particularly in markets where land is constrained and for consumers facing daytime peak demand and high-power prices.

In recent years private actors have provided the largest portion of financing for clean power in Latin America, with Southeast Asia following closely behind in terms of attracting private funding (see Section 2.4). Latin America has indeed taken the lead in implementing long-term capacity auctions and opening competitive markets for distribution, and contracts have mainly been awarded to private companies. Conversely, Eurasia and the Middle East and North Africa tend to rely much more heavily on state-owned enterprises (SOEs).

Grids and storage

The focus of discussion on power sector investment is typically on the generation side, but our projections underscore the urgent need for spending to modernise and expand power grids so as to integrate renewables and meet the growing demand for electricity. Annual investment in grids more than triples in the NZE Scenario in EMDEs, totalling USD 640 billion annually by the early 2030s. Half of this increase occurs in China, followed by investment in India, Southeast Asia and sub-Saharan Africa. Distribution accounts for the majority of the total investment (which includes transmission), though there is some variation by region. For example, distribution lines account for 70% of the grid capital spend in Southeast Asia, a region with dispersed geography and local integration challenges. Around 15% of the increase in EMDEs is attributable to renewables integration, while 20% goes on the replacement and modernisation of existing infrastructure.

As power systems decarbonise and variable renewables become more prevalent in the NZE Scenario, energy storage becomes increasingly critical in ensuring reliable supply. EMDEs require assets that can provide both short-term flexibility, for frequency or voltage control, and long-term reserves that can cover gaps in wind and solar availability. Thermal generation (coal and gas) continues to provide important system services during the next ten years, but many countries are also ramping up low-carbon options for energy storage, notably hydropower, including pumped-storage hydro, and batteries. Low-carbon hydrogen may also play a role in meeting longer-term storage needs in the future. Batteries are a suitable option for remote locations, where they can be paired with solar PV in mini-grid systems, or in systems that experience daily rather than seasonal fluctuations in demand. This translates into a more than tenfold increase in investment in storage in EMDEs by the early 2030s, with India and China together accounting for 60% of the annual spend.

Low-emission fuels

During a rapid clean energy transition, clean power generation, grids and storage, and energy efficiency and end use typically receive the lion's share of clean energy investment. But low-emission fuels also need to scale up. To do so, they need to overcome a range of challenges, first and foremost related to costs. While renewable electricity is often more cost-effective than traditional sources of supply, the same cannot be said for low-emission fuels, which hinders their development particularly in price-sensitive EMDEs.

In the NZE Scenario, investment in transport biofuels, biogas and biomethane, as well as low-carbon hydrogen supply, increases significantly from a low base of less than USD 10 billion currently to over USD 130 billion per year by the second half of this decade, and over USD 200 billion per year in the early 2030s. By this point, clean fuels account for more than a third of the overall capital investment in fuel supply in EMDEs.

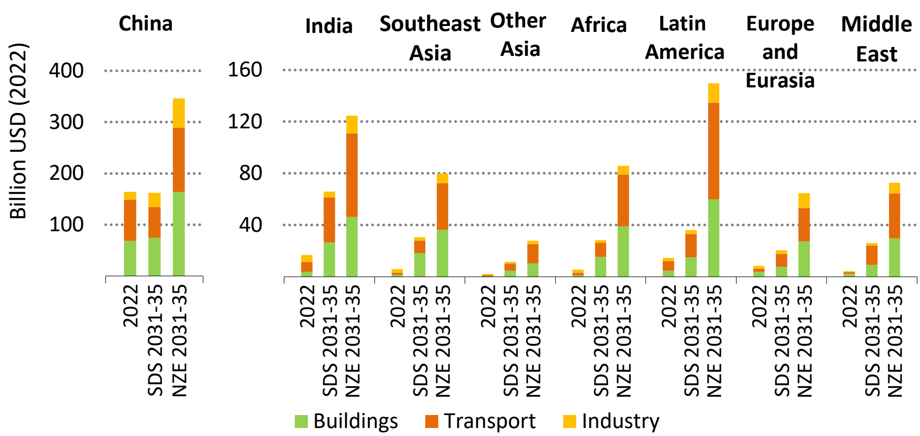
Investment in modern biofuels accounts for almost all the spending on low-carbon fuels today, 70% of which takes place in either China or Latin America, primarily Brazil – the second-largest market for transport biofuels. Biogas projects continue to receive development finance to achieve energy access targets, particularly in sub-Saharan Africa where annual spending increases to reach USD 10 billion by the early 2030s in the NZE Scenario. The upgrading of biogas to meet the quality requirements of natural gas, known as biomethane, is also gaining support in several emerging markets, such as India and Brazil. These markets have high potential to utilise organic waste and other feedstocks, and the widespread adoption of biomethane could result in several co-benefits, such as rural and agricultural development, enhanced human health, job creation and reduced natural gas imports.

Annual investment in low-carbon hydrogen reaches USD 25 billion by the early 2030s in the NZE Scenario, with the Middle East, Southeast Asia, China, and Latin America receiving the largest share of this investment. Electrolytic hydrogen shows promise, particularly in countries that have some of the world's best solar resources. Chile is becoming an attractive destination for hydrogen investment because of its abundant renewable resources, expensive fuel imports, and sectors that are compatible with hydrogen use cases, such as mining. Resource-rich countries can also benefit from hydrogen produced through CCUS, and conventional hydrogen production is already significant in refineries in locations such as Kuwait, Russia and Saudi Arabia.

Efficiency and end use

Investment in energy end use and efficiency in EMDEs increases from about 15% of total energy investment today to more than 30% by the early 2030s in the SDS and the NZE Scenario (Figure 2.13). While all regions see an increase in investment in renewable and efficient end uses, the strongest growth is in India or Latin America where they account for close to 40% of the total, followed by Southeast Asia and China. Africa sees very strong growth from a low base. The overall energy intensity of EMDE economies improves by about 4-5% per year over the next ten years.

Figure 2.13 ▷ **EMDE investment in energy efficiency and end use in the NZE Scenario and the SDS**



From a very low baseline, investment in efficiency, electrification and renewables for end use more than quadruples in EMDEs in the NZE Scenario

Note: Annual investment in clean energy in 2022 and average annual investment between 2031 and 2035 in the NZE Scenario and the SDS.

The growing demand for services and appliances in EMDEs is driven by rapid economic growth, urbanisation and improvements in living standards. In the buildings sector, which accounts for nearly one-third of final energy consumption, almost 2 billion new urban inhabitants are expected by 2050 in EMDEs. The efficiency and emissions profile of buildings represents an increasingly crucial factor for energy transition strategy, and a huge opportunity for sustainable policies given that most of these buildings have yet to be constructed. Meeting this opportunity will entail investing more than USD 400 billion in EMDE energy efficiency improvements in buildings each year to 2035. The investments cover a range of interventions and equipment, including the careful early-stage design of the building envelope, as well as passive measures such as reflective paint, external window shades and air sealing, which provide the most significant energy savings. It is worth noting that only 3% of overall spending in buildings in EMDEs is dedicated to retrofitting the existing building stock. By the early 2030s, the total number of air-conditioning units in use is expected to surpass 3 billion. India accounts for a quarter of the new air-conditioning unit purchases, while Southeast Asia and Africa together account for another fifth.

In the transport sector, investment in electrified transport needs to increase almost sevenfold, with annual investment of USD 370 billion in EVs. Unlike the current concentration of EV sales in a few EMDE regions, transport investment is expected to grow more evenly across all EMDE regions. China contributes around 30% of this investment, followed by a significant role played by Latin America and India. Although EVs account for the bulk of this investment (90%), other transport enhancements such as energy efficiency and EV charging stations also have a significant impact. Investment in the electrification of public transport also receives a significant boost, especially in countries such as India where public bulk procurement of electric buses started ramping up in 2022 and rail electrification is progressing.

EMDEs' economic, energy and emission profiles are increasingly influenced by the industrial sector. Their real industrial value added is expected to increase by over 30% in the next decade due to investment in infrastructure, urban housing, factories and equipment that require materials. While all regions are predicted to experience growth, India and Southeast Asia are anticipated to have the most significant expansion in industrial value added and production, followed by sub-Saharan African economies. Because industry requires high levels of heat and is widely reliant on fossil fuels, investment in decarbonising the sector is currently limited, as very few technical solutions are readily available. Industry is a major consumer of coal, second only to the power sector. Avoiding a rapid continuing increase in coal use as developing countries industrialise is a multifaceted task. Investment in energy efficiency and electrification of industrial processes more than doubles by the second half of this decade in climate-driven scenarios to reach more than USD 65 billion. It almost quadruples by the early 2030s, mainly as a result of rapid electrification of manufacturing production in China, which accounts for about half of the total investment in the sector. Beyond electricity, annual investment in CCUS by industry significantly ramp up as plants in China and India increasingly rely on the technology to mitigate emissions from hard-to-abate processes.

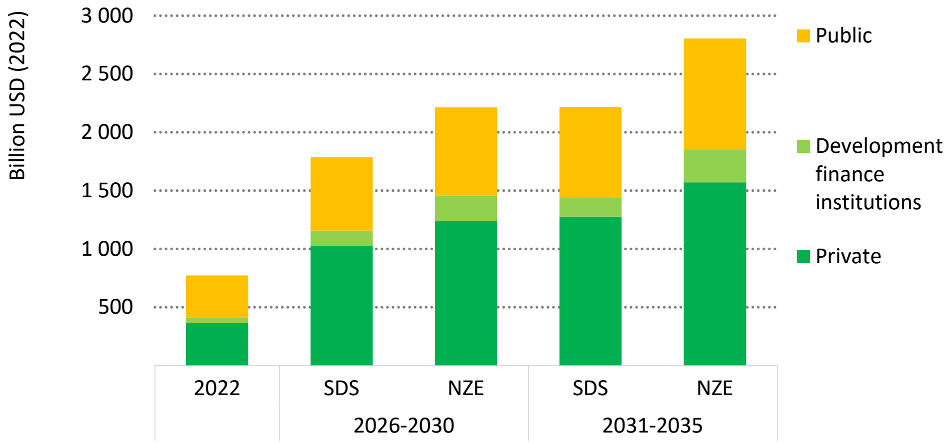
2.4. Public and private finance for investment

Where will the money come from for these investments? The different potential sources include: governments and development finance institutions (DFIs), including multilateral and national development banks; philanthropies; commercial banks; institutional investors such as pension funds, insurance companies and sovereign wealth funds; private equity funds; firms that reinvest their profits; and households and individuals.

DFIs and philanthropies can help to mobilise private capital by de-risking investment through co-investment and the provision of concessional funds, grants, guarantees and other de-risking mechanisms. As these public and philanthropic funds are limited, the argument of this report is that they need to be used strategically to leverage high multiples of private funding and to support the development of less mature technologies where risks are too high to attract adequate capital from the private sector. Where equity capital is in short supply, public funds can be used to fill the gap to allow high leverage ratios and access to debt capital.

The majority of financing needs to come from the private sector (Figure 2.14). Firms, private equity funds and institutional investors, and to a lesser degree households and retail investors, are the important providers of equity capital, while commercial banks, private equity funds and institutional investors are the significant providers of debt capital.

Figure 2.14 ▷ Estimated sources of finance for clean energy investment in EMDEs in the NZE Scenario and SDS



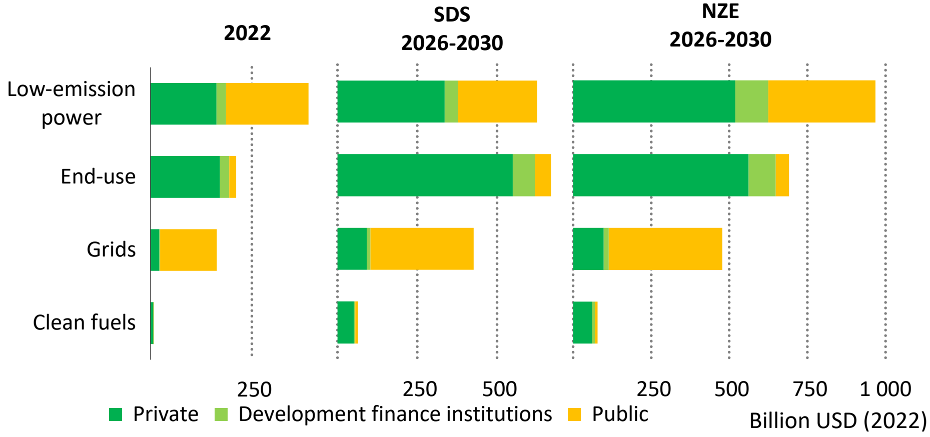
The private sector takes an outsized role in scaling up clean energy financing in our scenarios, helped by public policy and the catalytic role of public financial support

Notes: Annual investment in clean energy in 2022 and average annual investment between 2026 and 2030 and 2031 and 2035 in the NZE Scenario and the SDS; DFI = development finance institutions; public sources of finance include funds from governments, state-owned commercial banks, SOEs and sovereign wealth funds; DFIs include funds from national development banks, and bilateral and multilateral development banks.

At the moment, less than half of EMDE investment in clean energy is financed by the private sector. This share needs to rise. In our estimation, to reach climate and sustainable development goals the private sector will need to finance at least 60% of the clean energy investment in EMDEs to 2035 (IEA, 2022c). This implies a much higher rate of growth in private investment. While public entities roughly double their overall financing of clean energy investment over the next decade in such scenarios, private sector financing triples.

2

Figure 2.15 ▷ Estimated sources of finance for clean energy investment in EMDEs by sector in the NZE Scenario and SDS

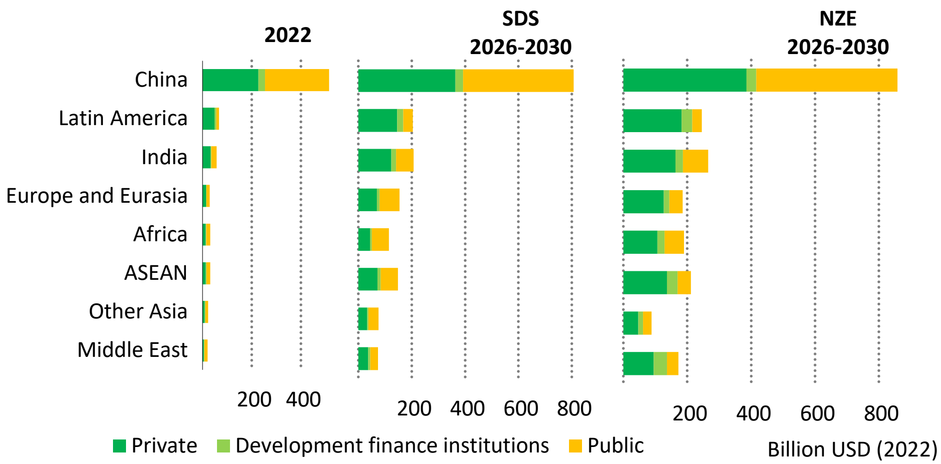


The private sector and households play vital roles in scaling up clean energy deployment, especially in renewable power and in end-use sectors such as buildings and transport

Note: Annual investment in clean energy in 2022 and average annual investment between 2026 and 2030 in the NZE Scenario and the SDS.

Private financing is assumed to take the lead in expanding the deployment of low-emission power, with the exception of nuclear and large hydropower projects (Figure 2.15). It is likewise pivotal to the transformation of end-use sectors, by enabling households and corporates to finance efficiency improvements and investments in electrification. Public sources predominate when it comes to grid infrastructure in most EMDEs. DFIs play an increasingly important role in our scenarios by structuring bankable projects, providing financial de-risking mechanisms, co-financing projects with private sector capital providers, and facilitating capital disbursement. DFIs also extend credit lines to financial intermediaries and firms, particularly for energy efficiency, as well as providing guarantees for loans and projects.

Figure 2.16 ▻ Clean energy investment in EMDEs by public and private ownership and region in the NZE Scenario and SDS



All regions need to see a sharp uplift in financing from private actors in order to get on track with energy-related SDGs and to tackle climate change

Note: Annual investment in clean energy in 2022 and average annual investment between 2026 and 2030 in the NZE Scenario and the SDS.

As regards their geographic distribution, all regions see a significant increase in private financing for clean energy (Figure 2.16). China is by far the largest market for clean energy investment, but the most rapid increases occur elsewhere, notably in the Middle East, Africa and Southeast Asia. The role of public financing is largest in some of the major hydrocarbon resource-owning regions in the Middle East and Eurasia, where SOEs are assumed to continue to play important roles.

Our analysis of the evolution of capital structures in the NZE Scenario suggests that debt financing is likely to be favoured as investment shifts from fuels to electricity and end-use sectors. Investment in the electricity sector often relies heavily on debt financing, especially in EMDEs where long-term power purchase agreements or regulated remuneration are common. End-use sectors such as building efficiency improvements see significant debt financing (Box 2.4).

Certain riskier categories of investment imply an increase in reliance on equity. Privately sourced debt is limited in lower income countries due to higher risks associated with power purchase reliability, a lack of projects meeting bank lending criteria, and underdeveloped local banking systems and credit markets. Emerging technologies such as battery storage and low-carbon hydrogen, as well as more complex projects, rely more on balance sheet and equity finance for their initial capital needs. However, as these technologies establish a proven track record with banks and policies are put in place to support business models with dependable cash flows, project finance and debt become more prominent.

Box 2.4 ▷ The investment actors

Who will be making all these investments in clean energy in EMDEs? This will vary according to the institutional and regulatory context, but ultimately the tripling of investment needed in clean energy will need to come from governments (at national or subnational levels), from firms (including SOEs, large corporates and small and medium-sized enterprises [SMEs]) and households.

All of these market participants will need to play a part, but each faces different opportunities and constraints. We estimate that investments undertaken by public entities account for well over half of EMDE clean energy spending currently. However, EMDEs are not in a position to rely on scarce national public funds to support a broad scale-up in clean investment. The contention in this report is that the private sector – large corporates and SMEs – and households will need to play an outsized role in moving EMDEs towards a cleaner and safer energy future, but they will not have the incentive to do so unless a host of public actors – including international financial institutions – provide the necessary policy, regulatory and financing support.

The respective roles and responsibilities of the different public and private actors vary by country, but there are common themes. SOEs tend to be major players for EMDE investment in electricity networks, and in nuclear and large hydropower projects. The direct role of governments as investors typically focuses on major infrastructure projects – sometimes in partnership with the private sector. Direct public support is also vital for the development of more nascent technologies, via funding for research and development and for first-of-a-kind projects. Public procurement policies offer an opportunity for governments to establish and grow markets for efficient and low-carbon equipment and materials. This can help drive down costs and provide consumer confidence in the adoption of such technologies.

In many EMDEs, regional governments and municipalities play important roles in electricity and energy provision as well as public transport. Building up clean energy infrastructure can be an important element of broader strategies to attract non-energy investment, especially as firms integrate sustainability criteria into investment decisions and look for locations with access to renewable and other low-carbon sources of electricity and fuels. This is a growing issue for many EMDE firms as they see on the horizon that access to certain major international markets may be shaped by their environmental performance, as with the Carbon Border Adjustment Mechanism in the European Union.

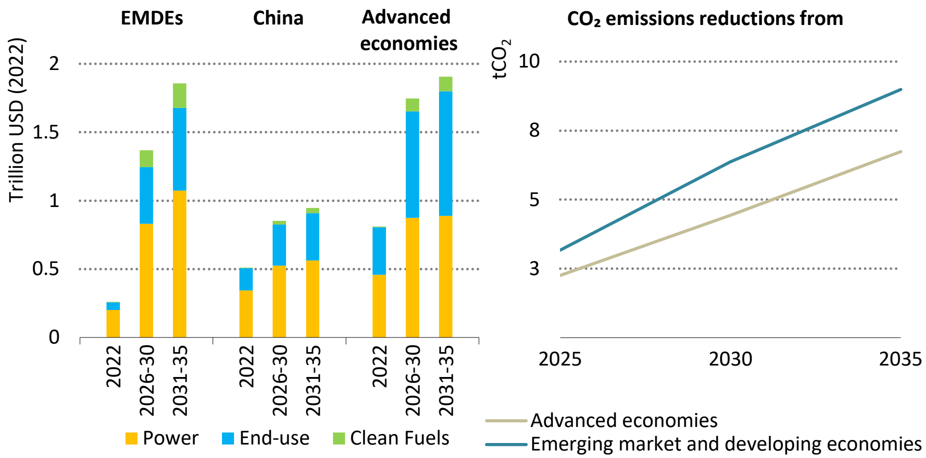
2.5. Implications

An unprecedented increase in clean energy spending is required to put EMDEs on a pathway towards their energy-related SDGs and net zero emissions. For the moment, with few exceptions, this surge in investment is not yet visible. Without it, EMDEs will not be in a position to meet rising demand for energy services in a sustainable way, prolonging reliance on fossil fuels and leading to consistently high global emissions.

As things stand, the trajectory for clean energy deployment in EMDEs is not sufficient to curb rising demand for oil, gas and coal. In the STEPS, clean energy investment rises and the development trajectory for most EMDEs is significantly less fossil fuel intensive than that followed in the past by advanced economies (and by China). Output from low-emission sources of power in EMDEs more than doubles by the early 2030s. There are numerous bright spots and individual country successes. However, this is not enough in aggregate to ease reliance on fossil fuels. In the STEPS, EMDE oil demand rises to 2035 by 10 million barrels per day (an increase from today of just over 20%), as car fleets expand and the use of oil as a petrochemical feedstock rises rapidly. Coal demand in 2035 is only slightly below today's levels, and gas demand is up by almost 20%.

This has clear implications for emissions: energy-related emissions in EMDEs are set to grow in the coming decades unless much stronger action is taken to transform their energy systems. With the exception of China and parts of the Middle East and Eurasia, EMDE per-capita emissions are among the lowest in the world. In the STEPS, total emissions from EMDEs (excluding China) are projected to grow by about 2.5 Gt by 2035. In contrast, they are projected to fall by 3 Gt in advanced economies and to start tailing off post-2030 in China.

Figure 2.17 ▷ **Clean energy investment in the NZE scenario by region and CO_2 reductions from USD 1 spent on clean energy**



EMDEs including China account for the largest share of investment over the next ten years, and this investment is typically a very cost-effective way to reduce emissions

In aggregate, EMDEs are currently investing slightly less in clean energy than advanced economies. But the need for this investment is significantly higher; by the early 2030s, EMDEs need to be investing around a trillion dollars more each year than advanced economies in order to get on track for a 1.5°C stabilisation in global average temperatures. This reflects the increasing preponderance of these economies in global energy demand. It requires very high upfront investment in EMDEs at a time when the macroeconomic situation creates significant headwinds, but there are major benefits for energy security, air quality, employment and sustainable growth.

Investment in clean energy in EMDEs is also a more effective way to reduce emissions; this is because there are generally more "low-hanging fruit" available in EMDEs, particularly for low-cost renewables and efficiency, while many advanced economies are moving on to higher-cost abatement opportunities (Figure 2.17). Every dollar invested in clean energy in EMDEs results in 12 tonnes of emission reductions in 2035, or 30% more than in advanced economies. This is a key reason why it makes sense for advanced economies not only to step up their own decarbonisation, but to help others make the same journey.

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Improving risk-adjusted returns

How can policy makers crowd-in private capital?

SUMMARY

- EMDEs are set to see a rapid rise in energy needs over the coming decades and it is imperative that this need is met wherever possible with clean energy. This will require increases in all sources of financing, including a massive increase in private capital inflows. Private financing seeks suitable risk-adjusted returns that are competitive with other projects seeking funding. This requires well-designed enabling frameworks, strong institutions and strategic use of concessional resources to close the gap between private and social returns, as well as to address adjustment costs.
- Improvements in energy sector policies, governance and financing conditions are mutually reinforcing as progress in one area facilitates positive developments in others, but these all need to be tied together by a commitment to an ambitious and credible transition vision. Addressing cross-cutting issues such as fossil fuel subsidies and unclear pricing policies, lengthy licensing processes and unclear land use rights is also crucial to the prospects for investment.
- There are examples of private finance being successfully raised for solar PV and wind projects in EMDEs with transparent and predictable policy frameworks. However, more needs to be done in many countries to open up electricity systems to new entrants, improve the return profile, and encourage investment into other dispatchable sources of generation as well as the networks and storage needed for secure and sustainable supply.
- Efficiency needs to be embedded as a priority across government via standards and other policies that increase demand for energy-efficient products and services. Many of the investments have strong underlying economics, but still need policy and financing support to manage upfront costs and create market scale.
- While mature clean technologies are often the least-cost option for new power generation investment, attracting greater private financing for low-emission fuels often needs stronger policy interventions to close the gap with traditional fuels, stimulate demand and underpin infrastructure development. Emissions-intensive sectors with robust, credible net zero strategies need dedicated transition finance to facilitate uptake of cleaner and more efficient technologies.
- Investment in clean energy supply chains – from the extraction and refining of minerals to manufacturing – also represents an opportunity for greater private sector funding. EMDEs with the potential to be globally competitive beyond primary production need to put in place policies to spur domestic value added.

3.1. Risk-adjusted returns – a key metric for private investors

The financing requirements discussed in the previous chapter cannot be set apart from the clean energy policies, regulatory frameworks, public resources and institutional settings that are needed to accelerate the pace of the clean energy transition. This is because changes to all of these are required to raise the risk-adjusted return on projects to meet the requirements of private investors. This chapter discusses the risks and opportunities facing the private sector, and how the public policy context affects the incentive to invest.

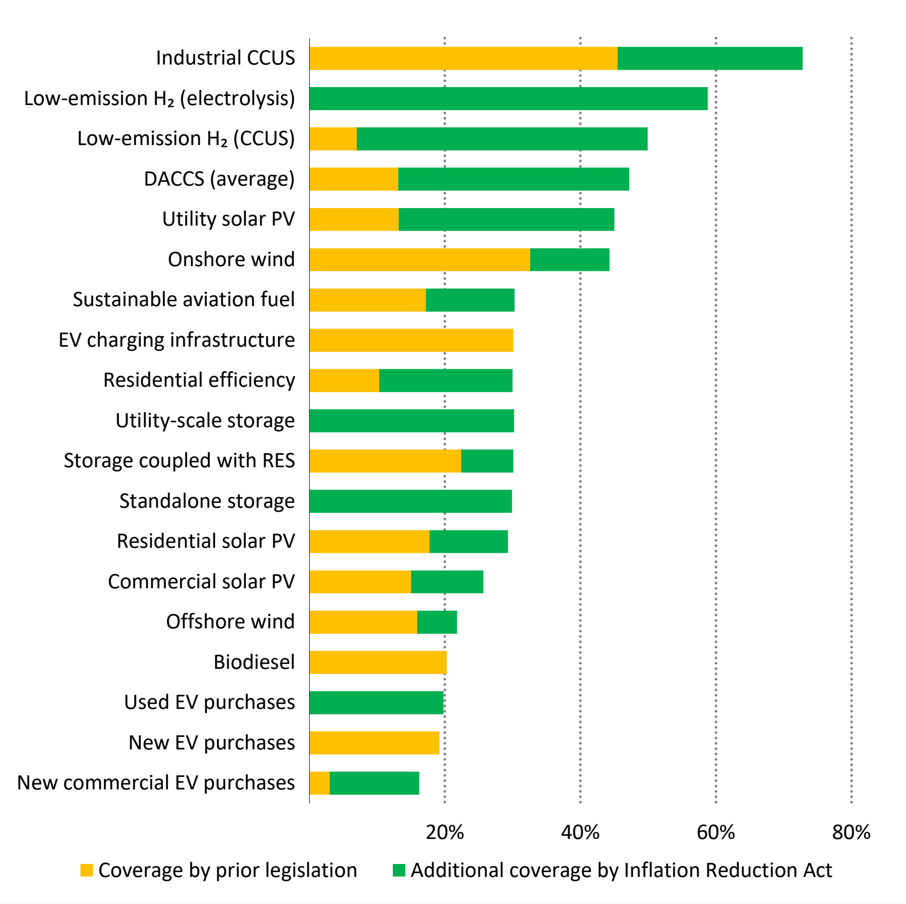
A radical change in incentives will be required to achieve the energy-related Sustainable Development Goals (SDGs) and emission reductions set out under the Paris Agreement. Pathways to achieve these or similar transitions require a range of price and non-price measures to increase the attractiveness of clean energy investment by improving risk-adjusted returns, by both mitigating risks and enhancing returns, as well as measures to strengthen energy sector institutions. The pricing measures include removing fossil fuel subsidies and introducing carbon pricing or an equivalent. The non-pricing measures are as important as the pricing policies, including a wide range of regulatory measures, targets and policies that lower the cost of capital as well as raise the returns on clean energy investment. In addition, managing the adjustment costs (including their distributional impacts) have significant public policy resource transfer implications.

Private capital for clean energy projects in emerging market and developing economies (EMDEs) often does not find the right balance between risk and return, even though investors are increasingly looking at such projects. Government subsidies in advanced economies are making investment in clean energy more attractive, but most EMDEs lack the fiscal space to provide similar incentives and, in the absence of strong international support, may find it challenging to meet the return requirements expected from private investors (Box 3.1). Strengthening macroeconomic fundamentals and policy predictability, and removing red tape, are complementary key actions to enable EMDEs to compete for global private capital.

Box 3.1 ▷ Advanced economy support programmes: A mixed bag for EMDEs

The US Inflation Reduction Act provides significant incentives for private investment in clean energy (Figure 3.1), with a goal to reduce carbon emissions by roughly 40% by 2030 compared to 2005. Congress has approved estimated new spending of USD 369 billion over the next ten years, although actual expenditure could be significantly higher (or lower). Public funding will be delivered through a mix of tax incentives, grants and loans. Tax incentives for corporations account for the lion's share of funding. The act also includes measures that directly benefit consumers by lowering the cost of energy-efficient appliances, EVs, rooftop solar panels, geothermal heating and home batteries.

Figure 3.1 ▻ US Inflation Reduction Act tax credits and other incentives as a percentage of the average total cost of each technology



Together with previous benefits, the Inflation Reduction Act has secured substantial support for key clean energy technologies in the United States

Notes: CCUS = carbon capture, utilisation and storage; DACCS = direct air capture with carbon storage; EV = electric vehicle; H_2 = hydrogen; RES = renewable energy sources; PV = photovoltaic.
Source: Adapted from Goldman Sachs (2022).

Applying the same tax incentives implies a differential impact on the bottom line according to the different cost of the technology. Overall, carbon capture, low-emission hydrogen and solar PV benefit the most. Relative to prior legislation, low-emission hydrogen, carbon capture, energy storage and energy efficiency technologies benefitted from the largest changes.

The generous support package is prompting some multinationals to redirect investment to the United States. In response, the European Commission has proposed the Green Deal Industrial plan, which would increase support for the EU's industrial transformation by speeding up the granting of financing for clean tech production in Europe, supporting green skills and trade, and promoting a predictable and simplified regulatory environment.

While it is too early to see the impact on EMDEs, it is anticipated that it could be mixed. On the one hand, advanced economy incentives should help bring down the cost of some key technologies, benefiting EMDEs as they adopt them over time. On the other, absent compensatory action, they also have the potential to move investment away from EMDEs, which typically have much less fiscal space to replicate these incentives.

Investors' return expectations depend on country-, sector- and project-specific factors. The cost of capital for clean energy projects in EMDEs is higher than those in advanced economies, potentially making these projects less attractive to investors unless other costs, such as land and labour, are significantly less than in advanced economies (see Chapter 2). Central bank policies and global conditions also play a significant role, as risk perceptions are relative. When central bank interest rates are close to zero (or even negative, as in the euro area in the aftermath of the 2007/08 financial crisis), investments in EMDEs become increasingly more attractive as investors look abroad for opportunities that align with their future liabilities (e.g. pension and insurance payments), and a relatively higher financial return in EMDEs may look attractive. But with interest rates on the rise, foreign investors have less incentive to invest abroad and will require higher returns to invest in markets with higher macroeconomic and financial risk profiles.

The spectrum of investors in EMDEs covers a wide range of entities, each with a different set of expectations with respect to risk-adjusted project returns, as the private sector is diverse with different perspectives and motivations (Box 3.2). Commercial banks, the real sector and institutional investors seek market returns that are a function of the project, sector and country risks. However, environmental, social and governance (ESG) policies and regulation, as well as growing investor interest in sustainable and transition finance issues (especially by impact investors), have broadened market perceptions of returns beyond the financial to include ESG impacts. These encompass investing in clean energy as well as the integration of climate risks into portfolio evaluation.

Box 3.2 ▹ Attracting different types of private capital for EMDE transitions

EMDE energy transition projects seeking to attract private capital have to compete with investment opportunities outside the clean energy sector, as well as similar opportunities to invest in energy transitions in advanced economies. Private finance needs to be mobilised from a variety of sources, primarily commercial banks and institutional investors, both domestic and international.

Figure 3.2 ▹ Types of investors and return expectations

Entity type	Returns spectrum
• **Private companies** of all sizes • **Commercial banks** • **Institutional investors** such as pension funds, sovereign wealth funds, other asset managers	**Market-rate returns**
• **Bilateral, multilateral and national development banks** (private sector arms) • **Impact investors** (seeking impacts and returns)	**Quasi or blended returns**
• **Philanthropies and NGOs** • **Bilateral, multilateral and national development banks** (public sector arms) • **Impact investors** (not seeking market returns) • **Governments**	**Below market-rate returns by design**

The higher return expectations of private investors can be offset by lower public sector return requirements

Source: Modified from Tall et al. (2021).

Total bank loans to the private non-financial sector amounted to around 100% of global annual GDP in 2020, roughly USD 85 trillion (Prasad et al., 2022). Banks can invest in shorter-term finance and are typically engaged in both corporate and project finance. They are therefore best suited to finance the construction and operational phases of a project. Regulatory requirements, such as Basel III, call for greater liquidity and lower leverage to reduce risks, thereby requiring banks to secure longer-term, higher-cost sources of funding when investing in long-term, illiquid assets (including energy/infrastructure projects) (CPI, 2018).

Institutional investors (including pension funds, insurance companies, investment funds, sovereign wealth funds, and foundations and endowments) globally hold more than USD 100 trillion in assets and are a promising source of such financing (OECD, 2021). Traditionally, institutional investors hold mixed assets, while most of their funds are invested in equities and bonds. However, the structure of their investments depends on their medium- to long-term liquidity needs, their risk appetite and the expected type of payments institutional investors need to make to their clients. Furthermore, most institutional investors do not have the in-house expertise and/or ability to invest directly in renewable project debt and equity, with constraints including high transaction costs and large minimum ticket sizes (CPI, 2018). Suitable large-scale investment vehicles that bundle projects will be needed to attract financing from these investors. Additionally, pension funds and insurance companies must comply with domestic regulations that limit the amount of funds that can be invested abroad, as well as meeting their fiduciary duty and specific investor mandates.

Impact investing refers to employing capital to obtain financial as well as measurable social and environmental returns. In some rare cases these investors may accept below market rate returns, but the majority work under investment mandates that seek risk-adjusted market-rate returns and employ specialist fund managers with expertise to evaluate and invest directly in projects with high social impact. The global impact investment market was valued at USD 1.2 trillion in 2021 and is expected to grow rapidly by the end of the decade (Hand, Ringel, and Danel, 2022).

Public and philanthropic financing can provide additional value in cases where no market financing is available. This can help build market confidence, demonstrating the viability of technologies and creating a crowding-in effect. The use of innovative funding and financial risk management tools can help to support market development (discussed in Chapter 4).

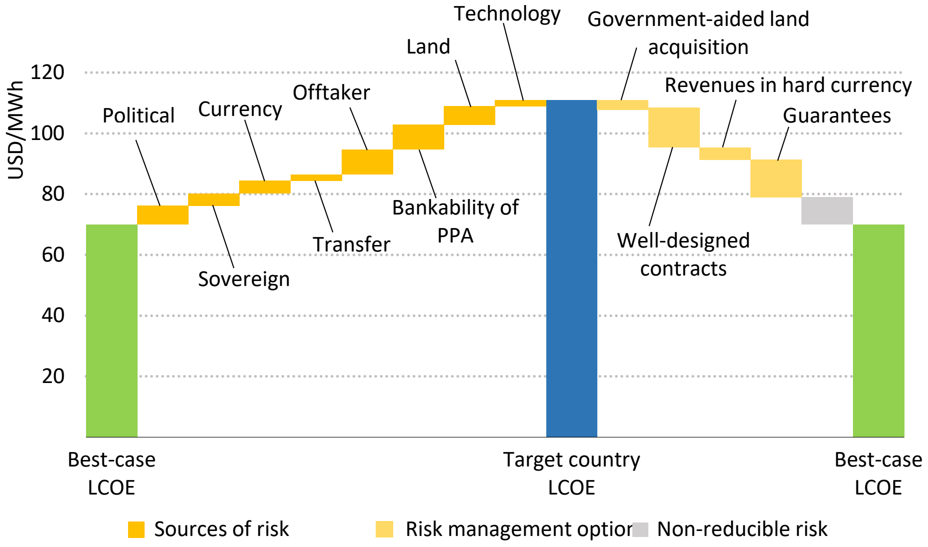
3.2. Risks affecting energy transition investment

Improving risk-adjusted project returns for EMDEs across the power, fuel and energy end-use transitions depends fundamentally on mitigating risks related to domestic factors.[1] This subsection looks in greater detail at measures to mitigate risks that are relatively common across these energy transitions, starting with political and macroeconomic risk and risk associated with insufficiently developed local capital markets, regulatory risk, technology-

[1] World Bank (2023a) presents a comprehensive framework on the process and sequencing of reforms, and how financing can be sourced for the transition to clean power. It emphasises the need for institutional strengthening and the role of governments and appropriate institutions in developing a pipeline of projects.

related risk, offtake and curtailment risk, and risk related to insufficient available data and information (Figure 3.3)[2] These risks determine the cost of capital for clean energy projects, which can vary significantly across countries (Box 3.3).

Figure 3.3 ▷ Risks affecting variations in the LCOE and the role of risk management options in improving the LCOE



Potential policy solutions to overcome country and project risks are to the right of the target country LCOE

Notes: LCOE = levelised cost of electricity; PPA = power purchase agreement.
Source: IEA (2023a).

Box 3.3 ▷ Cost of capital

The cost of capital of a project largely reflects two sets of risks: those associated with the country (the base rate) and those associated with the sector or project type (the premium). The base rate incorporates risks associated with the country's general investment conditions, such as sanctity of contracts, political stability and capacity to pay back sovereign debt (generally referred to as country risk), as well as issues around domestic inflation, exchange rate variations, convertibility rules, etc. (currency and inflation risk). These risks are associated with the overall market, and affect all projects in a country. Meanwhile, the premium incorporates risks associated with the specific

[2] Detailed analysis on the risk premium assumptions can be found in the IEA's Cost of Capital Observatory (IEA, 2023a).

project (e.g. sector regulation, technology maturity, offtaker risk in the case of a power project). Liquidity risk can also be included in the premium, depending on the asset type.

The degree and distribution of these risks varies considerably among EMDEs. For example, some countries have an investment-grade debt rating (indicating lower risk of credit default) and considerable experience attracting capital to energy projects, while others may be under conflict, and have low economic growth and little investment.

If we look at estimates of cost of capital for large-scale solar PV plants in a set of EMDE countries, we see that the base rate accounts for the majority of the overall cost of capital, from around 60% to almost 90% (IEA, 2023a). This relationship may differ in developed economies, which tend to have relatively lower country-associated risks, so the base rate can account for a much lower portion of the overall weighted average cost of capital. These shares are not static, however. Interest rate hikes in recent years have mostly increased the country risk impact on the overall cost of capital across economies.

3.2.1. Political, macroeconomic, and foreign exchange risks

For private investment (foreign and domestic) to occur in EMDEs on a scale commensurate with net zero goals, it is essential to meet certain preconditions that provide investors with visibility over the medium to long term, including the rule of law and a strong measure of security and stability. EMDEs face higher macroeconomic risks and therefore have more constraints on capital than advanced economies. Sound macroeconomic management and the stability it provides is thus a public good of paramount importance.

Addressing the root causes of high macroeconomic, financial and exchange rate risk requires both short- and medium-term structural reforms. During the process of macroeconomic and financial reform, continuous support in the form of project-specific risk reduction measures is critically important. Measures include access to risk-sharing platforms and markets, and the use of risk-resilient financing instruments. They should not only take the form of guarantees, but also see development finance institutions (DFIs) sharing risks as co-investors, signalling the seriousness and commitment of the government to reform, and the importance of clean energy investment.

The ability to mobilise private capital for low-carbon projects in EMDEs is thus directly linked to the enabling environment. For example, analysis using IFC's equity investments shows that a 1% increase in cumulative annualised GDP growth over the life of the average IFC investment results in a 6.6 percentage point increase in returns (Cole et al., 2020).

Multilateral institutions such as the World Bank and the IMF have an instrumental role to play in promoting a better environment by providing assistance in the implementation of sound macroeconomic policies and solid fiscal management, and in the design of cross-sectoral decarbonisation policies and assessment of climate-related country risk. Their involvement, together with IFC and other private sector-oriented institutions, is an important source of reputational capital and credibility of commitments, sought by private investors. There also needs to be clarity and predictability in policies and procurement approaches. In some EMDEs, policy announcements are not followed by actual steps to implement the announced legislative and regulatory measures.

For EMDEs with shallow capital markets, much of the funding for the transition must be raised externally. This carries foreign exchange risks and/or extra costs (e.g., relying on foreign exchange hedging facilities or, for long-lived projects that are structured as concessions, adjusting the length of the concession period depending on the projected exchange rate trajectory).

3.2.2. Regulatory risks

For the moment, many EMDEs do not yet have a clear vision or a supportive, predictable policy and regulatory environment that can drive rapid energy transitions at the speed and scale required, increasing the risk of investing in these countries and lowering risk-adjusted returns. Rule of law and other governance-related issues, lengthy, unclear and changing procedures for licensing, permitting and land acquisition, and restrictions on foreign direct investment (FDI) are cross-cutting issues that discourage investment in energy transitions (IEA, 2021a).

Rule of law, contract sanctity and other governance issues

Broad governance factors, including political stability, rule of law and the effectiveness of governing bodies, have a major impact on the perception of risk and investment protection. Low political stability can raise expropriation risks, while lack of rule of law in contract enforcement and property rights can also raise the spectre of financial losses in disputes. Government effectiveness (e.g. quality of public services and policy formulation) determines how well regulations are designed and implemented, and the administration of state-owned enterprises, which affects both public and private investment.

Licensing and permitting

Delays, long lead times and unclear processes to obtain project licences and permits further compound the challenges. When not designed properly, processes for obtaining licences, permits, rights and other approvals to build, own or operate an energy asset can add economic burdens and uncertainties to project development, contributing to cost overruns and delays. These procedures can relate to a range of activities, including the titling of property, establishing interconnections, conducting environmental impact assessments and acquiring land, and can sometimes add months or years to project timelines. Streamlining permitting and licensing procedures, in a way that still addresses system requirements, can reassure developers as well as reduce the costs and increase the speed of project development.

Suitable programmes to streamline permitting and licensing depend on the country context, although general principles can help reduce transaction costs and ease the process. Seven principles of a well-functioning licensing or permitting process for the authorisation of renewable energy projects are: legal consistency, transparency, institutional capacity, a clear time frame, public consultation, monitoring and evaluation, and enforcement and recourse (World Bank, 2015). Several countries have also implemented programmes to centralise permits and approvals, such as "one-stop shops" for energy project development (Box 3.4).

Box 3.4 ▹ One-stop shops and financing early-stage project development

Developing bankable energy projects is a high-risk activity. Only 10% of infrastructure projects mature from pipeline to financial close, and around 80% of projects fail at the feasibility and business stage plan (McKinsey, 2020).

The creation of "one-stop shops" for services related to project development has helped accelerate investment and deployment of renewables in several markets. Morocco's success in attracting capital into renewable power was enabled by formation of the Moroccan Agency for Sustainable Development (MASEN), which acts as tendering agency, intermediary offtaker and hub for most project-related inquiries. The Tanger Med Zones, also in Morocco, act as one-stop shops for investors looking to locate in the Tangier region, helping companies to obtain the permits, authorisations and licences required to start operations as fast and smoothly as possible.

One-stop shops have also been set up more broadly in EMDEs. Economic zones and port authorities, such as the Sohar Port and Freezone in Oman, are also facilitating clean energy planning around industrial hubs, supporting investment in energy efficiency and potentially low-carbon fuels.

Combining efforts with public funds and programmes for pre-feasibility and feasibility studies can help close the gap between the early development phase and the construction phase. This includes offering legal advice, such as the African Development Bank's African Legal Support Facility, project preparation/development funds, such as InfraCo in Africa, and co ordinating platforms.

Land acquisition

Land acquisition for energy projects is affected by various factors, including local land use regulations and registration and ownership matters. In countries or cities with high population density, land availability is additionally challenging. It may also be expensive, depending on its other potential uses. In India, utility-scale solar PV and wind projects with better access to land and timely grid connections are associated with lower risk perceptions by investors (Dutt, Arboleya and Gonzalez, 2020).

Land-related risks can be particularly important for renewables, with differences by technology. For instance, the land use requirement (the area needed to produce a given amount of electricity) is generally higher for solar PV than hydropower, while wind power is generally lower than hydro. At the same time, the modular nature of solar PV means it can be installed in urban places more easily than other renewables. Other considerations, such as the presence of local populations or endangered species, can also affect investment decisions, especially in the case of the geographical footprint associated with hydropower development.

Some governments have introduced programmes to address land constraints. The Solar Energy Corporation of India (SECI) has been developing solar parks with state governments and takes on the risk of acquiring and bundling land, with developers paying a user fee. Single-window clearances have also been set up in a few Indian states to expedite approvals. Still, land approvals remain slow and development of solar parks lags government targets. In the United Arab Emirates land acquisition has been addressed directly in PPAs, and very low-cost solar projects in Dubai have benefited from land provided as part of the contract.

Regulatory uncertainties linked to overlaps, contradictions and ambiguity in land ownership and acquisition laws and procedures pose significant risks to any investment. They disproportionately disincentivise medium-sized to large investments in renewables.

Restrictions on foreign investment

FDI has been a significant source of financing for low-carbon technologies globally and an important channel for technology transfer. But several EMDEs impose some of the world's most restrictive conditions on FDI (OECD, 2023). Stringent foreign equity restrictions and significant requirements for FDI screening and prior approval are widespread and disincentivise investment. Similarly, imposing high local content requirements for project approval impedes investment in countries without the manufacturing capacity to meet such requirements or the potential to become globally competitive in the selected supplier industries, and directs investment elsewhere due to the associated increase in costs.

3.2.3. Technology risks

Speeding up technology development and diffusion is necessary for meeting net zero targets (IEA, 2021b). One important set of risks facing EMDEs concerns the timing to invest in a new technology given uncertainty surrounding future cost decreases and further technological improvements. Most of the global reductions in emissions up to 2030 are expected to come from the rapid deployment of available technologies, so adoption of these tried technologies carries low risk. However, by 2050 almost half of the reductions are projected to come from technologies that are not yet market-ready, but still at the demonstration or prototype stage. For these evolving technologies, it may be in the interest of the adopter to wait for further cost reductions.

There are a range of policies that can help lower additional risks related to technology adoption and diffusion within EMDEs. Business advisory and technology extension services increase local awareness of new and evolving technologies, and strengthen required worker and management skills, among others. They typically benefit from some level of government support (Cirera, Comin and Cruz, 2022). DFIs have a role to play in crowding-in investments and associated capabilities required for technologies that have yet to be adopted.

3.2.4. Payment-related risks

Creditworthiness of offtakers

If the wholesale and/or distribution offtaker is bankrupt or inefficient in its operations, the risk of not being paid for any power generated and supplied is likely to be too high for any investor. Under such circumstances, the private sector will not be willing to invest in renewables without a sovereign or multilateral guarantee (e.g. World Bank Partial Risk Guarantee) for the offtake. The underlying issues need to be addressed by governments and regulators, including regulated tariffs that are below the cost of services, poor planning and procurement, and operational inefficiencies.

Curtailment

One of the biggest risks for investors in renewables is grid curtailment.[3] To create security and reduce curtailment risk for investors, it is important for transmission system operators to be fully transparent in their operations for wheeling power. The problem can be compounded if more intermittent renewables are added before the rest of the system is ready to accommodate them. Well-regulated markets can help reduce curtailment risk transparently by delivering the price signals for investment in sources of flexibility, such as dispatchable sources of generation or storage, to complement renewables and ensure that the overall system is balanced. Long-term contracts for renewables could also help, as short-term markets alone are unlikely to reduce the cost of capital.

3.2.5. Data and information

Data and information are an important public good for investors needing detailed statistics on the available natural endowments that establish the potential for renewables in a country or region. Analysis of climate information allows a better assessment of the magnitude and likelihood of climate variability and its related impact on a potential clean energy project's production and thus its economics. For investors to accurately assess the risk profile of different investments and compare the risk–return combinations, climate risks need to be adequately measured. This requires climate data to be available (of good coverage,

[3] Grid curtailment is the deliberate reduction in output below what could have been produced to balance energy supply and demand or due to transmission constraints. It can be interpreted as a measure of the lack of transmission capacity, creating the risk of new renewable energy plants not being able to sell their power.

granularity and accessibility), reliable (good quality, auditable and transparent) and comparable (with clear data labels, taxonomies and identifiers).

Improving the availability of clean energy performance data and default rates across different projects can help to overcome perceived risks associated with clean energy technologies. Information asymmetry poses risks to project development, as the lack of reliable performance and resource data makes it difficult for financial institutions to undertake project due diligence, leading projects to be considered unbankable.

The public sector, in concert with multilateral development banks and DFIs, can play a significant role in improving the availability and reliability of data and information necessary for project evaluation. The private sector can also offer innovative approaches to data management and to developing interactive platforms that deliver data and information services to a broader audience and better inform investors' decision-making.

Georeferenced and date/hour-specific granular information on, for example, the speed, direction and height of winds is of extreme importance to calculate the volume of energy and the extent of intermittence, and therefore the potential returns for investing in a wind farm. This type of information made public would lower entry barriers and reduce project risks. Improved climate data would also support the development of solar and hydro projects.

Initiatives that provide highly granular data can attract private sector interest and help scale necessary investments. As an illustration, the Federation of Industries of the state of Ceará in the northeast of Brazil produced a highly granular wind-solar atlas that was made widely available in 2019 (CEARA, 2019). This initiative contributed to attracting to the state a large volume of investment in wind and solar projects and positioned the state as a hub for green hydrogen production. It also stimulated other Brazilian states to make similar data available.

3.3. Regulation and policies for energy transitions in power, fuels and end use

Improving risk-adjusted project returns for EMDEs in each of the specific sectors – power, fuels and end-use energy transitions – depends on a judicious mix of measures that both mitigate risks related to sectoral factors and enhance returns relative to fossil fuel production and use. This subsection looks in greater detail at measures required to mitigate risk as well as enhance returns to reflect the full social benefit of investments, starting with multi-sector regulation and policy frameworks, and then discussing investments in clean electricity generation, grids and storage, low-emission fuels, and energy efficiency and end-use sectors.

3.3.1. Multi-sector regulation and policy frameworks

Regulation and policy frameworks have a major role in risk mitigation and the enhancing of returns for private investors. This subsection focuses on areas that have a critical impact on attracting private capital to finance projects in more than one of the energy sectors.

Clean energy strategy and energy systems planning

Clear energy goals, targets and strategies provide evidence of a government's long-term commitment to the energy transition and serve as critical signals to attract investment. Pre-announced project pipelines provide visibility of such government commitment to investors and facilitate the bundling of projects across regions within countries and, over time, across neighbouring countries. Nationally determined contributions (NDCs) and other emission goals (notably relating to air quality) provide a foundation for emission reductions. While a number of EMDEs have set targets around emission reductions and energy access, strategic plans do not always provide clear pathways to meet sustainability goals.

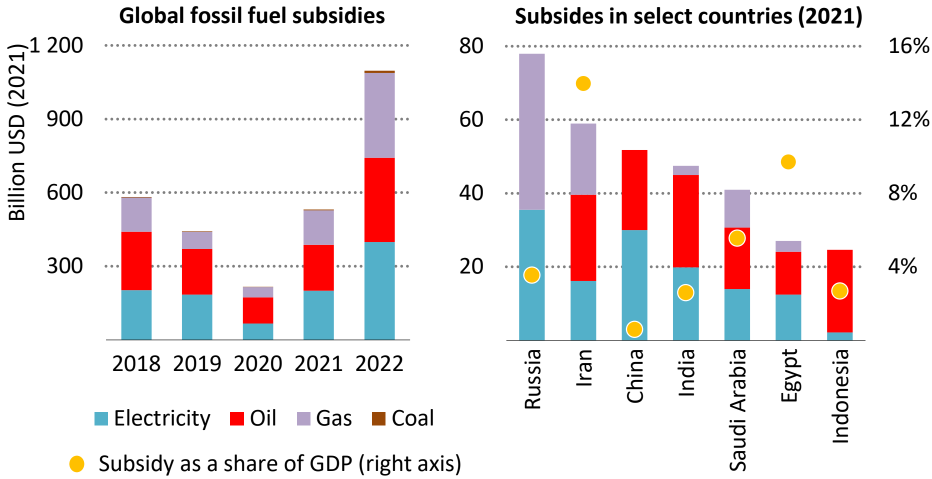
Emission goals are backed by varying degrees of sectoral ambition. Renewable power targets are much more common than those pertaining to harder-to-abate sectors in industry and transport. At a regional level, 85% of the countries in sub-Saharan Africa have set renewable power targets (quantified and included in their NDCs), 45% in Asia and nearly 70% in the Middle East and North Africa, compared with about 30% having set renewable energy targets for heat and transport (IRENA, 2020).

Strong leadership and buy-in to sustainable energy goals are crucial, but the capacity to implement these targets is equally important. An integrated action plan that includes supply- and demand-side elements needs to be designed, and resources assigned. These also need to be embedded in other policies (e.g. national development plans or renewable energy actions plans) and consistent with sector planning, such as long-term planning for enabling infrastructure to integrate renewable power or setting buildings codes that include energy savings. These efforts need to be accompanied by stakeholder engagement at all stages, and a strong focus on enforcement and compliance, as well as the ability to review and refine the approach over time.

Fossil fuel and electricity consumption subsidies

Fossil fuel consumption subsidies (including subsidies for fossil fuel use for electricity) have long been deployed in countries seeking to make energy affordable and protect consumers from price fluctuations. However, such subsidies have tended to be poorly targeted and fiscally costly. They are environmentally damaging because they discourage energy saving and lower returns on alternative clean energy investments. Despite some progress in reducing fossil fuel and electricity end-use subsidies, policy-induced price distortions remain in place in many countries (Figure 3.4).

Figure 3.4 ▹ Fossil fuel subsidies by fuel and country



Rising energy prices have contributed to rising fossil fuel subsidies, and in some countries such as Iran and Egypt, they constitute a large share of GDP

Source: IEA (2023b).

On the back of lower oil prices and efforts by some governments to implement more cost-reflective energy pricing, these subsidies were reduced during the second half of the decade to 2020 in some EMDE countries such as Ecuador, Indonesia, and Mexico. While there have been some examples of countries where fossil fuel subsidies have been gradually reduced or better targeted (such as Egypt, India and Tunisia), there have also been cases among EMDEs of policy reversals or postponements, leading to an increase in global fossil fuel subsidies in 2022 and distorted investment incentives, especially in major oil and gas producer economies.

Removing fossil fuel subsidies has proven to be politically complex and prone to setbacks when energy bills rise: in 2022, during the global energy crisis, fossil fuel consumption subsidies rose to USD 1 trillion, the largest value recorded to date (IEA, 2023b). Successful reforms tend to have a clear plan and communication strategy, fairly compensate those who are hit the hardest, provide a “vision” of how change can benefit everyone, and deploy affordable and clean alternatives to ensure continued energy access. Indonesia’s experience illustrates how reforms can be successful, but also short-lived if not accompanied by deep structural changes. In 2014, when crude oil prices were declining, the country embarked on a series of dramatic reforms to fossil fuel subsidies, reallocating resources to the health and education sectors. However, the reforms started unravelling in 2018 when global energy prices rose. It may be more politically sustainable to reallocate the subsidies as direct transfers to former beneficiaries, as demonstrated for example by the India’s Direct Benefit Transfer (DBT) scheme.

Carbon pricing

Carbon pricing is the most direct way to internalise the negative externality generated by carbon-related emissions. It can be accomplished either by taxing or by setting a cap on the total greenhouse gases (GHGs) that can be emitted, for the whole economy or for certain sectors. It may be beneficial to provide compensating domestic support to industry or establish international co-ordination to address the risk of substantial capital outflows following implementation. As a tax, proceeds could help compensate for local dislocation and losses.

Implementation of carbon pricing remains relatively rare in EMDEs. South Africa is implementing a phased carbon tax for large emitters. Chile set a carbon tax in 2017 at USD 5/tonne of CO_2 for power plants with a capacity of at least 50 MW and is considering emissions trading (IEA, 2021a). Indonesia is implementing carbon pricing in the power sector and an emissions trading system for coal power plants was due to start in April 2022, but has been delayed. However, as of March 2023, the average carbon price was less than USD 15/tonne of CO_2 for EMDEs, versus more than USD 40 in advanced economies, providing only limited price signals to support climate financing (World Bank, 2023b).

Pricing carbon could help to open a new source of finance for EMDEs. The Paris Agreement provides a framework to trade Internationally Transferred Mitigation Outcomes (ITMOs), where a country which is achieving climate objectives faster than it pledged to in its NDC can sell ITMOs to countries making slower progress (although the negotiations on rules for these carbon markets have yet to be concluded).

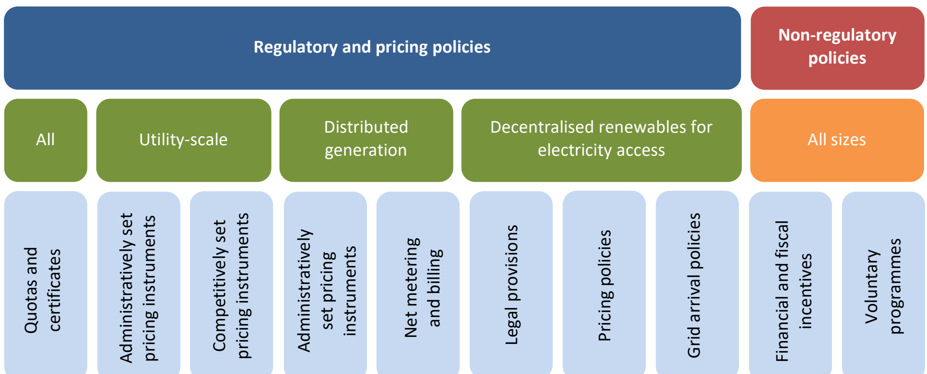
Finance from corporates or countries with net zero pledges, which aim to contribute to carbon reductions outside their direct value chain by financing nature-based solutions or other mitigation activities, may also constitute a new funding source for EMDEs. Other initiatives implicitly putting a price on carbon, such as those in the European Taxonomy or the proposed Carbon Border Adjustment Mechanism, can also influence the availability of finance by guiding capital to markets and sectors with more robust clean transition efforts.

In the absence of institutionalising carbon prices at a sufficiently high level within and across EMDEs, substitute policies will be needed that mimic its impact on relative returns (that boost returns on clean energy projects relative to fossil fuels). These policies will require significant additional resources. Considering the tight fiscal constraints in most EMDEs and the reality that EMDEs as a group are not responsible for most of the global carbon build-up to date, a strong case can be made for most of these resources to be forthcoming from advanced countries. Such resources are needed both to close the gap between private and social returns (that is, as substitutes for carbon taxes), and to address issues of stranded assets and social adjustment costs. Chapter 4 discusses the amount of such concessional resources required to spur private capital to provide the remaining amounts.

3.3.2. Clean electricity generation

In addition to the multi-sector regulation and policy frameworks highlighted in the previous section, a policy framework is needed that supports private investment in clean electricity generation. Key to this are predictable revenue streams, with pricing policies central to the viability of projects. A number of different regulatory measures have been applied in EMDEs to support renewables, including demand creation (targets and obligations/quotas), pricing policies (feed-in tariffs, feed-in premiums and auctions) and non-regulatory policies (financial and fiscal incentives, and voluntary programmes). The most appropriate policy mix will depend on the scale of the generation (utility, distributed or decentralised for energy access), country-specific considerations and technology maturity (Figure 3.5).

Figure 3.5 ▻ Policies in the power sector that can help crowd-in clean energy investment



Appropriate policy support varies according to the scale and usage of renewables

Source: Adapted from IRENA, IEA and REN21 (2018).

While nuclear and carbon capture, utilisation and storage (CCUS) will also play an important role in decarbonising the electricity sector, this section focuses on policies to support private investment in renewable electricity technologies in EMDEs. Given the individual investment costs and the political and security considerations relating to nuclear and CCUS, public financing will need to play a much larger role in those low-carbon power technologies.

Renewable energy targets

A supportive policy environment for clean electricity development starts with clear and ambitious short-, medium- and long-term targets. Targets need to be supported by implementation polices that can help create demand for investment in renewable generation. Renewable energy quotas and obligations provide mandatory and binding targets to those who are assigned to achieve them (usually utilities), but require monitoring and an effective compliance mechanism that includes a system to enforce penalties for non-compliance. Renewable purchase obligations (RPOs) played an important role in establishing India's renewables market, but compliance varies significantly across states. While the poor financial health of some distribution companies has made enforcement challenging, state and central government auctions have driven the growth of India's renewables market in recent years.

Renewable pricing policies for utility-scale and distributed generation

Renewable energy pricing policies are central to enhancing a project's revenue stream. Early development in many markets has relied heavily on the use of feed-in tariffs (FITs). FITs provide investors with visibility on electricity prices and future revenues. However, they can be challenging to set at an appropriate price that is neither too high, leading to excess profits borne by bill payers, nor too low and creating a disincentive to investment. FITs can be used to fix tariffs for both utility-scale and distributed generation. Placing quantity limits on the amount of power to receive a given FIT can help to avoid boom and bust cycles and establish markets for different renewable energy technologies, while keeping costs under control. It also allows for the integration of cost reductions into future FITs or a shift to competitive auctions to facilitate price discovery. Viet Nam's solar FITs created one of the largest solar markets in the world in record time, leading to high curtailment levels due to congestion on the grid and delays to connections. The end of the FIT also saw a drop-off in solar development, highlighting the importance of applying quantity limits to manage costs and provide visibility to investors.

In liberalised electricity markets, feed-in premiums (FIPs) are used to determine prices. Premiums can either be a fixed premium (usually with a price floor and cap to reduce pricing risk and keep costs under control) set above the prevailing market price, or a floating premium where a reference value is set and the premium is determined by the difference between the reference value and the reference market price. Contracts for difference are a variation of a FIP, with the added element that if the wholesale market price is above a certain strike price, generators must return the difference. Administratively set tariffs (either FITs or FIPs) remove much of the pricing risk for investors and can be an effective way to attract investment into new markets or new technologies. FITs and FIPs that are indexed to the USD or EUR protect investors from currency risk and ease access to financing.

As the cost of renewables, particularly solar PV and wind, has fallen sharply, countries have moved to competitive auctions as mechanisms for price discovery. Auctions have typically been combined with other policies to help manage risk. In India, investor concerns around non-payment by highly indebted distribution companies reflected significant offtaker risk, with land access, grid connection and congestion issues creating additional challenges and concerns on project bankability. Solar energy auctions were managed by the government-owned SECI and implemented as solar parks with land and transmission infrastructure provided by the government for a fixed price. PPAs are signed with SECI, which takes the offtaker risk with the distribution companies. Cambodia followed a similar approach to India, with Électricité du Cambodge, Cambodia's state-owned utility, providing land and transmission access and signing long term PPAs with solar developers. With much of the project development risk taken by the government, the auctions implemented in India and Cambodia led to great interest among developers, significant reductions in solar energy costs and record low auction prices.

Revenue and offtake risks can also be managed through the use of financial guarantees to back electricity contracts. DFIs have been actively supporting renewable development, providing technical assistance on auction design, concessional financing and credit-enhancing mechanisms (guarantees) around the world, including in Argentina (Box 3.5).

Net metering and net billing policies can be used to incentivise investment by enhancing returns on distributed generation for self-consumption. Net metering schemes allow owners of distributed generation assets to offset surplus power sold to the grid against future electricity purchases, often eliminating the variable portion of electricity bills. Net billing is similar to net metering, allowing for excess generation to be exported to the grid, but unlike net metering, the selling price is determined at the moment the electricity is exported. Brazil's attractive net metering policies, which permit systems up to 5 MW to sell back surplus power to the grid and allow for banking of credits for up to five years, has enabled such installations to account for 8.4GW or almost 65% of the total grid connected solar capacity in the country. The electricity regulator ANEEL is now seeking to reform the net metering law to reduce the compensation rate and balance the burden between PV and non-PV consumers in maintaining the power grid.

Policies supporting rural electrification and clean cooking

Achieving universal energy access by 2030 (as proposed by SDG 7) will require a combination of supportive regulation and policies, additional funding from public and philanthropic stakeholders and enhanced collaboration with the private sector to accelerate project development. Co-ordinated and targeted national policies will be critical to achieving universal energy access, as will be the provision of international support.

Energy access policies that go beyond the mere provision of connections – to facilitate the productive use of energy – can have wide-ranging benefits that boost economic development in rural and remote areas. In addition, they can also lead to an increase in energy demand that can help offset the high initial investment costs in the provision of access to remote areas in particular. Policies that support business development in agriculture or micro enterprises, and those that provide credit for appliances that reduce manual labour or increase productivity, can facilitate the uptake of energy in newly connected areas. Such measures provide strong signals to business and capital to invest and finance access projects.

Pricing policies to support electricity access in the poorest regions need to provide affordability support for both upfront costs and energy costs, with the eventual goal to ensure that most people are able to afford to pay the full cost of supply by boosting incomes.

Tiered rates for electricity, where the lowest energy consumers pay the lowest price, are a commonly used and administratively clear way to make electricity more affordable to newly connected households in the short term.

Subsidies to help cushion the high upfront cost of connections are used in some African countries such as Kenya and Mozambique, where the initial cost of connecting households to the grid is supported by government subsidy and/or regulation and then recovered through an added fee on electricity bills. Such measures could also be extended to off-grid electricity providers to offer more affordable services to poor households.

Policies should also be designed to target investment in mini-grids and stand-alone systems that are needed for more than half of all the connections required to achieve universal electricity access. Policies including the provision of credit, guarantees and grants for equity can support the development of new business models such as pay-as-you-go (PayGo) business models. PayGo models focus on the provision of energy services (such as lighting and refrigeration). They package equipment and energy together and sell a final service. Such models can be set up as rent-to-own or leasing arrangements and typically include access to finance and to digital payment methods for customers without access to traditional banking services, enabling them to build up a credit history.

Policy frameworks to support switching to clean cooking fuels require a long-term and holistic strategy to overcome various barriers. High upfront costs for stoves and equipment can be prohibitive and fuel purchasing exposes consumers to global fuel price fluctuations and affordability concerns. PayGo models have been adopted by clean cooking companies such as Kopagas, an LPG distributor in Tanzania that has seen rapid sales increases, with Kenya's PayGo Energy and Envirofit Smart Gas achieving similar success.

Scaling up financial flows for modern energy access will require a boost in funding from both national governments and international sources, including concessional finance. Local green banks and micro-finance institutions will require strengthening and development in the poorest countries to be able to create suitable financing vehicles. Development aid could focus on reinforcing or creating rural electrification and clean cooking agencies by providing training and funding for positions within these agencies. Funding the set-up of field offices in rural provinces can also support the uptake of projects among the local population where there is a distrust of centralised efforts.

In addition, DFIs and donors should also ensure that greater shares of limited development assistance are allocated to small island developing states and the least-developed countries, and are designed to support new business models that can overcome affordability and access to finance barriers. This can help to mobilise private capital for investment in clean energy access. DFIs could support the replication of successful models such as PayGo into new countries by helping to share country experience and providing seed capital to local entrepreneurs.

Investment rules and voluntary programmes

A number of investment-related policy barriers exist that increase the risk and/or cost of developing renewable electricity projects. These include local content rules, foreign ownership restrictions and domestic versus international arbitration. Countries will need to carefully evaluate the suitability of local content rules and consider where along the supply chain they should be focused.

Lifting foreign ownership restrictions can make the difference between a project going ahead or not, particularly for highly capital-intensive projects such as offshore wind, where international developers will want to own a controlling stake in projects. Attracting foreign investment in renewables development, particularly for technologies not currently on the market, can bring much needed know-how and experience together with private capital. In the Philippines the lifting of foreign ownership restrictions for renewable electricity projects in late 2022 led to a jump in requests for offshore wind energy service contracts, as the country hopes to kick-start its offshore wind sector.

Arbitration rules are another important policy area determining the international bankability of PPAs. International developers typically require international arbitration to manage the political risk associated with retroactive policy changes and enforcement of contracts. In Viet Nam, domestic arbitration rules apply to PPAs such that international developers have considered them an unmanageable risk and unbankable, as foreign banks were not willing to finance projects without an international arbitration clause.

Market reforms can also facilitate the development of new business models for renewable energy projects, as shown in China where, since late 2021, large commercial and industrial consumers have been exposed to market-based electricity prices. New regulation enables larger consumers to sign clean energy PPAs for new projects developed without subsidies. The government also introduced a new target requiring 50% of all large public buildings and new buildings in industrial parks to have rooftop PV installations, providing an additional push for development (IEA, 2022a).

Voluntary programmes driven by the private sector have also played an important role in supporting the development of renewables globally. The global RE 100 campaign – led by major multinationals committed to sourcing 100% of their electricity consumption from renewables – provides a major incentive for renewable energy developers in EMDEs where these firms operate. With some committing to this target as early as 2025 or 2030, ensuring renewables are available could soon become a requirement for attracting FDI.

While these programmes are typically led by the private sector, governments can support such initiatives with policies that permit and facilitate bilateral (or corporate) PPA contracts and make it economically attractive for self-consumption via net metering or net billing policies. In Morocco, corporate PPAs have led to a boost in onshore wind development, while private sector initiatives such as corporate decarbonisation goals in Brazil have helped to drive renewables development by raising awareness and creating demand.

In markets with a high perceived risk of investing, addressing the key constraints to a country's renewable development can make such investments attractive at scale. This is illustrated by the RenovAr Auctions Programme (see Box 3.5).

Box 3.5 ▻ RenovAr Auctions Programme, Argentina

In early 2016 the government of Argentina called on both the World Bank and IFC to provide advice on the structuring and implementation of a new tender process for its large-scale RenovAr programme. The IFC team provided advice on the overall attractiveness of the programme to private investors and developing bankable project documentation. The World Bank team prepared a guarantee programme to support the financing of RenovAr projects.

RenovAr improved project bankability through the following key features:

- Electricity generated by RenovAr projects given priority on the grid ahead of other sources.
- PPA tariffs in USD, but payable in ARS.
- Provisions to ensure that the lender has to give prior agreement to any amendment or renegotiation of the PPA.
- A pre-funded liquidity and guarantee fund (FODER) to provide payment in case offtaker is not able to pay.
- A dispute resolution mechanism based on international arbitration.
- Compensation triggered by payment default or convertibility/transferability restrictions, in the form of a put option granted by the government and payable out of FODER and with additional backstops from the Ministry of Energy and Mines, the Ministry of Finance and earmarked government securities.
- Optional World Bank guarantees in the event that the abovementioned compensation is not paid or in the event of inconvertibility or non-transferability.

Since its inception, the RenovAr programme has awarded 154 projects representing almost 5 GW of renewables at highly competitive prices. The programme is also providing important lessons to other markets interested in scaling up renewables investment.

The fact that renewable generation is becoming cost-competitive raises the question of whether renewable investment should continue to receive public support. Country circumstances, including regulation, market design and the maturity of renewables development, should determine whether support is warranted. Where regulation to reduce or ban coal and fossil fuel use is absent and in the absence of carbon pricing to integrate negative externalities into investment decisions, continued support for renewables may be warranted.

Sustainable and green finance regulation and taxonomies being adopted in many countries will also create additional incentives for low-carbon electricity development as investors look for projects meeting these criteria. These policies have also made it more difficult for developers to access capital to finance fossil fuel projects. Commitments made by the financial sector to stop financing coal-fired generation have led to numerous delays and cancellation of coal-fired projects, as has financial regulation set by a growing number of countries, including Japan and Korea, to no longer permit the financing of coal. China has announced it would no longer finance coal abroad.

Policies and initiatives supporting the phase-out of coal and other fossil fuels in power

Policies supporting clean electricity should also include commitments to end the use of coal and other fossil fuels in the power sector; these policies enhance the returns on investing in clean energy. They include regulations on the permissible life of new coal and diesel generators and clear time-bound commitments to phase down and out the use of coal and diesel, replacing inefficient and highly polluting units with renewables and zero-carbon sources. Regulation banning new coal-fired plants and the phase-out of inefficient coal and diesel generators, combined with ambitious renewable energy targets, provides a strong signal to the market that a country's power sector is on a path towards net zero.

As of December 2021, 71 countries had made commitments to phase out coal. Most of these commitments were made as part of more ambitious NDCs required under the Paris Agreement and include major coal users such as Botswana, China, India, the Philippines and Viet Nam. In September 2022 Indonesia adopted a regulation on the early retirement of coal power plants and a moratorium on new coal-fired plants after 2030. The power development plan also has a policy to phase out diesel generators and replace the capacity with renewables.

In addition to policies to fully phase out coal, governments can also introduce pricing measures to reduce the level of coal-based generation, repurposing coal plants to provide flexibility services helping balance supply and demand during peak times. Repurposing has the advantage that some elements of the existing plant, such as the grid connection, can continue to be used and some of the workers can continue to be employed, if necessary, with retraining. Where plants are retired early (before the end of their economic lifetime), the site may be converted for other uses, including renewables generation. Both cases entail losses for the incumbent operators/owners of the plants relative to a scenario where plants continue to operate as is (i.e. until voluntarily retired by owners), so will need additional mechanisms to create incentives for owners to undertake the transition, including consideration of co-benefits to investors for implementing a coal phase-out. Financial mechanisms for coal phase-outs are covered in the next chapter.

Greater use of competitive wholesale markets is an efficient market-driven way to displace coal. Rising shares of lower-cost renewables, complemented by dispatchable renewables and batteries in wholesale markets, can facilitate a reduction in the dispatch factor of coal plants, incentivising them to shut down. As demonstrated in Chile, the competition introduced by wholesale markets acts to accelerate renewables penetration and the clean energy transition.

International co-operation, public financial support and well-designed integrated approaches that incorporate the need for a people-centred transition are essential in the move away from unabated coal. The Just Energy Transition Partnerships (JETPs), which have so far been agreed with South Africa, Indonesia and Viet Nam, with discussions for Senegal underway, provide a useful framework for international collaboration.[4] Developed as a G7 initiative, JETPs include a financial commitment from donor countries to help countries finance their low-carbon energy transition. JETP funding will use various mechanisms including grants, concessional loans and risk-sharing instruments to finance and mobilise private capital for the early retirement of coal plants and investment in low-carbon energy technologies, as well as support for reskilling and compensating affected workers and communities. The JETPs are designed to be country led and implemented. The first JETP announced at COP28 in 2021 for South Africa had a financial commitment of USD 8.5 billion followed by commitments for Indonesia of USD 20 billion and for Viet Nam of USD 15.5 billion in 2022. However, so far, only a small proportion of that money has materialised, much of it as World Bank loans not provided on concessional terms.

Another set of countries that are potential candidates for international co-operation and financing are those undergoing a severe macroeconomic or energy crisis and lacking cleaner energy options. For countries that have significant gas-fired capacity but lack the foreign exchange to import gas, building new coal-fired plants may be the least-cost option for them, absent international support. A similar situation may arise when countries face excess energy demand that results in either planned blackouts or a breakdown of networks.

Recognising that the majority of investment for the transition will need to come from the private sector, donors' financial commitments will need to focus on mobilising private capital, de-risking projects and assuring adequate risk-adjusted returns. Funds will also be needed to support just transitions for citizens and communities affected by the transition, providing jobs and economic opportunities. Country investment plans can help to provide strong signals to investors on priority projects; their implementation should be supported by investor dialogue between government, project developers and financial institutions.

3.3.3. Grids and storage

Decarbonising the power sector will depend on the availability of electricity networks to connect new renewable generation with consumers and provide additional system flexibility from energy storage and digitalisation to optimise the supply of clean electricity. Access to

[4] See Adrian et al. (2022), look at this as a deal-making problem and raise the possibility that for some coal-dependent countries the unilateral cost of the transition is likely higher than the unilateral benefits, while the external benefits are so large that it would be in the interest of rich countries to support or pay for the transition of these countries. They further suggest that tapping private finance through blended finance schemes would greatly reduce the public expenditure required to finance the necessary renewable energy scale-up that must accompany the coal phase-down.

grids continues to be a major barrier to investment in renewable generation, and curtailment risk is seen by financiers as one of the greatest risks to the bankability of projects. Governments need to adopt regulation and policies that can help manage this risk by ensuring timely expansion of grids, together with investment in energy storage and advanced metering infrastructure to help integrate growing shares of variable renewables.

Transmission and distribution

A combination of state ownership and strong regulatory oversight shapes most investment in grids. In many countries, private sector participation is not allowed. Even where private actors participate, investor interest has been generally low, except, for example, in some Latin American countries and India's interstate transmission network. With budgetary pressures growing and the need to accelerate investment in the electricity sector, opening up investment in networks to private investors can help to improve network reliability and tap new sources of capital.

A good regulatory and institutional environment is key to being able to raise adequate capital for investment in transmission. If cost recovery and lack of private sector involvement remain structural challenges, development finance can play a big role in helping to finance investment. DFIs are well placed to take on more regulatory and political risk and may have influence in system modernisation efforts. When reforms are put in place to improve cost recovery, private sector financing can play a larger role, particularly for new lines.

A few models have been applied across the world to mobilise private capital in the transmission sector (Table 3.1). These vary in coverage, contract duration, revenue setting and risk allocation. The choice of business model also depends on the country's regulatory capacity, as some models require much stronger implementation. In EMDEs, the build, own, operate and transfer (BOOT) model is one that has been implemented more successfully in various South American countries (largely in Brazil, Chile, Colombia and Peru) and in India for interstate transmission lines.

Table 3.1 ▷ Main business models for privately financed transmission

Business model	Long-term concession	BOOT	Financial ownership	Merchant line	Dedicated line (for IPP)
Description	Private company manages and operates existing assets and expands its area of operation	Private company finances, builds and operates line under long-term contract; transfers later to government	Private company partially finances new line; built and operated by system operator	Private company finances, builds and operates line; revenues from short-term wholesale market	New line evacuates power from IPP to existing grid
Contract duration	Long term (30-50 years) or indefinite	Long term (often 25+ years)	Indefinite; optional system operator buy-back	Indefinite	Same as IPP, unless transferred up front

Contract coverage	All existing and new lines in a country/region	New line (or package of lines)	New line	New line, often HVDC	New line
Revenue/ tariff setting	Regulated revenues, subject to periodic review	Majority of revenues defined by winning bid, for entire duration	Congestion rents or regulated revenue to operator	Wholesale market; price mechanisms (e.g. cap-and-floor)	If line not transferred, revenues part of IPP contract
Examples	Philippines, United Kingdom	Brazil, Chile, India, United Kingdom, Australia, United States	Denmark and Germany	United States and Australia	Globally applied

Notes: HVDC = high-voltage direct current; IPP = independent power producer.
Source: Adapted from IEA (2021c).

The BOOT model can help reduce system costs and mobilise new sources of finance. Investors generally compete by bidding an annual transmission price, subject to a price cap defined by the regulator's expected cost. Evidence from Brazil and Peru shows that winning bids were generally below the estimated cost, with average discounts on the cost estimate of almost 30% in Brazil over the last 20 years and 36% in Peru in 15 tenders between 1998 and 2013 (World Bank, 2017). In India, BOOT developers have also issued non-recourse bonds receiving an AAA credit score and have successfully refinanced their debt.

The concession model has also been applied in a few EMDEs, with varying degrees of success. In the Philippines, a private consortium formed by international and local players has a concession to operate, maintain and expand the transmission sector from 2009 until 2034, while the government retains ownership of the country's transmission assets. Cameroon, Mali and Senegal implemented long-term concessions in sub-Saharan Africa over the past two decades, but these were either terminated earlier than expected or the government regained a majority ownership of the concession (World Bank, 2017).

The power sector reforms in Türkiye illustrate the benefits of combining the strengthening of regulation with pricing policies and utility reform, including unbundling transmission from generation and distribution, and privatisation of distribution to mobilise private investment (Box 3.6).

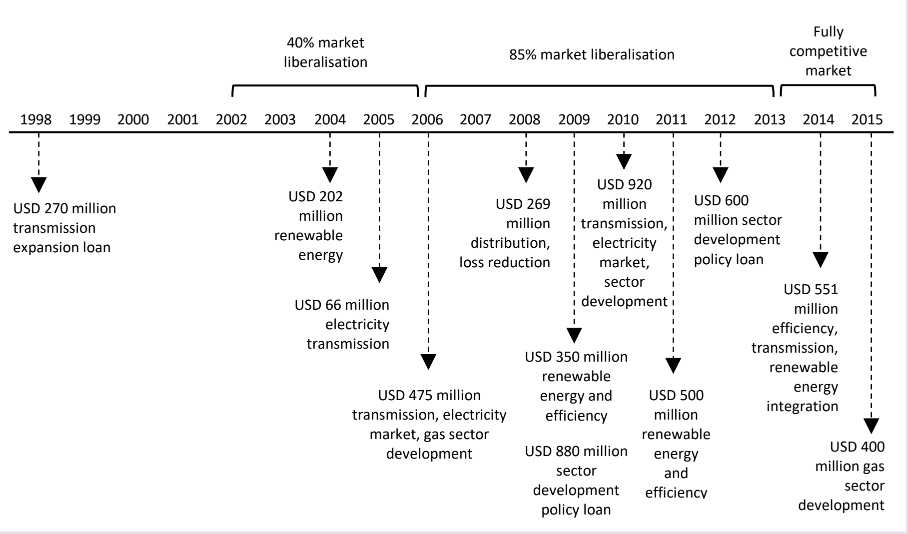
Box 3.6 ▷ Türkiye power sector transformation

The government of Türkiye engaged with the World Bank and IFC to liberalise its power sector and privatise electricity distribution. The goal was to create greater efficiencies, enlarge supply, and lower prices for both consumers and user enterprises across the economy. Leveraging IFC's experience of financing merchant power in deregulated markets, Türkiye unbundled its state-owned utility and introduced a competitive wholesale market. It also implemented additional elements of the standard textbook of liberalisation and regulatory reform, and had a strong competition agency providing input, especially with regard to unbundling. As a result, the number of wholesale actors grew exponentially, making the industry more competitive. Increasing private sector investment in generation without long-term PPAs or large-scale state guarantees allowed energy security to be achieved without jeopardising macro and fiscal balances.

The reforms established a regulatory framework with certain and predictable pricing, clear targets and an independent regulator. The private sector's response to reform has been noteworthy, with around 31 GW of new generation capacity developed with no sovereign guarantees and the successful privatisation of all distribution companies. With the power sector transformed into an open and competitive market, this support has helped to catalyse more than USD 55 billion of private sector investment since 2000 (Figure 3.6).

IFC made considerable investments in both generation and distribution, allocating USD 1.8 billion in debt capital and USD 407 million in equity capital across different power generation companies, as well as USD 150 million in debt for a distribution company. By increasing energy supply, electricity tariffs for end users declined and industrial power use increased.

Figure 3.6 ▷ A timeline of World Bank and IFC-supported reforms and investments in Türkiye's energy sector



Digitalisation

Supporting investment in digital technologies in the electricity sector can provide multiple benefits to the system, for example through the roll-out of smart meters and increased automation in the distribution network via deployment of sensors and monitoring devices.

Greater network digitalisation enhances system flexibility and provides much-needed data and information that can improve the predictability of variable renewable generation, facilitate demand-side management, promote energy efficiency and reduce network losses.

Policies supporting smart grid investment include the development of least-cost system plans, a shift towards integrated planning processes for supply, demand and flexibility, and correct network tariff designs. Performance-based regulation needs to establish adequate pricing regimes that can incentivise smart grid development by valuing the broader benefits of grid modernisation.

To secure smart grid investment, policy makers can develop action plans that: highlight a pipeline of projects and adequately value the broader benefits of power system modernisation; design projects that align with the preferences and capacity of different types of investors; and seek to leverage investment from a broad range of investors, including sovereign-owned entities, DFIs and the private sector. Aggregation models that pool projects on both the demand and supply side of investment can increase the potential mix of investors and help to achieve economies of scale.

A growing number of EMDEs are including smart grid initiatives in their NDCs. By aligning national energy plans and policies more closely with NDCs, smart grid targets and goals can be better integrated into policy to reflect their contributions to climate change mitigation and adaptation. Colombia estimated that without smart grids, reaching its NDC commitment by 2030 would cost an additional USD 42 million per year. Egypt's updated NDC submitted in 2022 included smart grids as an important pillar of its climate strategy, particularly to integrate larger shares of renewable energy generation. In ASEAN, Indonesia, Thailand and the Philippines are also prioritising smart grid development as a way to meet energy and climate goals.

Electricity storage

As the share of variable renewables rises in a power market, so too does the need for system flexibility and the benefits of electricity storage to the grid. Policies to incentivise the deployment of flexibility that can rapidly respond to fluctuations in supply and demand should improve the business case for grid-scale storage. Market rules may also need to be updated to make it easier for storage to provide and be remunerated for the different services it can provide. These range from short-term balancing and operating reserves, ancillary services for grid stability and deferment of network investment, to long-term energy storage and restoring grid operations following a blackout. Updating regulation to allow "value stacking" enables energy storage to maximise revenues by bidding into different markets, also improving the business case for investment. The revenue model for storage in most EMDEs is unclear, making it difficult to attract finance and investment into projects. Suitable financing solutions will vary depending on the different business models used, whether this is around providing ancillary services or as a virtual power plant.

One approach to incentivising investment in storage is to set specific targets based on optimised cost-effective power plans. In Viet Nam, specific pumping and battery storage sites were identified in the National Electricity Development plan for 2021-30, and around 2.4 GW of hydropower stations for storage purposes and 300 MW of battery storage are expected to come online by 2030 (Viet Nam, 2023). Another option is to offer hybrid renewables-plus-storage auctions. In 2022 SECI held such a tender in India, awarding contracts for 2.2 GW (Energy Storage News, 2022).

3.3.4. Low-emission fuels

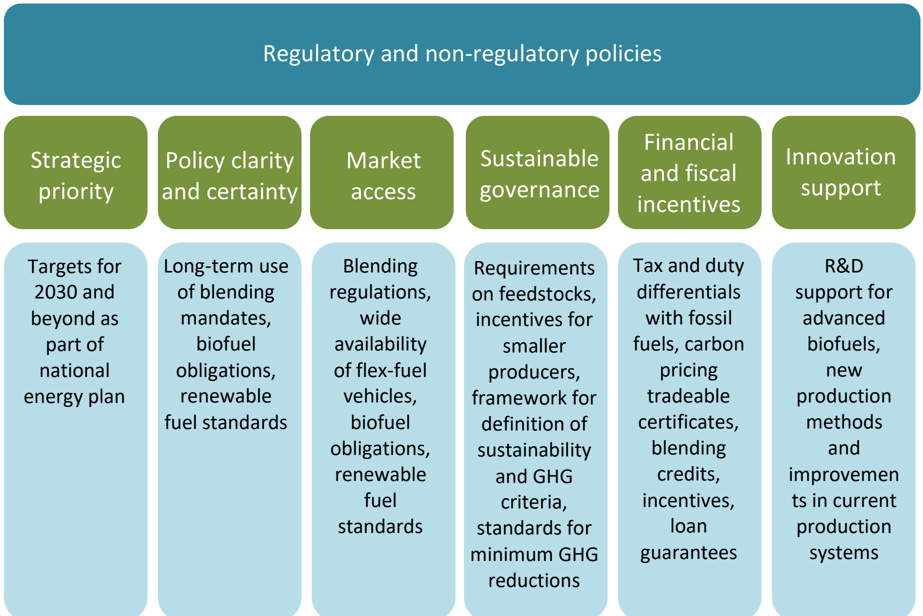
Where the electrification of end uses is not feasible, or in countries with abundant bioenergy resources, the development and use of low-emission fuels can play a notable role in decarbonising the energy sector (Box 3.7). Biofuels and low-carbon hydrogen are the key focus in this section, although natural gas with and without CCUS could also be considered (Box 3.8). The development of standards and certification schemes to ensure sustainable supply chains will be critical for scaling up production of both biofuels and hydrogen, while avoiding potentially harmful environmental, economic and social impacts.

Biofuels

Biofuels are widely used for transport in some EMDEs with abundant bioenergy resources and strong policies (e.g. Brazil, India and Indonesia). The policy blueprint developed by the Biofuels Platform, a Clean Energy Ministerial Initiative, highlights six key areas for biofuel policy development and provides a useful framework for countries to follow in their development of biofuel policies (Figure 3.7). An important part of this framework is sustainability criteria to ensure that only biofuels that meet stringent sustainability requirements receive policy support. Countries must ensure that rigorous sustainability governance is linked to biofuel policy support. Biofuel mandates, low-carbon fuel standards, carbon pricing and financial incentives can help to establish and sustain biofuel demand. Support for innovation and the development of new technologies using waste and residues with CCUS are also needed. Loan guarantees to de-risk projects can help to facilitate financing, and specific biofuel quotas for emerging fuels can provide demand visibility and address revenue risks, improving the bankability of projects.

RenovaBio, one part of Brazil's package of biofuel policies, was designed to support the country's climate commitments under the Paris Agreement and focuses on the promotion and development of biofuels. The policy provides a framework to certify biofuel production according to its efficiency in reducing GHG emissions and allows for the sale and trade of decarbonisation credits (Cbios), helping to increase remuneration for producers enrolled in the programme. Regulation includes criteria to score domestic biofuel producers for their energy and environmental efficiency, defines requirements for the accreditation of certification inspectors and certification of individual plants, and establishes RenovaCalc, an analytical tool to measure a biofuel's carbon intensity score compared to fossil fuels.

Figure 3.7 ⊳ Policy options for the development of biofuels



Source: Biofuture Platform (2022).

India's Roadmap for Ethanol Blending 2020-2025 outlines an annual plan to increase domestic ethanol production in line with its National Policy on Biofuels (2018) and its Ethanol Blended Petrol programme, which aims to reach a blend of 20% ethanol in petrol (E20) by 2025/26. In June 2022 India achieved an average blending rate of 10% ethanol (E10). Key to India's success is the combination of ethanol blending requirements, a guaranteed ethanol price, reduced taxes on ethanol and support to new ethanol production facilities.

Biodiesel blending mandates combined with financial incentives have been the key policy driver in Indonesia, with mandates now reaching 30%. Subsidies are provided to offset the price differential between biodiesel and fossil diesel and are paid for by a levy on palm oil exports. Future increases in the blending mandates will depend on engine performance at higher blending rates. Indonesia's updated NDC includes a target for biofuels to account for 46% of transport energy use by 2050, providing long-term policy visibility.

Low-emission hydrogen

Creating markets and attracting investment for low-emission hydrogen development in EMDEs will require a range of support policies that can address risks around uncertain demand, unclear regulatory frameworks, lack of infrastructure and non-existent or very limited operational experience. While much of the investment in low-emission hydrogen development has been led by advanced economies, activity can also be seen in major emerging economies such as Chile, China, Egypt, India, Oman, Saudi Arabia and the United Arab Emirates. The driver of low-emission hydrogen development in EMDEs varies from developing hydrogen production hubs for export based on low-cost solar and wind, and decarbonising industry and transport, to improving energy security by reducing dependence on imported fuels.

Box 3.7 ▷ Supporting energy transitions in fuel producer economies

Specific challenges face economies that rely heavily on fossil fuels for revenue from exports and taxes, and energy transition planning must account appropriately for them. As demand for fossil fuels falls, they will need to adjust the structure of their economies to diversify away from fossil fuels. This will require capital investment, potentially during a transition period of declining income.

Initial steps that countries can take to diversify revenue include tax reform. For example, Bahrain, Oman, Saudi Arabia and the United Arab Emirates have introduced value added taxes in the past five years to widen the tax base. There are also measures that can be taken to maintain their role in global energy trade as it shifts towards low-emission fuels. International trade in low-emission hydrogen and hydrogen-based fuels from the Middle East reaches almost USD 100 billion by 2050 in the NZE Scenario. While this is significantly smaller than its more than USD 500 billion of oil and gas export revenues today, it is considerably larger than the fossil fuel revenues the region receives in the NZE Scenario by 2050 and could become a durable source of economic advantage. However, as with the expansion of LNG trade before it, investment in the infrastructure to spur hydrogen trade will also depend on co operation between importers and exporters. Export projects representing over 12 million tonnes of hydrogen globally have already been announced, but rapidly developing bankable projects across complex value chains will require countries to work together on clear regulatory incentives, offtake contracts, financing schemes and capacity building.

Countries seeking to support low-emission hydrogen development can tailor their policy packages to the specific roles for hydrogen that they foresee in the near and long term. To establish a common framework for stakeholders, these roles can be enshrined in national energy strategies, complemented with a national hydrogen strategy or roadmap. For example, India launched a National Green Hydrogen Mission (NGHM) in 2021 to communicate the government’s vision and direction for low-emission hydrogen development. The NGHM aims to develop India as a global hub for the manufacture of hydrogen and fuel cell technologies. Approved in early 2022, the NGHM targets by 2030: 5 Mt per year of low-emission hydrogen from electrolysis using renewable power; investment of USD 97.5 billion; creation of 600 000 jobs; reduction in fossil fuel imports of USD 12 billion; and avoidance of 50 Mt of GHG emissions. It also provides USD 2.1 billion in incentives and includes blending mandates for low-emission hydrogen in the refinery and fertiliser sectors to create commercial demand that can substitute today's fossil fuel use for hydrogen production.

Around the world, governments are designing similar packages of policies based on their context and expectations. A key issue is the higher cost of products made with low-emission hydrogen – such as steel, fertiliser and fuel – which necessitates support policies that either create commercial demand for these products or guarantee revenue for producers via government budgets. Government procurement is a measure that both creates demand and supports producers directly, as are coalitions of first-mover industries that commit to a certain level of demand for low-emission products. Carbon pricing, low-carbon fuel mandates and low-carbon material mandates are in place or have been implemented in some advanced economies to stimulate demand by raising the prices of products from traditional fossil fuel-based routes. These measures have the potential to support commercial investment in the supply chain and could even encourage investment in EMDEs for export of low-carbon products to these countries. To guarantee adequate revenue for low-emission hydrogen producers, policies such as tax incentives or auctions for so-called carbon contracts for difference have been proposed. The US Inflation Reduction Act is an example of the use of tax incentives and Germany's H2Global scheme is an example of the latter. Notably, H2Global, launched in 2021, seeks to support production in EMDEs for export to the European Union, underpinned by ten-year contracts that bridge the gap between production costs and users' willingness to pay. A similar concept is under development by the European Commission.

In addition to economic market support, other actions can build investor support and help EMDEs generate value from low-emission hydrogen value chains. These include international collaboration on potential import-export infrastructure and harmonising standards (for equipment, safety and certifying emission intensities). Public support for R&D and demonstration projects in new areas can help countries to compete in markets for equipment and components, which are set to become engines of economic growth. For example, to reach the EU goal of 20 Mt H_2/year by 2030, half via imports, it is estimated that nearly half of the total capital investment of USD 700-850 billion would need to be in assets in exporting countries (IEA, 2022b).

Box 3.8 ▹ CCUS policy development in EMDEs

Increasing the deployment of CCUS can help some EMDEs achieve their sustainability goals while enabling cleaner productive use from their existing carbon-based assets. The average age of China's coal-fired power generation fleet is only 13 years, Indonesia's is 12 years and Viet Nam's is just 8 years. Policies and measures supporting investment to retrofit these facilities with carbon capture will be needed to decarbonise the power sector.

In many EMDEs, the lack of a clear legal and regulatory framework for CCUS can deter the necessary investment. Such frameworks serve multiple objectives, with the foremost being to ensure safe, secure and permanent CO_2 storage in deep geological formations. CCUS laws and regulations must also ensure the protection of the environment and public health, clarify the rights and responsibilities of CCUS stakeholders, and provide a legal foundation for the development, operation and long-term management of CO_2 storage resources. Importantly, effective regulation of CCUS activities can help to build public confidence in, and acceptance of, the technology.

Indonesia has made significant progress in building the necessary tools to facilitate CCUS investment to meet its net zero goal by 2060. It has gained early experience through the Gundih Pilot Project and has demonstrated strategic interest in CCUS through the launch of the Institut Teknologi Bandung Centre of Excellence for CCS and CCU in 2017 and the early development of several planned commercial CCUS projects. To facilitate the deployment of CCUS, the Ministry of Energy and Mineral Resources introduced a regulatory framework for CCUS in March 2023, the first of its kind in the region. The framework relies on the holders of oil and gas leases to spearhead CO_2 storage development and operation. The framework also includes a transfer mechanism whereby the government assumes long-term monitoring, stewardship and liability following the approval of site closure.

Identifying CO_2 storage resources is another important enabling factor. The first atlas on geological storage resources in South Africa was published in 2010. Prepared by the Council of Geosciences and the Petroleum Agency of South Africa, it covers depleted oil and gas reservoirs, unextractable coal seams and deep saline aquifers. The agencies used existing data from seismic surveys and historic drill cores to estimate the on- and offshore storage potential of each resource type. The Atlas on Geological Storage of Carbon Dioxide in South Africa estimates the theoretical capacity of South Africa's storage resources to be around 150 Gt, with more than 98% of that capacity located offshore.

Multilateral finance institutions have played a key role in supporting the development of CCUS-enabling environments in EMDEs through trust funds. The World Bank CCS Trust Fund, funded by the United Kingdom and Norway, which is set to close in 2023, has allocated nearly USD 55 million to CCUS programmes in more than ten EMDEs.

3.3.5. Energy efficiency and end-use sectors

Energy efficiency and transformations in the use of energy among the major end-use sectors – namely industry, transport and buildings – are critical to the decarbonisation of economies everywhere. This is especially true in the case of EMDEs, as they have been witnessing more rapid increases in industrial production, transport demand, construction of new buildings, uptake of appliances and other economic activities relevant to end-use energy demand. Beyond emissions, policies that address energy use at an economy-wide level have a critical role to play in the pursuit of other desirable outcomes such as lower costs, higher productivity, competitiveness and growth, improved air quality and a reduced fossil fuel import bill (Filippini et al., 2020). Policies to promote energy efficiency, circular economy material and energy savings and reuse are good candidates for front-loading as part of national strategies.

Energy efficiency forms a core pillar of emission reductions by reducing energy use in existing and new activities (Figure 3.8). Some EMDEs have economy-wide energy efficiency mandates that have helped reduce their emission intensity per unit of GDP. For example, India has in place a National Mission for Enhanced Energy Efficiency (NMEEE) that is implemented by the Bureau of Energy Efficiency, as well as Energy Efficiency Services Limited, a public sector company established to scale up market interventions. Under this broad mission, there are energy efficiency programmes in industry, appliances, buildings, lighting and transport. Through the NMEEE and developments in technology and markets, India's total final energy consumption per unit of GDP has improved at a rate faster than the global average, as well as among EMDEs.

This section takes a closer look at the various policy options available in major end-use sectors in EMDEs to help align them with the long-term net zero trajectory.

Buildings

Climate objectives covering the built environment can be achieved through a combination of regulations (building codes) and financial incentives. However, in many countries national building codes and their enforcement are not strong enough to promote the necessary transition. Many cities have more aggressive building codes and standards than the national averages but cannot enforce them effectively (OECD, 2022). With well-enforced regulations to improve energy efficiency and strong enough financial incentives, decarbonisation in buildings can be achieved through decentralised support schemes.

A suite of policy options can help unlock private sector investment in the buildings segment by providing policy clarity and financial incentives, as well as by reducing existing barriers that are risks to investors. As an overarching measure, building codes that are aligned with long-term net zero and national decarbonisation targets provide the necessary signals to the industry to invest into supply chains for low-carbon alternatives in buildings, as well as innovative options to promote their uptake. For example, in 2019 Australia agreed to implement a Trajectory for Low Energy Buildings that sets a pathway to zero emissions and carbon-ready buildings in the country.

Policies that provide financial incentives and promote innovation for the uptake of clean energy technologies in buildings include tax breaks, tax credits and low-interest loans. They should promote the role of distribution companies in enabling individual choices, and select policies that support the emergence of energy service companies, which can encourage energy efficiency through innovative business models.

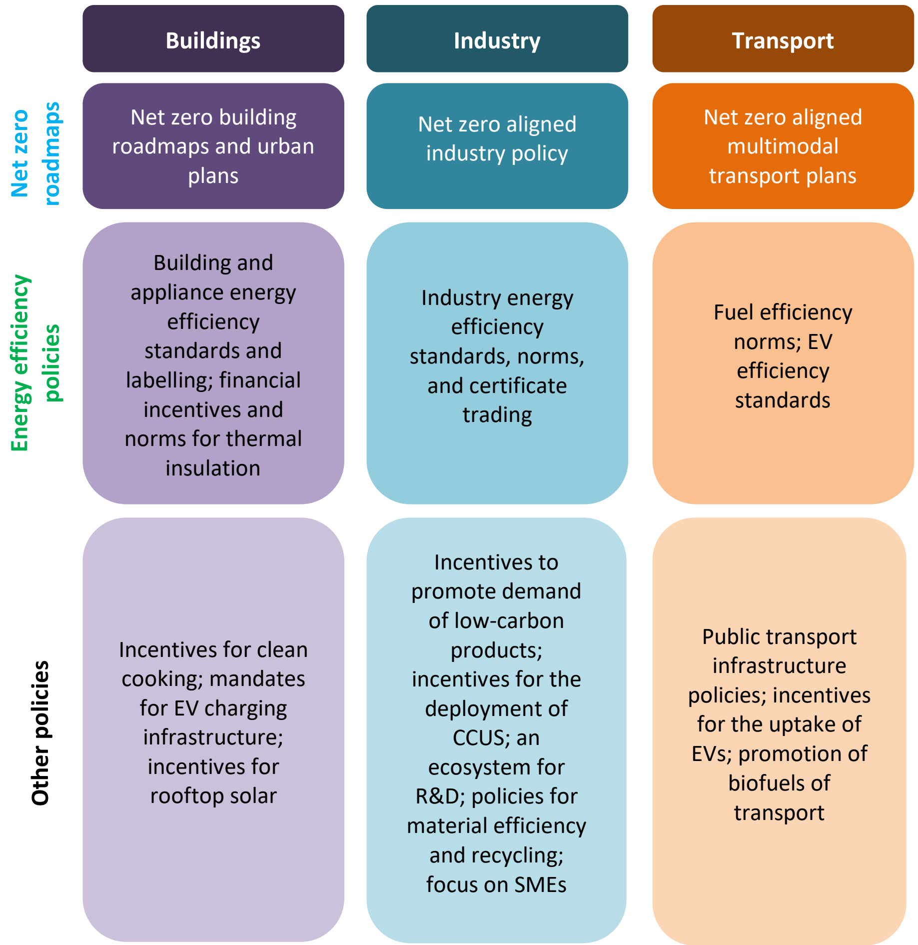
Building codes that incorporate complementary decarbonisation technologies, such as solar rooftops and electric vehicle charging, can further crowd in investment into clean power generation and transport. For example, the 2019 Building Energy Efficiency Standards in California (United States) require solar panels to be fitted to new single-family homes and low-rise apartment buildings in the state.

With rising temperature variability and extreme weather events, policy frameworks and strategies that address emerging cooling and heating needs provide vital signals for the creation of an ecosystem of players to address these concerns. For many EMDEs, cooling is a key concern due to their geographical and meteorological characteristics. Some EMDEs have therefore laid out national strategies in this regard. For example, Rwanda's National Cooling Strategy of 2019 identifies priority interventions to address the country's growing cooling demand (IEA, 2020). The strategy is aligned with Rwanda's longer-term decarbonisation pathway. It includes minimum energy performance standards, labelling and other measures that encourage the deployment of energy-efficient cooling. In addition, mandates and innovative programmes can promote the uptake of building envelope technologies, such as insulation materials and other thermal comfort options, in new construction as well as retrofits in existing buildings. For example, in the state of Telangana (India), under the Cool Roof Policy, certifications are given to qualifying buildings only if they incorporate insulation layers in the roof. Furthermore, bulk procurement of energy-efficient appliances can provide the necessary signals to manufacturers and consumers to choose energy efficient cooling and heating.

The role of subnational governments is critical in the buildings sector as the implementation and deployment of these measures largely happens under their domain. It is therefore vital for subnational building codes to align themselves with national plans. Capacity building at the subnational level is an important aspect that is often overlooked. National and international initiatives on training and capacity building are needed to ensure that the most efficient technologies, practices and methods are deployed, leading to enhanced private investment in buildings sector decarbonisation.

Energy use for cooking has both access and sustainability dimensions. As EMDEs pursue universal access to clean cooking, the immediate focus is rightly on the most affordable alternatives to traditional biomass cookstoves, including improved biomass cookstoves and LPG. EMDEs can also promote the uptake of high-efficiency and low-emission electric cooking options, including induction cookstoves, in those regions with adequate and stable electricity supply. This can be achieved through targeted subsidies to households without access and the improvement of supply chains and reliability of power supply.

Figure 3.8 ▷ Policies to promote clean energy deployment in end-use sectors



Notes: CCUS = carbon capture, utilisation and storage; R&D = research and development; SMEs = small and medium-sized enterprises; EV = electric vehicle.

Industry

In the absence of sustainable industrialisation policies, low-cost energy sources and technologies – that are often carbon-intensive – have dominated the growth of industry in EMDEs. As countries now pursue long-term decarbonisation goals, policies to align industry with a low-carbon pathway can provide the momentum towards greater clean energy investment in industry.

Industry sector roadmaps that are aligned with national decarbonisation aspirations lay the overarching framework beneath which more specific regulation can be enacted. As industrial transformations are often capital-intensive and require big ticket investments, policy certainty behind long-term sustainability targets helps industry participants factor increased costs into their long-term strategies. A level playing field for the industry also assuages concerns relating to market competition among companies. Industry roadmaps promote not only energy efficiency and renewable energy capacity in industry, but also electrification of processes and the adoption of clean fuels such as low-carbon hydrogen and biofuels. The political economy of industrial decarbonisation can be tricky, however, and can derail implementation of these strategies unless they are carefully designed with these considerations in mind.

Policy and fiscal support for low-carbon products are particularly vital, and send the appropriate signals needed to attract private sector investment, especially where they are accompanied by appropriate frameworks for transition finance that channel funding towards companies with credible, robust emission-reduction plans. Innovative proposals for incentivising such production in advanced economies include carbon contracts for difference for the steel industry in Germany (Agora Industry, FutureCamp and Wuppertal Institute, 2023). Under such contracts, governments can support investment in and the operation of a low-carbon manufacturing plant by covering part of the incremental costs of production due to the cleaner processes.

Industry-specific policies that promote the uptake of carbon capture in new facilities as well as retrofits in high-emission industries can provide the long-term signals needed for CCUS technologies. Measures include the provision of capital grants, tax incentives, linkages with emission trading schemes, and the public procurement of low-carbon industrial products. While carbon capture is likely to have a relatively small role in reducing EMDE emissions over the coming decade, it will have a larger role in the following decades as these technologies mature. Appropriate incentives at an early stage can orient the industry towards investment in R&D and pilots.

Policies that promote the circular economy and material efficiency can help avoid emissions and also create new supply chains, attracting fresh private sector investment. Investments in the reuse of materials and the minimisation of waste aligned with circular economy principles require public support, as market mechanisms alone do not result in sufficient investment. They also require a change in individual consumer behaviour and in attitudes towards the reuse of materials and resources. Increased investment will require a combination of regulation, information and incentives, supported by adequate public and private resources. Policies include the provision of concessional finance for recycling projects, limitations and taxes on landfill, mandates for waste separation, and product take-back legislation that can help improve the quality of scrap feedstock. Take-back systems that hold manufacturers responsible for the collection and disposal of products discarded by their consumers are in place in advanced economies such as Germany. China has an e-waste recycling scheme in place that has led to the emergence of e-waste recycling companies that separate significant quantities of scrap from waste televisions, air conditioners, washing machines and other appliances (OECD, 2014).

The creation of a market for carbon emissions and energy efficiency can provide the necessary signals and incentives to existing industries to reduce their emissions and energy use, while also rewarding overachievers. For example, India's Perform, Achieve, Trade (PAT) scheme has led to a thriving energy efficiency trading market. Under the PAT scheme, energy-intensive industries are identified as Designated Consumers (DCs). These DCs in turn have to file energy consumption returns every year and conduct mandatory audits. The Bureau of Energy Efficiency, the implementing agency, sets sector-wide energy efficiency targets, and then these DCs are able to trade Energy Savings Certificates among one another, underachievers purchasing certificates from overachievers. The first cycle of the PAT scheme between 2012 and 2015 managed to reduce the energy consumption of more than 400 DCs by over 5% (IEA, 2021d). There have been at least seven subsequent cycles of PAT, cumulatively leading to claimed energy savings of around 30 Mtoe since the start of the scheme (PIB, 2022). For reference, India's industrial sector (including sectors that are not covered under PAT) has been consuming energy at an average of about 300 Mtoe over the past five years.

In addition to sector-specific policies, the industrial and trade policies of EMDEs should be aligned to international benchmarks that can help unlock additional exports to countries and regions where carbon border adjustments are expected to be implemented. Industrial policies should also target small and medium enterprises (SMEs), which are far more numerous and do not always have the necessary capacity and technical capability to pursue large-scale transformations. With the appropriate incentives and resources, SMEs can be nudged towards increased clean energy investment.

Transport

In the absence of adequate investment into low-carbon options such as public, shared, electric and non-motorised transport, privately owned internal combustion engine (ICE) vehicles have become the default option for commuters in EMDEs. Policies that seek to decarbonise transport must incorporate multiple desirable objectives to increase the acceptability and impact of proposed measures.

The reliance on private road vehicles is also a feature of the built environment that necessitates long travel times, while making public transport infrastructure infeasible due to the lack of density. As a result, modern transport is not inclusive and accessible, especially in low and lower-middle income countries. As incomes rise, the demand for private ICE-based mobility would grow at a similar pace, unless more efficient and cleaner alternatives are made available.

As EMDEs are witness to rapidly growing demand for built spaces and increased urbanisation, there is a strong need for integrated transport and urban planning. An integrated approach can help reduce transport demand and promote non-motorised transport, especially with a focus on mixed-use neighbourhoods and innovative concepts such as "10-minute cities", where the daily needs of residents can be met by facilities and infrastructure within walking distance. Further, building codes that mandate EV charging in new dwellings and new and existing commercial properties can help support individual decisions to opt for EVs. In Italy, non-residential buildings over 500 m^2 or buildings with more than 10 residential units have been required to install EV charging facilities since 2018 (IEA, 2019).

Transport infrastructure policies that prioritise the safety of non-motorised transport, and also expand public transport, can enable shifts to low-carbon modes. They can also provide the incentives for local governments and consumers to invest in micro- and shared mobility. Some EMDEs have benefited from a recent infrastructure push for modern urban light rail systems. In South Asia, for example, metro systems are in operation and now expanding in Dhaka in Bangladesh, in Lahore in Pakistan, and in 15 Indian cities (with construction ongoing in 7 other cities). In India's case, the Metro Rail Policy of 2017 has most recently laid out criteria for cities to be eligible for such an urban transport system. Cities with at least 2 million residents and a Comprehensive Mobility Plan are eligible to start planning metro rail infrastructure. This has led to the crowding-in of infrastructure investment by international banks and private investors, and has also led to the growth of a manufacturing industry largely enabled by private capital.

Alongside public and non-motorised transport, road vehicles will also need to be decarbonised. A suite of policy options include support for technology switching, efficiency and biofuels. Mandates and targets for the uptake of EVs and other low-emission vehicles can help drive growth. For example, China's New Electric Vehicle credit mandate of 2017 has driven EV sales by setting targets for manufacturers as a percentage of their annual vehicle sales. For consumers, supporting subsidies and tax incentives can encourage investment into such vehicles. These subsidies can be designed to meet the inclusive development needs of specific EMDEs, with for example a larger focus on two- or three-wheeler EVs that target lower-income consumers.

Financing mechanisms that allow consumers to spread the higher capital costs of EVs over time, such as subsidised consumer credit lines or EV (or battery) leasing models, are likely to be more cost-effective and scalable in many EMDEs (Briceno-Garmendia, Qiao and Foster, 2022). India, for instance, offers a publicly subsidised first-loss partial credit guarantee to financial institutions to unlock commercial financing at concessional rates for the purchase of two- and three-wheeler EVs. China, India, Thailand and increasingly countries in Africa are offering battery-as-a-service (BaaS) business models where the purchase of the battery – the costliest EV component – is decoupled from the vehicle with a combination of battery leasing and swapping to reduce the upfront EV cost. More generally, mobility-as-a-service (MaaS) business models, with leasing, per-trip payment or monthly subscriptions for users, provide a practical way to shift the burden of higher capital costs to firms with potentially easier access to credit, such as EV buses in Chile where the utility becomes the asset owner and investor that leases buses to operators.

Another major source of transport sector emissions is related to road freight. A multi-modal freight transport plan that targets interoperability and a growing modal shift towards low-carbon options including rail and shipping could encourage investment in these modes. For example, India's Gati Shakti National Master Plan for Multi-Modal Connectivity, launched in 2021, envisages seamless connectivity of various modes and integration with industrial clusters and centres of demand (PIB, 2021). With an objective to facilitate efficiency in transport, the policy can potentially crowd-in private investment into multi-modal logistical parks and transport infrastructure.

As for road trucks themselves, increasingly stringent corporate average fuel economy (CAFE) norms can help reduce energy demand from ICE vehicles, especially among freight trucks that are likely to be slower to transition to clean energy technologies. Clearly stated and increasingly stringent CAFE norms send the necessary signals to manufacturers to invest in clean energy technologies in their vehicle range. Relatedly, innovative programmes to accelerate the deployment of biofuels, biomethane, hydrogen and other relatively cleaner energy options for the decarbonisation of road freight vehicles can put EMDEs on a longer pathway towards decarbonising trucks.

3.4. Regulation and policies to address cross-border issues and supply chain challenges

3.4.1. Cross-border issues and regional integration

While clean energy efforts are typically centred on individual countries and their subnational jurisdictions, regional multi-country projects can sometimes offer more cost-effective solutions for achieving energy transitions. Especially for the power transition, countries may have complementary resources where the investment case is improved by linkages to neighbouring markets, either because of market size or because of system reliability, for example linking a solar- or wind-rich market with one that has ample hydropower. This may require co-ordinated multi-country investment in power generation, networks and storage. In addition, the efficient production of hydropower in a downstream country may depend on the location and sizing of hydropower facilities and other river uses (such as agricultural irrigation) further upstream in other countries. It may also depend on investment to prevent deforestation, soil runoff and silting, which reduces the size of reservoirs, the intensity of river flow and the efficiency of turbines.

Additional regulation and policy action beyond the national level are required to make valuable multi-country clean energy projects attractive to private investors. Well-established and functioning multi-country jurisdictions, such as the European Union, provide examples of what may be required. Any multi-country project is intensive in governance, including the ability to convene, inform, communicate, convince, co-ordinate, plan and efficiently execute the multiple activities involved in a large-scale multi-country project while ensuring that the affected populations across countries have a real stake in the project. Additional enforcement powers will often be required to ensure that all participating countries fulfil their pledges. There is also a need to harmonise certain technical standards and to converge on common regulations and norms, although these should not be regarded as first-order obstacles.

Box 3.9 ▹ The Zambezi watercourse and the Southern Africa power hub

The Zambezi River is a critical power generation endowment – in addition to supplying many other services – to the population of a number of Southern Africa countries. It has suffered from deforestation, leading to a loss of water volume and the runoff of sediments, affecting the efficiency and maintenance costs of hydroelectric turbines. It remains a critical natural asset for the supply power to the subregion: the Zambezi has the potential to produce over 20 000 MW of electricity, of which only 23% has been developed, supplying electricity to riparian and neighbouring countries through the Southern African Power Pool.

Despite the importance of moving forward with hydro projects to respond to the power demand of the subregion and help South Africa to switch away from coal, progress has been slow. ZAMCOM, the Zambezi Watercourse Commission, was established in 2014 as an intergovernmental organisation to promote the utilisation of the water resources of the Zambezi as well as its efficient management and sustainable development. ZAMCOM brings together eight countries that share the basin: Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe. Supporting the development of hydropower projects appears to go beyond the mandate of ZAMCOM.

The initial policy action needed to move forward is a multi-country technical assistance cost–benefit study to bring more confidence to the presumption that the levelised cost of hydro is lower than the equivalent for wind/solar, and that the associated multiple benefits that hydro could bring are higher – to each country and to the region, with a particular emphasis on Mozambique as supplier and South Africa as offtaker. If one or more large hydro projects in the Zambezi pass the test, then the key is a financially sound offtaker, so that the contract(s) it signs with new power suppliers may be used to raise finance to build the hydro facility and the new North–South high-voltage transmission lines. Clearly the restructuring, capitalisation and overall reorganisation of ESKOM is a necessary condition to get this regional project off the ground.

DFIs can play a pivotal role in providing impetus and resources, as well as support for appropriate governance structures, to move the most relevant and urgent of these multi-country projects forward.[5] The river basin countries of the Zambezi in Southern Africa and the power markets across selected Central and South Asian countries provide illustrations of the potentially high impact of putting the required additional regulation and policy frameworks in place (Box 3.9 and 3.10).

Box 3.10 ▹ Central Asia-South Asia electricity and transmission project

Interregional cooperation can expand renewable energy access and deliver substantial benefits to regional power grids. The Central Asia-South Asia electricity and transmission project (CASA-1000) seeks to bring 1 300 MW of hydro-produced electricity from Central Asia to high-demand electricity markets in South Asia. Summer rainfall and significant water flow from the mountains contribute to producing surplus electricity in the Kyrgyz Republic and Tajikistan during the summer months. By building over 1 300 km of transmission lines and associated infrastructure, CASA-1000 is facilitating the export of this energy to Afghanistan and Pakistan, two South Asian countries contending with chronic electricity shortages, especially during the sweltering summer months.

The project involves upgrading the power grid complex, building new substations and installing a high-voltage transmission line for an estimated cost of around USD 1.2 billion. To facilitate the decision-making process, the four countries established an inter-governmental council tasked with agreeing on costs, rates and procedures. To ensure viability and timely delivery, the project was divided into ten contracts that were each competitively tendered and financed by a consortium of international development institutions. The last of the tenders has been completed recently and electricity is slated to start flowing in the near future. The complex financing structure may serve as a template for other large-scale public-private partnerships. Besides part of the financing, the World Bank Group has provided policy and regulatory support to facilitate cross-border energy trade and investment.

3.4.2. Overcoming supply chain challenges

The energy transition in EMDEs and elsewhere is threatened by high market concentration, both in specific products and geographic areas. This encompasses the extraction of natural resources, the production of materials and fuels, and the manufacturing of components and assembly. Dominance of individual countries in the production of inputs weakens the resilience of clean energy supply chains. Against the background of geopolitical tensions that have led to an increase in trade restrictions, the reliable procurement of raw materials and

[5] As recent examples of the involvement of DFIs in supporting cross-border trading, IFC together with the ADB and the EBRD invested in a joint venture between India's Tata Power and Norway's Clean Energy to construct and operate the Shuakhevi hydropower plant in Georgia in 2015. In addition to satisfying Georgia's demand, it will foster cross-border electricity trading by exporting power to Türkiye through a transmission line financed by the EBRD. IFC also invested in Nepalese hydropower plants that are now exporting surplus electricity to India.

intermediate products remains critical for the private sector, and policies to overcome supply chain challenges remain key for businesses and policy makers.

China has been at the centre of global supply and demand for renewable energy, leading it to account for about 40% of capacity growth from 2015 to 2020, followed by Europe, the United States and India. The four markets together accounted for 80% of global capacity growth during the period and are projected to further increase that share between 2021 and 2026.

China has been instrumental in lowering the global cost of solar PV by scaling up significant investment in solar PV manufacturing capacity. Since 2011 China has invested over USD 50 billion in new PV supply capacity, becoming a leader in energy transition investment. China's share of all manufacturing stages of solar panels exceeds 75% today, and for key elements such as wafers this is more than 95%. This rapidly increasing investment in PV manufacturing capacity has reshaped global supply chains (IEA, 2022c).

China has also grown to dominate the downstream segments of other critical clean energy supply chains, such as EV batteries and hydrogen fuel cells. With substantial backing from the Chinese government, Contemporary Amperex Technology Co. Limited (CATL) has transformed from a business with a few employees manufacturing iPod batteries to the world's largest producer of EV batteries. Increased geographical concentration of global supply chains allowed China's producers to "ride down" learning curves and exploit economies of scale and scope, including agglomeration. But it poses geopolitical challenges and makes supply chains less resilient and potentially less competitive. Hundreds of factories across the country are producing millions of EV batteries for both the domestic market and foreign carmakers like BMW, Volkswagen and Tesla. China's share of the market for lithium-ion batteries could be as high as 80% (IEA, 2023c).

Clean hydrogen can substantially decarbonise hard-to-abate sectors, such as heavy industry and long-haul transport. Regions are expected to significantly differ in terms of cost-competitiveness and potential demand. The mismatch between the most cost-effective production locations and the demand centres implies that realising these potential benefits hinges on developing nascent clean-hydrogen value chains. Critical infrastructure to enable cross-border trade is lacking, and investment is needed in terminals, large-scale storage for hydrogen, hydrogen carriers, conversion technologies and refuelling station networks. Partnerships could allow equipment and infrastructure developers to make the necessary investments with minimum utilisation guarantees.

In recent years, EMDEs have also sought to provide the policy signals necessary for expansion in these sectors; however, they have not been as expansive in scope and as specifically targeted as the Inflation Reduction Act and the Bipartisan Infrastructure Law of the United States. Nonetheless, some EMDEs have made important first steps that they could build upon in the future. For example, in 2021 Brazil announced a policy to support new investment in strategic minerals production, specifically targeting those minerals that are critical to high-technology sectors. In the same year, Brazil declared certain minerals as being in the strategic interest of the country, including cobalt, lithium and others that are critical to clean energy production. In the future, targeted support such as dedicated tax and financial incentives for the sector could help crowd-in further investment.

Similarly, South Africa introduced a Targeted Critical Minerals and Metals List in 2022, which includes critical minerals and metals that are "essential for responding to the shift towards the green economy, low carbon energy, and digitisation among others" (IEA, 2022d). The South African government also has a business development agency that provides direct funding for mining projects (IEA, 2022e).

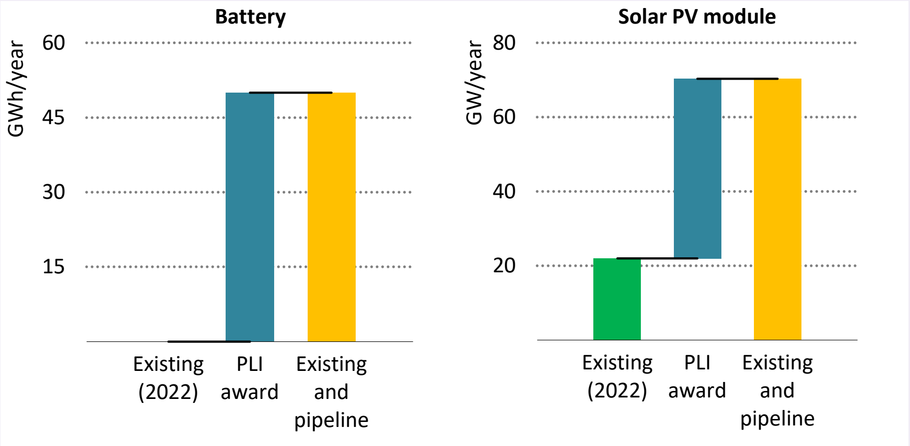
Other EMDEs seeking to establish and grow their clean energy technology manufacturing capacity will need to work on a range of reforms and measures, including the provision of skills, the simplification of permitting and other regulations, and in some cases even budgetary support towards new capacity. India has gone down this route with a new policy that subsidises greenfield manufacturing of products that are integral to clean energy transitions, such as batteries and solar PV modules (Box 3.11).

Box 3.11 ▷ India's policies to build a clean energy manufacturing base

India has been relying on imports to meet its requirements for clean energy equipment and materials. In 2021/22 India's annual import bill for lithium-ion stood at USD 1.8 billion, and for solar cells (both assembled into panels and unassembled) an additional USD 3.4 billion. In 2020 the government of India announced the Production Linked Incentives (PLI) scheme to promote domestic manufacturing in certain strategic sectors. The scheme provides qualifying companies with subsidies to help establish new manufacturing capacity in identified sectors, including solar PV modules, advanced chemistry cell battery storage, and the automobile and automobile component sectors, which include EVs.

As a part of this scheme, the Indian government selected four companies in 2022 that together propose to establish 50 GWh per year of battery manufacturing capacity. These companies are expected to commence manufacturing within two years, and the incentives budgeted at USD 2.2 billion will then be passed on to the companies for the next five years. For solar PV, the government has budgeted USD 2.4 billion to target 65 GW per year of new manufacturing capacity, which is three times existing capacity. These manufacturing units are also required to source 20% of their electricity from renewable sources. Of the target of 65 GW per year, two tranches with a cumulative capacity of 48.3 MW had been awarded by March 2023, and are targeted to be operational by 2026.

Figure 3.9 ▷ India's existing and pipeline battery and solar PV module manufacturing capacity under the PLI scheme



Financial incentives under the PLI scheme target an exponential increase in battery and solar PV manufacturing capacity in India

Note: Pipeline capacity under the PLI scheme is targeted to come online in 2-3 years
Source: IEA analysis; PIB (2022); PIB (2023)

In recent years, Viet Nam has proven to be a success story in solar PV manufacturing. The country has attracted broad-based investment into manufacturing in sectors including clean energy, steadily raising the share of manufacturing in its GDP and exports. Viet Nam scaled up its solar PV module manufacturing capacity fourfold in the past five years to reach 35 GW per year. The country is now the world's second largest solar crystalline silicon module producer behind China. This has been enabled by competitive labour costs, political stability, ongoing economic reforms and regulatory openness to foreign direct investment, particularly for high-technology sectors. A suite of new laws encourages private investment, including the Securities Law, which seeks to remove foreign ownership limits on investment in most industries, the Investment Law, which facilitates private sector financing of such projects, and the Public Private Partnership Law, which seeks to increase linkages between foreign investors and Viet Nam's private sector players.

Continued multilateral collaboration is critical to minimising supply chain disruption, lowering trade costs and creating a conducive cross-border business environment that allows for long-term investment in clean energy. Infrastructure investment in EMDEs, such as in ports and other transport infrastructure, is central to supporting regional integration, lowering import costs and increasing the competitiveness of exporters.

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Financial instruments

Blended finance, new instruments, and platforms

SUMMARY

- "Blended finance" is a combination of concessional funds from donors and commercial funds from private investors and development finance institutions. It is used to enable investment in projects that have high development impact but are not yet commercially viable, such as those with high upfront costs or involving adoption of new technologies that have not yet scaled up. Concessional funds are deployed to provide partial guarantees or subordinated debt or equity, cover some project development costs, or create performance-based incentives for project sponsors to meet targets.
- We estimate that as much as USD 83-101 billion of concessional finance may be needed annually until 2035 to facilitate USD 1.2-1.6 trillion of private finance, as part of the USD 2.2-2.8 trillion total investment needs in the NZE Scenario.
- In addition to (or in combination with) blended finance, new financial instruments and platforms are needed to mobilise private capital at scale. Green, social, sustainable and sustainability-linked (GSSS) bonds have the potential to attract more private climate financing into EMDEs. However, issuances remain low relative to the USD 1.2-1.6 trillion of private finance needed: in 2022 roughly USD 136 billion of GSSS bonds were issued by EMDEs, with China accounting for about half. Further growth of the market depends on developing industry guidelines, harmonised taxonomies, and robust third-party certification.
- Project aggregation platforms and securitisation vehicles can overcome the asymmetry between the relatively small size of most energy transition projects in EMDEs and the relatively large minimum investment size that major institutional investors require. These platforms can pool large numbers of smaller projects and thereby create standardised investment-grade multi-asset portfolios, reducing transaction costs, diversifying risk and attracting interest from institutional investors.
- Voluntary carbon markets have the potential to channel more resources into clean energy investment in EMDEs, but need strong oversight to grow from today's low base. Carbon credits linked to real, verifiable emission reductions could be a valuable revenue stream for EMDEs, but there is still much work to be done on standards and monitoring, reporting, and verification processes.
- Deepening local capital markets and financial systems is necessary to scale up domestic private investment in the clean energy transition. Domestic private investment - rather than foreign capital - has been a major source of investment in the clean energy transition in some countries, such as China and India. Developing domestic bond, equity and derivatives markets (e.g. currency swaps) can enable local funding of EMDE climate projects where revenue streams are typically denominated in local currency.

4.1. Introduction

Successful clean energy transitions in emerging market and developing economies (EMDEs) will depend on a significant increase in funding from the private sector. As shown in Chapter 2, achieving net zero emissions by 2050 will require as much as USD 1.2 trillion of private finance per year from 2026 to 2030, rising to USD 1.6 trillion annually from 2031 to 2035. However, as discussed in Chapter 3, there are many challenges to scaling up private capital for clean energy projects. The good news is that innovative climate finance instruments and approaches, including blended finance, have emerged to address some of these hindrances. This chapter presents a set of feasible and complementary tools for different cases and country circumstances.

4.2. Concessional finance to attract private capital: How much is needed and where?

4.2.1. What is blended finance?

Blended finance involves combining concessional funds from donors and philanthropic sources with commercial funds from private investors and development finance institutions (DFIs) to de-risk high-impact projects in priority areas such as climate, thereby expanding the pool of bankable activities and crowding-in private investment[1]. Its long-term objective is to achieve commercial sustainability with concessional support reducing over time. Box 4.1 showcases examples where blended finance was deployed to back projects that were subsequently able to lessen their dependence on concessional support.

Box 4.1 ▹ Blended finance-supported projects achieving commercial sustainability

Sustainable energy finance in Türkiye: Four credit lines (the first three with blended finance co-investments) were provided to financial intermediaries in support of energy efficiency and renewable energy lending in Türkiye. The provision of blended finance encouraged the intermediaries to enter a new market that they previously perceived as too risky. Over time, the level of concessional funding gradually declined as the financial institutions benefiting from blended finance support learnt how to operate in this sector and the market grew. In the 2010 fiscal year, the first two credit lines had implied concessional funding of 7.2% and 5.5% of project cost respectively. In the 2013 fiscal year,

[1] This definition differs from the OECD definition of blended finance: "the strategic use of development finance for the mobilisation of additional finance towards sustainable development in developing countries", where the DFIs' own-account co-investments to projects supported by blended finance are considered to be blended finance resources.

a credit line to another financial institution had concessional funding of 1.7%. The following year, a new credit line was provided without the need for any blended finance.

Solar PV in Thailand: In 2011, the Solar Power Company Group received blended finance loans for the construction of two 6 MW plants. At the time there were only 2 MW of installed solar PV capacity in Thailand. After the demonstration of proof-of-concept, the company was able to rapidly expand and by the end of 2015 it had reached 260 MW of solar PV capacity in operation. Soon after the first blended finance-supported investment took off, Thailand's solar market saw significant growth without the need for DFI financing or blended finance.

Wind in Jamaica: In 2014 IFC provided a blended finance loan to BMR Wind, the first wind-based independent power producer to be funded privately in Jamaica, with 36 MW of capacity. This helped the project to attract debt financing from other lenders at terms that allowed the project to achieve viability at the proposed tariff. The successful track record of this project encouraged the government to issue a second round of renewable energy tenders, which attracted significant interest and received responses from numerous private developers. In 2015 another 37 MW solar project was competitively tendered and awarded, at a lower tariff than BMR Wind. By late 2021, building on BMR Wind's commercial success, sponsors were able to raise financing from local commercial banks on such attractive terms that they could refinance the IFC concessional blended finance loan. Three other Caribbean nations have seen Jamaica's success and issued similar requests for proposals.

The crowd-in effect of blended finance is best illustrated by its "leverage",[2] defined as the ratio of commercial financing (from DFIs, sponsors and private financiers) to the amount of concessional funds. Based on IFC's experience, USD 1 of concessional donor funding has leveraged on average nearly USD 7 of additional finance, comprising USD 3-4 of IFC own funds and USD 3-4 of commercial third-party capital from private sponsors and investors.[3] Similarly, a recent study estimated that co-financing syndicated lending can mobilise about USD 7 of bank credit for each USD 1 provided by multilateral development banks (MDBs) (Broccolini et al., 2021).

For climate transactions, the ratio tends to be higher (USD 1 to USD 10), comprising USD 3 of IFC's own funds and USD 7 of commercial third-party capital. This is due to relatively large project finance structures (using senior and mezzanine debt products) and significant

[2] While one can think of this also as "mobilisation", we avoid the use of that term as it may imply a causal relationship between the use of the concessional funds and commercial funds that are invested in the same transaction. Instead, the term "leverage" focuses more generally on the flows of concessional and commercial funds into a transaction.

[3] The third-party capital includes the sponsor's equity contributions, as well as financing from other co-lenders and parallel lenders, such as other DFIs and private commercial banks.

deployment in middle-income countries that are able to crowd-in more commercial finance due to their generally lower country risk.

4.2.2. Concessional finance needs in the NZE Scenario

Effective policy actions, regulatory frameworks and public sector interventions are critical prerequisites for increasing the pool of potentially viable climate projects that can take off with minimal use of concessional resources. Although the scarcity of concessional resources to blend remains a key constraint, a more pressing issue is the lack of projects in EMDEs that are on the cusp of commercial viability. As discussed in Chapter 3, shoring up this pipeline requires sector-wide reforms and the strengthening of key institutions, such as utilities, before blended finance can intervene to mitigate remaining risks. Furthermore, the quantum of concessional finance required would be highly dependent on whether domestic policies provide incentives to direct capital towards clean energy investments. For instance, supportive policies such as removal of fossil fuel subsidies, adoption of carbon taxes, regulatory steps to facilitate the adoption of electric vehicles and taxes on hydrogen produced using fossil fuels that make low-emission hydrogen more competitive would generate greater momentum for blended finance to leverage private capital on a larger scale with the same amount of concessional resources.

Following the definition of blended finance presented earlier, this section estimates the concessional finance required to support the USD 1.2-1.6 trillion of annual private investment necessary in EMDEs to reach Net Zero Emissions by 2050 (NZE) Scenario goals. The estimates exclude blended finance needs for investments that are public, using public funds from governments and public entities such as state-owned enterprises (SOEs) (USD 975 billion to 1.2 trillion per year). The analysis derives the concessional finance needs by multiplying the estimates of total private finance need by the estimated share of private finance that would require blended finance, based on historical IFC experience and expected technological and market developments. [4] These are divided by estimated leverage ratios based on historical experience for mature technologies and expected market and technology developments for nascent ones over time. The calculations are done separately for each region, sector and time period (2026-2030 and 2031-2035), as presented in Chapter 2.

In all cases, only sectors and regions that would demonstrate a strong rationale for the use of concessional resources are included, which means that only a subset of the USD 1.2-1.6 trillion of private investment needs would require blended finance, and that different degrees of support will be needed depending on the geographical markets and sectors. For instance, in many middle-income countries, commercial scale solar and onshore wind projects are viable without subsidy. In contrast, technologies that are newer and present more uncertainty in their commercial viability, such as low-emission hydrogen, e-mobility or distributed generation with batteries would require blended finance. In low-income

[4] Across all EMDEs, historically approximately 10-12% of IFC investments have received blended finance support.

countries that face high macroeconomic and political risk, even mature sectors such as renewable power generation may require blended finance support. In this analysis, we find that Africa may have the highest share of blended finance needs.

The development of alternative clean fuels (e.g. low-emission hydrogen, ammonia and bioenergy) and storage would require more blended finance given the sector's current state of development. While transmission and distribution are one of the key bottlenecks in attracting private investment to clean energy transitions in EMDEs, most of the investment in them is expected to come from public sources since utilities are often SOEs. However, due to risk of deliberate reductions in output to balance supply and demand of electricity (i.e. curtailment risk) as well as a lack of transmission capacity, private renewable generators or industrial offtakers are increasingly incentivised to build their own transmission lines. We therefore assume that private investment (and blended finance support) in transmission and distribution would increase moderately in the second half of the forecast period (2031-2035).

Table 4.1 ⊳ Blended finance to support private sector finance under the NZE Scenario for 2026-2030 and 2031-2035

USD billion per year	Total annual clean energy investment (2026-2030) – (2031-2035)	Private finance (% of total, period average 2026-2035)	Concessional funds to crowd in private finance (2026-2030) – (2031-2035)
Total (EMDEs excluding China)	1370 – 1857	61%	83-101
By sub-sector			
Low-emission power generation, grids and storage	836-1079	43%	44-53
Energy efficiency and end uses	416-609	81%	29-36
Low-emission fuels and CCUS	118-169	78%	10-12
By region			
India	263-355	60%	12-15
Middle East	202-318	42%	4
Europe and Eurasia	188-232	57%	6-7
Latin America	243-332	73%	13-15
ASEAN	185-244	67%	7-9
Africa	203-265	66%	37-46
Other Asia	85-112	53%	4-5

Notes: These figures cover only the concessional finance that mobilises private capital. They do not cover other potential needs for concessional funding, e.g., to SOEs that rely on public financing and exclude concessional finance for China, where domestic finance is available.
CCUS = carbon capture, utilisation and storage; the higher bound represents estimates over the period 2031-2035; the lower bound indicates the period 2026-2030.
Source: IFC estimates based on IEA NZE Scenario investment requirements.

The amount of blended finance needed also requires assumptions regarding the expected cost trajectories for new climate technologies in EMDEs (i.e. whether the cost of batteries, low- emission hydrogen or carbon capture would come down sufficiently in the next ten years to compete with alternatives without subsidies). We choose a conservative approach to estimating the cost reduction of these nascent technologies over the next decade, and hence the analysis considers strong and sustained blended finance support up to 2035. This also takes into account competition from OECD markets, where current policies provide substantial subsidies for climate investment and may attract substantial private investment capital flows that could have gone to EMDEs.

Based on these assumptions, it is estimated that up to USD 83 billion of concessional finance could be needed annually to support private sources of finance in the NZE Scenario until 2030, stepping up further to approximately USD 101 billion per year in 2031-2035 (Table 4.1).

At present, the concessional funds available and deployed by DFIs fall far short of these NZE Scenario ambitions. The DFI Blended Concessional Finance Working Group (comprising 23 participating DFIs, including IFC) has reported that USD 1 billion of new concessional finance was committed to private sector transactions during 2021 for climate finance projects (IFC, 2023).

The current scarcity of concessional funds is a critical issue. In addition to climate, other emerging development challenges, such as food security, inflation and resurgent conflicts, are making it more challenging to secure already limited concessional funds and direct them to where they are needed most. Concerted efforts to work with existing donors and seek new providers of concessional finance will be key to meeting these needs. In addition, selecting instruments and structures that use the minimum amount of concessional funds needed to crowd-in private capital will be critical (see section 4.2.5 for a guiding framework for implementers of blended finance).

4.2.3. Blended finance instruments

In structuring blended finance projects, the choice of instruments is closely aligned with the rationale for using concessional funds, reflecting the project-specific investment risks or market failures. This helps ensure the minimum concessional funding necessary to achieve the desired outcome is used (IFC, 2021). Various blended finance instruments can address common constraints and increase the flow of private capital into EMDE climate projects by rebalancing the risk return profile of investments or providing behavioural incentives for clients to redirect capital to developmentally desirable outcomes such as clean energy transitions (Table 4.2). Common blended finance instruments include the following:

Table 4.2 ▹ Blended finance instruments

Instrument	Details
Concessional loan	Concessional senior loan, priced below market; or subordinated loan in liquidation and/or in payments to all senior lenders, also priced concessionally.
Guarantee	* First loss cover, up to an agreed maximum amount. Can be protected as a (funded or unfunded) guarantee on a single loan, or as a pooled first-loss guarantee on a portfolio of loans. * Particularly in the context of power generation projects, liquidity support guarantee can be provided on a revolving standby letter of credit (LC), that can be drawn by the project company if the offtaker fails to honour its payment obligation.
Concessional equity	"Lower-priced" equity with a lower internal rate of return to offer affordable equity funding; or subordinated equity with cash waterfall (distribution of all proceeds including exit and dividends according to a waterfall).
Investment grant[5]	* Performance-based incentive (PBI): rebates to provide incentives and disincentives to achieve desired outcomes or results (e.g. tie at least a portion of payments to achievement and aim to reward innovation and successful implementation). * Viability gap funding (VGF): capital grant provided up to certain percentage of total investment costs for projects that are not commercially viable yet due to long gestation period.
Bond investment	Instrument similar to a loan, can be traded privately or publicly, offshore or onshore. Can be used with PBIs.
Local currency support	Concessional funds to provide fully or partially subsidised currency hedge; or concessional loan with a subsidised spread (or with a swap-cost buydown) to absorb the high cost of currency hedge.

Blended finance instruments to support the clean energy transition specifically target two sets of barriers, with choice of instruments depending on project-specific risks, country context and sectoral dynamics:

- Country-specific barriers to mobilising private sector investment related to country-level risk, regulation and the policy environment.
- Sector-specific barriers to channelling capital flows to clean energy transitions, such as investment risks in disruptive technologies, retrofitting carbon-intensive assets and supporting new sustainable finance vehicles.

All of the blended finance structures can be used to address risks caused by factors endemic to EMDEs, such as uncertainty about the economic outlook, political stability, regulation, the enforceability of contracts, the credit profile of local enterprises, and weak security coverage. Blended finance can also mitigate mismatches between local currency receivables and the

[5] We note that while essential to the sustainability of transactions, grants for technical assistance/capacity building are not included in this table as they are not part of the DFI definition of blended concessional finance being used throughout this report.

currency of financing (which could include USD and other hard currencies) and the related costs of foreign exchange hedging instruments and foreign-exchange swaps. Traditional swap markets are also important (Box 4.2).

Box 4.2 ⊳ Case study: The Currency Exchange Fund

The Currency Exchange Fund (TCX) is a development finance initiative and global currency hedging facility that supports MDBs and other development financiers to remove currency risk from loans to private and public sector borrowers in low- and low-middle-income countries. The fund is supported by investment from the governments of the Netherlands, France, the United Kingdom, Switzerland and Germany, as well as the European Commission. It is also backed by impact investors and development institutions such as IFC, both for its own account and as implementing entity of the International Development Association (IDA) Private Sector Window (PSW). This has increased TCX's hedging capacity, allowing it to offer more long-term hedging products in IDA PSW eligible countries. Since 2007 TCX has hedged over 6 000 transactions in more than 100 EMDE currencies, exceeding USD 12 billion in markets where there are no commercial alternatives.

TCX offers cross-currency swaps, operating on principles that require it to act where markets are thin or absent, hedging only actual underlying exposures to the real economy, and with risk-reflective pricing. The latter is essential to mobilise international private capital for frontier market currencies. Cross-currency swaps ensure that debt service is indexed to the local exchange rate, protecting local borrowers against sudden macroeconomic or climate events that cause currency volatility.

The combination of funding costs, credit margin and swap rates can at times lead to unaffordable financing costs in low-income, high-risk countries. To improve the affordability of local currency financing, TCX has worked with the European Commission and other donors on an innovative blending approach to make hedging more accessible. An example is the Energy Poverty Reduction Facility, which aims to mobilise EUR 1.2-1.5 billion in affordable (indexed) local currency finance for small to medium-sized distributed energy investments in Africa in the next three years.

Because TCX pools the currency risk it takes in support of the cross-border lending activities of its shareholders, it can achieve diversification and scale that none of the development financiers can accomplish on their own. Its business model and theory of change have been tested by five global financial crises. TCX has been increasingly able to catalyse private sector currency risk markets, thus maximising the leverage of its public sector capital. Expanding TCX could be a significant step toward mitigating foreign exchange risk at scale and expand local currency financing for low-income countries. This would facilitate channelling cross-border funding from foreign currency investors into local currency financing for climate-focused projects in EMDEs and improve debt sustainability.

In addition to addressing country-level investment barriers, blended finance can enable private investment in new or unproven technologies and innovations, or in retrofitting existing systems before the end of their asset life. The solutions to these challenges entail encouraging investors to take on technology risks, bear higher upfront costs, and change behaviours to accelerate the flow of capital towards green transitions that would otherwise not meet the NZE Scenario timeline.

The return expectations of donors and other contributors of concessional resources can determine the risk absorption capacity of blended finance instruments. Blended finance can be structured as either capital-preserving (returnable capital) or flexible capital solutions. To support emerging climate technologies that involve market adoption or proof-of-concept risks, blended finance can be provided through capital-consuming, flexible instruments (e.g. grant-based, or deeply concessionally priced facilities), where donors do not expect a return from the principal invested.[6] These tend to have greater leverage and higher crowd-in power, as they have more capacity and appetite to bear risk. For instance, a senior loan priced at an expected loss, even though it may be concessional, may not be as effective as VGF in buying down the capital costs of newer technologies, such as low-carbon hydrogen or battery storage. In the past, blended finance of this type has successfully supported driving down the cost of climate technologies such as grid-connected solar PV and onshore wind projects in emerging markets.

Examples of suitable structures for these types of constraints include concessionally-priced loans, or equity investment with lower return expectations through waterfall subordination and longer investment horizons ("concessional equity"), where the investment risks are only partially priced. Other relevant structures include VGF or investment grants, highly effective in partially offsetting the high upfront capital costs associated with expensive technologies in climate investments, such as green hydrogen, battery storage, carbon capture, and energy efficiency. In addition, PBIs encourage investors to deploy funds where they will have the biggest developmental impact, in this case to activities supporting climate transitions in EMDEs. For instance, PBIs can be provided to local banks that commit to expanding loan portfolios to climate-related assets, or towards corporate entities that make investment in the low-carbon transition of their high-emission assets on an accelerated timeline. Furthermore, instruments like a first-loss guarantee can improve the viability of new green finance products such as climate-risk insurance for SMEs. Blended finance can also co-invest in emerging sustainable finance vehicles such as green bonds or climate-focused private equity funds, and support cross-currency swap buy-downs.

Although the capital-preserving instruments may be less effective in supporting new or expensive technologies and facilitating behaviour shifts, their advantage is the ability to redeploy the funds to new projects. For such instruments, the contributors of the

[6] These are blended finance instruments that do not have pre-set return expectations or requirements, and allow capital depletion. Examples include investment grants, interest rate buydown, PBIs and VGFs. Other financial instruments such as loans, guarantees and equity investments can qualify if there is no minimum pricing requirement and/or capital protection or return expectation.

concessional resources expect reflows or reutilisation of the principal, interest and other amounts, providing some protection of the capital invested at the portfolio level, and in some cases a small undefined return. Examples of multi-donor funds to mobilise investments in climate are presented in Box 4.3.

Box 4.3 ▷ Multi-donor climate funds: Opportunities and challenges

Several climate funds have been established as public-private partnerships (PPPs) to catalyse climate investment in EMDEs (Prasad et al., 2022). Notable examples include the Green Climate Fund (GCF), the Climate Investment Funds (CIF) and the Global Energy Alliance for People and Planet (GEAPP). These funds have the potential to mobilise significant volumes of private sector climate investment and have effectively worked with DFIs to provide blending solutions. Potential challenges to be considered include fragmentation, slow disbursement and low accreditation rates, due to prolonged and complex processes.

GCF, the world's largest climate fund, was created in 2010 under the UNFCCC framework at COP15 in Copenhagen, with the objective of mobilising USD 100 billion per year by 2020. The GCF receives contributions from advanced economies in the form of grants, loans and capital, as well as from the private sector and other sources. The fund quickly raised USD 8.3 billion during its original resource mobilisation period in 2014. It secured more than USD 10 billion from 34 contributors in the fund's first replenishment (2020-2023) as of September 2021, with another USD 1 billion commitment from the United States in April 2023. The GCF stimulates private sector investment through its Private Sector Facility, which provides concessional loans, lines of credit to banks, equity investments, guarantees and first-loss protection, among other financing instruments. During 2015-2020 the GCF co-financed or directly financed climate adaptation and mitigation investments valued at USD 23.4 billion in 117 developing countries.

CIF was launched by global leaders in 2008. It is an USD 8.5 billion multi-donor trust fund that provides support to climate investment in EMDEs. Collaborating with the private sector, governments and six MDBs, CIF offers a platform to pool and leverage financial resources from partners while de-risking investments through concessional financing and other facilities. As of the end of 2020 the fund had channelled over USD 60 billion from its global partners to co-finance green projects. CIF investments cover projects ranging from climate technology and sustainable forests to climate-smart cities and renewable energy integration. In 2021 the G7 committed up to USD 2 billion to increase its climate financing in EMDEs.

GEAPP was created at COP26 in 2021 by the Rockefeller Foundation and its partners, with USD 10 billion of investment. GEAPP's goal is to help catalyse a just energy transition by mobilising public and private capital to reach one billion people with reliable, abundant and clean power across multiple continents. The fund collaborates with different partners to deploy technical assistance, grants and investment capital where they are needed most. Its investment approach drives projects through a process that starts with grant-dependent pilot projects and eventually reaches maturity and a privately funded scale.

Blended finance can provide structural flexibility in tenor and other terms of financing in the case of loans supporting long-term PPPs with cash flow uncertainties. For example, for greenfield projects with uncertain future cash flows and long construction periods, concessional benefits can be given in the form of longer tenors and grace periods, back-ended repayments or a disproportionate disbursement profile (compared to other lenders) to assume greater financial risk and provide comfort to other lenders.

4.2.4. *Clean energy sectors and technologies in greatest need of blended finance*

The use of limited concessional resources should be prioritised for high-risk sectors and technologies where it is most needed to overcome investment barriers and crowd-in private finance.

Mature technologies in high-risk environments: Mature technologies such as solar PV and onshore wind may still need concessional support if deployed in countries with high macroeconomic, political or regulatory risks. For example, a utility-scale renewable power project, considered fully bankable on commercial terms in advanced economies and some middle-income countries, may still require concessional funds in low-income countries or fragile nations (Box 4.4).

Box 4.4 ▹ Project spotlight: Mozambique Mocuba Solar

Investment summary: The Mocuba Solar project involved the development, financing, construction, operation and maintenance of a 40.5 MW solar PV power plant in Mocuba, north-central Mozambique. Upon completion, the project will be the largest solar PV plant in Mozambique. It is located in one of the least developed regions of the country, which was severely affected by recent floods.

Project challenge and economic rationale for blended finance: Mozambique is highly reliant on hydropower for its electricity generation, and the country's Northern, Central and Southern power grids are not interconnected, operating largely as separate systems. The Northern grid, to which the project will be connected, does not directly benefit from recent and planned capacity additions in the Southern grid, despite a significant increase in energy demand. While solar PV is a proven technology in many markets, its application in Mozambique and sub-Saharan Africa is limited due to the lack of a track record for solar independent power producers. As the first utility-scale solar PV plant and one of the first independent power producers in the country, the project presents high perceived investment risk and capital costs.

Blended finance solution: Blended finance support was structured as a concessional senior loan of up to USD 21 million from the CIF, alongside an IFC A-Loan of up to USD 21 million and an IFC B-Loan of up to USD 22 million. The concessional CIF loan helped improve the economic competitiveness of the project so that it could proceed at a competitive tariff in the long run (for solar in Mozambique to reach grid parity with thermal electricity, as the country has large gas and coal reserves).

The project will help reduce climate risk in Mozambique's electricity sector by: (i) reducing its heavy reliance on hydropower, which makes it vulnerable to climate change impacts, and (ii) developing local electricity generation in a remote, climate-sensitive region, thereby reducing dependence on a long-distance transmission system, itself vulnerable to extreme climate events (including the flood in 2015 affecting the transmission line). By demonstrating the viability of utility-scale solar PV in the country and region with blended finance, the project will establish a precedent for other investors and developers in sub-Saharan Africa where climate-resilient infrastructure is needed. Mocuba Solar opens a new chapter in Mozambique's pursuit of low-carbon growth, helping to secure reliable and efficient energy for over 173 000 households in a remote and low-income area in north-central Mozambique.

Distributed generation. Distributed generation, in particular distributed solar PV, has been playing an increasingly important role in EMDEs. Between 2016 and 2022, capital spending in EMDEs' distributed solar grew from USD 20 billion annually to USD 110 billion. While it has benefited from the global reduction in the cost of solar PV modules, other factors such as the balance of system costs can still contribute to distributed solar having a high levelised cost of electricity (LCOE). Furthermore, third-party ownership of distributed generation has seen limited success in EMDE countries due to local regulations regarding ownership and market access (IEA, 2021). As an emerging industry formed by mostly young companies, distributed generation (especially in emerging markets) presents high perceived risks for investors, with the consequent rationale for deploying blended finance.

Battery energy storage systems (BESS). Although BESS technology has been available for more than a decade, its application in developing countries has been limited and it is still considered an emerging technology with high first-mover costs, lack of familiarity with storage technology and economic models among utilities, and unconducive regulatory environments. Blended finance in this case can be deployed with a senior concessional loan or a subordinated loan to allow this technology to compete with thermal-power alternatives. Alternatively, VGF can be considered to bring down capital costs.

Energy efficiency in buildings. The rapid increase in urban populations expected in EMDE countries implies that scaling up investment in green buildings and energy efficiency is crucial. However, the lack of access to affordable financing for developers (which are often SMEs) and perceived higher costs present significant barriers to attracting private capital to green buildings. Individual EMDE investments in buildings usually remain fragmented among small deals and are financed on the balance sheet of the developers, largely with equity. To improve access to finance for green buildings in EMDEs, blended finance can be deployed via a guarantee or risk-sharing structure to the aggregated green loans and mortgages in portfolios.

Sustainable urban infrastructure, including e-mobility solutions. Mobilising private investment in green urban infrastructure has been challenging because subnational governments are sometimes legally restricted from borrowing independently or may not be creditworthy. They often have little experience as long-term offtakers of infrastructure services and may under-charge, partly to ensure citizens' access, but also because it is difficult to increase tariffs before improving the service without additional financial support. They may also not be able to afford innovative climate technologies such as waste-to-energy or electric buses, due to high investment requirements. Blended finance can help address these constraints, increasing the viability of urban infrastructure investments while also enhancing the capacity of subnational entities to transition to commercial funding for future projects. In this setting, blended finance instruments that have been used to assist smaller municipalities and subnational entities include first-loss guarantees, or mezzanine financing to address risks such as the limited track record of a public offtaker. Providing long-term local currency financing along with credit enhancement tools for municipal PPPs has also been crucial in this area, since subnational entities are often mandated only to borrow in local currency.

4.2.5. Principles for deploying blended finance

All projects using concessional funds must include a rigorous assessment of market failures to support the need for temporary subsidies and evaluate the potential for unlocking development impact. The DFI Working Group on Blended Finance agreed in 2017 to a set of blended finance principles (IFC et al., 2017) designed to guide all DFI operations involving blended finance (Box 4.5). These principles help ensure that projects have a clearly defined economic rationale for concessional support, use only the minimum concessional funding required to make a project viable, and have a clear path to graduate from temporary concessional support to reach commercial viability (OECD, s.d.).

Box 4.5 ▹ DFI enhanced principles for blended concessional finance for private sector projects

Rationale for blended concessional finance: Making a contribution that is beyond what is available, or that is otherwise absent from the market without crowding out the private sector.

Crowding-in and minimum concessionality: Helping to catalyse market development and the mobilisation of private sector resources, with concessionality not greater than necessary.

Commercial sustainability: The impact achieved by each operation should be sustainable and contribute towards commercial viability.

Reinforcing markets: Addressing market failures effectively and minimising the risk of market distortion or crowding out private finance.

Promoting high standards: Encouraging adherence to high standards, including in areas of corporate governance, environmental impact, integrity, transparency and disclosure.

Source: IFC et al (2017)

Governance structures and clear decision-making processes are also important, to prevent any potential conflict of interest between the contributors of concessional funds and the implementers of blended finance or other commercial financiers. Strong governance processes must be in place to ensure that the principles are consistently applied, including a separate decision-making body for the allocation of contributors' scarce concessional resources. In addition to the standard due diligence process, blended finance co-investments may require additional review processes and assessments, with a primary focus on assessing the rationale for blended finance and the appropriateness of the proposed level of concessional funding (IFC, s.d.) in each investment. Transparency in the use of subsidies is also crucial.

4.3. Innovative financial instruments to expand climate finance in EMDEs

Mobilising private finance to support the clean energy transition will require the expansion of existing and the launching of new financial instruments, as well as innovations in establishing efficient platforms and partnerships.[7] This section describes these initiatives in more detail.

[7] Avenues beyond the issuance of new debt include the "greening" of debt restructuring through debt-for-climate or debt-for-nature swaps, enabling countries whose debt is unsustainable to direct capital towards green and sustainable investment.

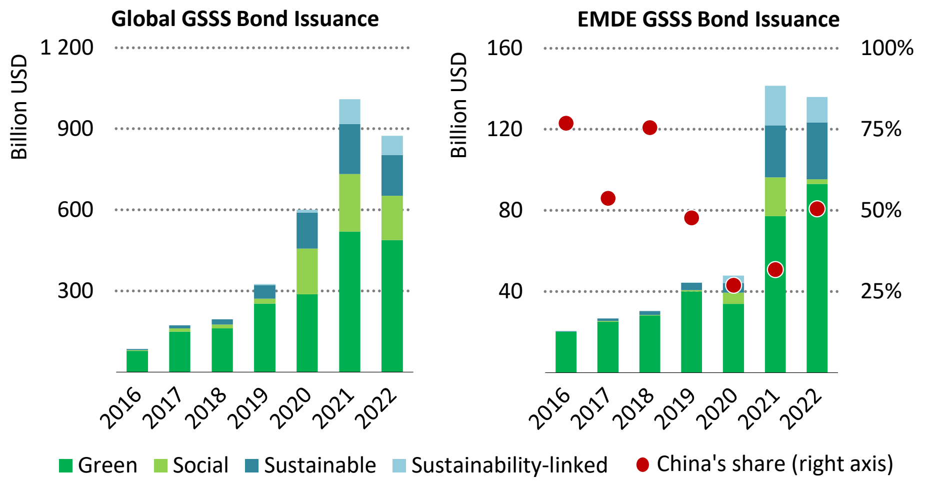
4.3.1. Green, social, sustainable and sustainability-linked bonds and loans

Market growth through to 2022

4

Innovation in financial instruments has helped accelerate global momentum behind green and sustainable investment over the past decade. Much of this has come in the form of green, social, sustainable and sustainability-linked (GSSS) bonds, which raised a cumulative USD 3.3 trillion from 2013 to 2022 (left panel in Figure 4.2).[8] GSSS issuance in EMDEs has grown rapidly, having tripled from USD 48 billion in 2020 to USD 141 billion in 2021. It remained almost as high in 2022 at USD 136 billion, or 16% of the global total (right panel in Figure 4.2). China was by far the largest issuer among EMDEs, accounting for 45% of cumulative EMDE issuance.[9]

Figure 4.1 ▹ Annual global GSSS bond issuance and annual EMDE GSSS bond issuance, 2016-2022



Green, social, sustainable and sustainability-linked (GSSS) bonds are on the rise

Source: Amundi (2022).

[8] Transition finance instruments aim to finance the transition to a low-carbon economy, with recommended disclosures from the International Capital Markets Association (ICMA) on the issuer's climate transition strategy and governance, the environmental materiality of its business model, whether the climate transition strategy is science-based and includes targets, and the transparency of implementation. Few labelled instruments have been marked with the transition label.

[9] For the purposes of this report, Chinese green bonds are defined as those with terms aligned with international standards as defined by the Climate Bonds Initiative.

Overall EMDE issuance eased in 2022, mainly due to difficult market conditions, and despite an increase in green bond sales in China following initiatives to widen the investor base and encourage bank issuance to fund energy transition project lending. Easing global inflation pressures and stronger post-Covid growth in China may be supportive of EMDE fixed-income issuance again, but only after the current cycle of global financial tightening eases, perhaps in 2024 or 2025.

Most GSSS bonds follow a "use of proceeds" model that links financing directly to projects with environmental or social objectives (Table 4.3). Green bond proceeds are earmarked exclusively for new and existing projects with environmental benefits in areas such as renewables, energy efficiency, water, transport, and climate change mitigation and adaptation. Social bond proceeds, similarly, are directed towards projects that aim for social benefits in areas like health, housing, education and gender equality. Sustainability bond proceeds are earmarked for a mix of environmental and social projects. Prior to issuance, issuers often develop their own green or sustainable bond frameworks, possibly aligning with international or national guidelines[10] and opting to obtain verification from an external party.

For investors, "use of proceeds" bonds offer yields commensurate with credit risk exposure along with the assurance that the funds raised will be channelled to projects with clear sustainability objectives. For issuers, these bonds offer the promise of a broader investor base, signalling to the market their commitment to sustainability considerations. Non-financial corporates have increased their issuance overall, although in EMDEs financial institutions have a greater share of issuance. In some cases, issuers have benefited from a "greenium", effectively lowering funding costs via a smaller spread than for a comparable conventional bond. Data are not available for the average greenium on the EMDE primary market. On the secondary market, however, the average greenium among EMDE green bond issues widened in 2022 to 6.8 basis points from 3.4 basis points in 2021.[11] Costs related to external verification and reporting offset some of the benefits to an issuer, however, as detailed below.

Sustainability-linked bonds are a more recent financial instrument, with global issuance growing from USD 10 billion in 2020 to USD 92 billion in 2021 before easing to USD 72 billion in 2022. They differ from use of proceeds bonds in that the funds raised are not earmarked. Instead, their financial terms can be adjusted (e.g. their coupon) based on whether the issuer meets predefined sustainability targets such as cutting greenhouse gas emissions, waste reduction, or transitioning to renewable energy from fossil fuels.

Data on GSSS loans are not as closely tracked or available as those for GSSS bonds. These loans can have similar characteristics, with proceeds required to be used for environmental or social projects, but they are generally smaller in size and attract less publicity. Some loans that could be labelled green or sustainable are not reported as such, but available data show that green loan disbursements have been steadily increasing and surpassed USD 100 billion in 2022.

[10] Such frameworks most often follow principles developed by the ICMA or corresponding national guidance.

[11] This refers to a benchmark average "greenium" for EMDE issues of green bonds. A negative "greenium" spread means that the bond traded at a lower yield than a conventional bond with similar characteristics. Data from forthcoming IFC-Amundi Emerging Market Green Bonds Report 2022.

Sustainability-linked loans have also grown, with more than USD 300 billion in disbursements in 2022. GSSS loans in EMDEs accounted for 17% of the global total, similar to the proportion of EMDEs in global GSSS bond issuance.

4

Table 4.3 ▹ GSSS bonds and loans definitions

Instrument	Definition
Green bond/loan	Fixed-income instruments with proceeds earmarked exclusively for projects with environmental benefits
Social bond/loan	Fixed-income instruments with proceeds directed towards projects that aim to achieve positive social outcomes
Sustainable bond/loan	Debt instruments that finance a combination of green and social projects
Sustainability-linked bond/loan	Performance-based debt instruments whereby financial or structural objectives, such as the coupon rate, are adjusted depending on predefined sustainability objectives

Challenges facing the GSSS finance market

How far and how fast the GSSS finance market can grow will depend on effective solutions to a range of major challenges. These include large informational asymmetries that make it difficult for potential investors to gauge accurately issuers' sustainability commitments and the likely impact of their bond issues. This is a key reason for increasing concerns about "greenwashing" whereby issuers make false or misleading sustainability claims, including exaggerating or obfuscating elements of their sustainability profile, as well as vague, immaterial or unambitious sustainability commitments. The Climate Bonds Initiative (CBI) found that less than half of green debt issuers reported on their intended use of proceeds or their broader expected climate impact (Vulturius and Tuhkanen, 2020). Greenwashing exists in implementation as well, with weak monitoring and enforcement allowing proceeds to be used for purposes other than meaningful sustainability objectives (Schumacher, 2020). Containing those risks will require paying more attention to measurement, reporting standards and designing instruments to maximise financing of genuine clean energy investments.

Potential solutions

Industry guidelines: The development of voluntary international guidelines by industry associations such as the International Capital Markets Association and the Asia Pacific Loan Market Association has helped to promote transparency in the market. However, the existence of multiple standards that are voluntary risks contributing to increased variability in sustainability claims and disclosure as firms label their debt instruments based on different criteria (Schumacher, 2020). Common impact methodologies and indicators could facilitate performance benchmarking and build trust between stakeholders (Vulturius and Tuhkanen, 2020).

Harmonised taxonomies: Lack of clarity around the definition of green assets or activities has also hindered the scaling up of green and sustainable finance. Taxonomies address this gap by setting out which economic activities can be considered environmentally sustainable for investment purposes. The EU taxonomy has become an international benchmark, with an increasing number of EMDEs (such as South Africa and Colombia) rolling out structures that align with it. Other models have emerged, however, including the ASEAN taxonomy, which has a more complex approach.[12] Attempts to harmonise taxonomies across national jurisdictions need to take local context into account while establishing consistent criteria and measurement mechanisms.

Robust third-party certification and monitoring: Efforts to improve transparency could also include promoting third-party certification and external review (Sartzetakis, 2021). For example, CBI provides sector-specific certification to debt issuances that conform to its Climate Bonds Standards.[13] These certifications impose costs on the issuer in the form of certification and audit fees. These can vary considerably, with some estimates by Chaudhary (2020), OECD et al., (2016) and Azhgaliyeva, Kapoor and Liu, (2020) ranging from USD 10 000 to USD 150 000. Additionally, issuers also face costs related to establishing internal processes and reporting mechanisms to meet certification requirements. These can be significant, particularly for small issuers, and may act as a barrier to wider adoption of third-party certification, though some costs may be recouped as evidence suggests that certified issuers have lower borrowing costs than their non-certified counterparts [Discussed further in Hyun, Park and Tian, (2021), Dortfleitner, Utz and Zhang, (2022) and Simeth, (2022)]. Nevertheless, external certification does not typically entail continuous monitoring post-certification, which would add further expense.[14]

Cost-effective regulation: Regulatory solutions to counter greenwashing must balance efforts to improve credibility with flexibility and containing unnecessary costs. Mandatory standards could help with credibility, but they may also dissuade sustainability-focused firms from issuing green debt if regulatory compliance costs are too high. One alternative to mandatory disclosure may be an EU proposal for a new European Green Bond (EuGB) label granted to securities that align with the EU green bond taxonomy and continually meet a uniform set of requirements.

[12] The ASEAN taxonomy has a foundational framework classifying activities as green, amber or red depending on whether they fulfil environmental objectives, as well as additional technical screening criteria for specific sectors. This approach encompasses activities that facilitate a low-carbon transition for countries heavily dependent on fossil fuels. The EU taxonomy focuses on assessing whether activities are sustainable or not, limiting consideration of transition activities.

[13] These align, in turn, with the Green Bond and Loan Principles of the ICMA. However, the CBI process does not entail regular monitoring and verification post-certification. This is problematic for investors seeking to ensure sustainability performance across the full tenure of their long-term investments (BIS, 2017).

[14] One low-cost continuous monitoring mechanism may be through green bond indices, which identify green-eligible bonds via use of proceeds documentation. This constitutes de facto external review with ongoing monitoring (as bonds can be removed from indices at any time). However, the subjectivity of green criteria and the binary nature of index inclusion makes this a weak monitoring mechanism.

Applying regulation to funds that hold green assets — in addition to the issuers — could make greenwashing more visible to investors and thereby increase demand for assets that more demonstrably contribute to sustainability objectives. For example, the EU Sustainable Finance Disclosure Regulation requires several levels of environmental, social and governance (ESG) disclosure for funds at both the product and entity level, with most of the key aspects already applicable in 2023. The US Securities and Exchange Commission has proposed regulation that would require thematic ESG funds to make explicit disclosures around how they are pursuing ESG strategies. Future policies could require ESG funds to disclose exposure to commitment and enforcement risks embedded within their sustainable debt holdings, facilitating improved signalling to investors on the expected sustainability impact of their portfolio (Curtis, Weidemaier and Gulati, 2023).

Better instrument design: The existing design of sustainable debt instruments does little to ensure strong commitment or accountability towards sustainability impact. Several improvements could alleviate greenwashing concerns. Requiring explicit sustainability commitments that are enforceable is critical (Curtis et al.,2023). Sustainability-linked bonds and loans are recent innovations that achieve this goal through incentivised sustainability targets. These instruments can be improved further, for example by ensuring financial penalties are sufficiently large to motivate issuers and by embedding sustainability targets that are both material and ambitious, ideally based on scientific evidence.[15] Loopholes that minimise penalty payouts also need to be eliminated. These include call provisions, fallback clauses and late target dates [Ul Haq and Doumbia (2022), and Ritchie (2022)]. Such design improvements should also be incorporated in industry guidelines and used as the basis for third-party verification.

DFIs can leverage their expertise in sustainable finance to encourage greater harmonisation in green taxonomies. The World Bank, IFC and the Asian Development Bank have provided technical assistance to governments seeking to create national green finance taxonomies and regulation, with tailored strategies that also encourage convergence to a standardised set of definitions.[16] This should increase comparability among bond issues and may ultimately lead to lower transaction costs (World Bank Group, 2020).

DFIs can also help create sustainability performance monitoring tools, increasing transparency for investors and regulators. For example, the Inter-American Development Bank has created a Green Bond Transparency Platform, which aims to bolster investor confidence by using first-hand data from issuers and third-party auditors to report on the development impact of individual bonds. At the issuer level, technical and capacity building programmes, such as IFC's Green Bond Technical Assistance Program, can assist green bond issuers in implementing monitoring and reporting systems that provide essential information

[15] Ritchie (2022) finds that the majority of existing sustainability-linked bonds have weak or irrelevant sustainability targets. See also Vulturius, Maltais and Forsbacka (2021).
[16] As a founding partner of ICMA, IFC has supported the creation of industry guidelines such as the Green Bond and Loan Principles.

to external platforms and verifiers. Lastly, DFIs can also play an important role in promoting better instrument design, both from the investor and issuer side.

4.3.2. Carbon credits and voluntary carbon markets

Revenues from carbon credit markets can help accelerate private sector climate investment. In response to requirements imposed by some governments for mandatory GHG emission reductions, carbon taxes[17] and emissions trading schemes (ETS), businesses in many countries have begun to take steps to reduce or remove GHG emissions from their operations.[18] Thus far, this has mainly been through efforts to improve efficiency by incorporating new technologies and streamlining processes. Scope for cost-effective emissions reduction with current technologies is limited, however, especially in sectors like heavy industry and transport. As a result, some companies participating in these “compliance” markets are buying carbon credits from sellers promising to reduce or remove emissions, in order to offset emissions that the buyers are not yet able to reduce themselves. In addition, companies adopting voluntary net-zero targets are particularly important buyers of carbon credits through self-regulated, voluntary carbon markets (VCMs).

Carbon credits provide revenue streams that can facilitate financing. This can come in several forms, including traditional project finance structures familiar in the electricity generating market.[19] As revenues rather than upfront financing, carbon credits cover the operating costs that sellers incur for carbon mitigation and debt servicing. The income can also be retained and reinvested or distributed to shareholders. Many carbon credit-generating projects are in EMDEs, where domestic financial markets may be underdeveloped, and funding options limited to small domestic banks. In practice, this means that many new carbon credit projects will require cross-border financing secured by the carbon credits that the offset projects subsequently generate. Importantly, if sustained by the development of high-quality offsets, carbon credit revenue streams can be securitised, unlocking capital market financing at scale via cross-border investment or domestic capital market issuance.

Innovative financial instruments based on carbon credits are beginning to emerge alongside more traditional financing structures. Some are newer than others. Carbon mutual funds,

[17] A recent National Bureau of Economic Research (NBER) report notes that carbon taxes and mandatory emission reductions with a cap-and-trade programme can achieve similar decarbonisation results, even though they do not necessarily have the same economic impacts. More generally, it provides evidence that carbon pricing is not harmful to growth or, in the long run, employment (although it will reduce employment in carbon-intensive sectors) (Metcalf, 2023).

[18] 1 649 companies have put in place science-based targets in line with net zero commitments, and more than 1 000 cities, over 1 000 educational institutions and over 400 financial institutions have joined the Race to Zero, pledging to take rigorous, immediate action to halve global emissions by 2030. 4 469 companies stated they are taking action and 2 299 companies had committed to science-based targets as of January 2023 (SBTi). Out of the 2 000 largest publicly traded companies in the world by revenue, 814 had net zero targets as of January 2023.

[19] Financing terms can include upfront payments under 15- to 20-year offtake agreements in which financing provided by the buyer (via the upfront payment) is returned in the form of carbon credits, subject at times to a floor price and indexed in some manner over the life of the project.

carbon exchange traded funds and carbon credit futures are examples of financing structures and instruments that have existed for some time. Some may also invest in carbon credit futures, although these are based mainly on carbon credits traded in compliance markets, where pricing is more transparent and markets are less fragmented, than those in VCMs. Investments in carbon credit futures and forwards still carry substantial risk, even in more transparent and less fragmented markets, with limited opportunities to diversify, making risks similar to those in single commodity markets such as gold, copper and oil.

Appendix A provides further information on ETS, compliance markets and VCMs in which carbon credits are traded, as well as the structure of international markets that are to be established under Articles 6.2 and 6.4 of the Paris Agreement. VCMs have grown rapidly in recent years and have considerable potential. But realising that potential will require greater harmonisation of standards for carbon credits, improvements in their monitoring, reporting and verification, and greater transparency and credibility on the part of buyers of carbon credits. Cementing the roles of the Integrity Council for the Voluntary Carbon Market (ICVCM) and the Voluntary Carbon Markets Integrity Initiative (VCMI) in developing best practices on the supply and demand sides can help to build robust, liquid VCMs while addressing credibility issues. Market participants, MDBs and other organisations play important roles in advancing the development of VCMs.

4.3.3. Co-investment, syndication platforms and pooled investment vehicles

Project aggregation platforms and securitisation vehicles can overcome the asymmetry between the relatively small size of most energy transition projects in EMDEs and the relatively large minimum investment size that major institutional investors require. These platforms can pool and de-risk large numbers of smaller projects and thereby create standardised investment-grade multi-asset portfolios, reducing transaction costs, diversifying risk and attracting interest from institutional investors.

DFIs have a long track record of syndicating investment opportunities in EMDEs, including support to clean energy projects. Co-investment models have been central to this, enabling private investors to broaden the types of risk they are willing to consider by leveraging DFI expertise and financial resources.

Co-investment models

DFIs' ability to mobilise capital is built on a foundation of co-investment: DFIs put a portion of their own capital at risk in every project. Provision of patient capital and ongoing involvement in projects as long-term partners creates an alignment of interests between the development banks and the private investors who invest alongside them. For climate investments, the co-investment model can lead private capital to support new and untested technologies, participate in markets and sectors where investors may have little prior experience, and lend at tenors to which they might otherwise be unwilling to commit.

While most investors can participate via direct funding, some, like insurance companies, can play an important role in facilitating climate finance through unfunded products. Products like credit insurance allow DFIs to fund and then transfer risk to the private sector, effectively creating a mobilisation solution in projects for which this would not have otherwise been possible. For example, IFC has worked with insurers to increase mobilisation in the financial sector, expanding partnerships to cover a growing range of assets including Basel III Tier 2 subordinated debt, debt securities issuances and local currency loans, helping to deliver capital in strategic focus areas such as expanding access to finance for women and increasing support for banks' climate lending.

For both funded and unfunded projects, most mobilisation occurs on a project-by-project basis. DFIs seek out investors to join them in individual projects. For example, IFC's B Loan product has helped commercial banks access one-off lending opportunities in more than 60 developing economies, and IFC is now introducing B Loan participants to sustainable lending products to help them improve climate outcomes. However, some investors may require scale and/or diversification that makes it difficult to participate in single projects. Portfolio approaches, through which development banks raise a pool of capital and then deploy it over time into a set of projects that meet relevant eligibility criteria, can therefore attract new sets of investors. Asset diversification and aggregation overcome important hurdles that previously curtailed the ability to mobilise. These portfolio approaches may offer particular promise for investment in climate mitigation and adaptation.

The Managed Co-lending Portfolio Program (MCPP) (IFC, 2022), IFC's portfolio syndications platform for institutional investors, has raised more than USD 11 billion from 11 partners to invest in portfolios of new EMDE loans. The platform follows a standardised process for multiple types of lenders, allowing sovereign wealth funds, private institutional investors and global insurance companies to take greater risk in emerging markets through the use of a set of customised vehicles—co-lending alongside IFC in eligible projects, or providing IFC with credit insurance coverage. Where necessary, these portfolios may be combined with blended finance to deliver appropriate risk-adjusted returns for investors and enable more projects to be funded. A new MCPP One Planet facility, launched by IFC in 2022, applies the same approach to climate projects and is the first vehicle to enable institutional investors to directly provide capital for 100% Paris-aligned lending. As more institutions incentivise mobilisation and couple this with a Paris alignment framework, the provision of both development finance and private investment to governments and firms on the front lines of climate change will continue to grow.

Pooled investment vehicles

Infrastructure investment trusts (InvITs) offer another example of an innovative instrument. These are pooled investment vehicles regulated by the Securities and Exchange Board of India that give investors exposure to infrastructure assets. The main goal of InvITs is to promote India's infrastructure sector by encouraging individuals or institutions to invest in assets that they would not otherwise have direct access to. InvITs allow developers to sell a portion of their revenue-generating assets to pension funds, sovereign wealth funds, insurers and private equity funds, and thereby recycle capital. India's first listed power sector InvIT is IndiGrid Trust, which presently owns two solar projects and 15 operating transmission projects. There are a number of variations worldwide that aim to achieve the same objective: attracting investors to operating infrastructure assets and allowing developers to free up capital to continue developing new ones. When appropriate, DFIs could participate in InvITs (or similar structures) in many EMDEs to attract foreign and domestic capital for the clean energy transition.

4.3.4. Financial sector development to support local currency financing

Deepening local capital markets and financial systems is necessary to scale domestic private investment in the clean energy transition. Domestic private investment – rather than foreign capital – has been a major source of investment in the clean energy transition in some countries, such as China and India. However, outside of a few large middle-income economies, most long-term investments in EMDEs today are financed with foreign currency instruments. In these economies, local currency financing is typically available in limited amounts, at short tenors and at higher interest rates than on cross-border loans. Currency depreciation risks can be significant, especially over the 15- to 20-year maturities of many energy sector project loans, which is a key reason interest rates are often much higher on local than foreign currency. Refinancing risks will also typically be greater for local currency loans, with shorter tenors that are characteristic of less developed local currency capital markets. Developing domestic bond, equity, and derivatives markets (e.g., currency swaps) can enable local funding of climate projects by tapping domestic banks and capital markets as well as using local currency swaps to convert into local currency the larger amounts and longer terms of foreign currency financing that cross-border investors can offer.

Local capital market development

For smaller climate-related activities, such as increasing access to EVs and solar energy for SMEs and households, domestic banks are likely to be a major source of financing. Domestic banks will also be able to fund themselves where markets are sufficiently developed, adding long-term funding and loss-absorbing capital to backstop shorter-term deposit funding. Larger projects, however, typically need to turn to capital markets, using instruments including bonds and securitisation funded by mutual funds, pension funds and insurance companies.

Well-functioning capital markets can allocate resources more efficiently through better information and governance. More resources can be mobilised for innovative projects, tapping investors with a higher risk appetite to fund riskier and more collateral-scarce activities than banks have traditionally served. Equity markets, moreover, have long been key to the financing of new businesses, particularly those relying on intangibles, R&D and human capital. Well-developed domestic capital markets can also facilitate climate-related foreign direct investment, especially via climate-focused M&A. Scope for this kind of financing is largest where governments have put in place policies that support fundraising by local businesses, including an appropriate regulatory environment and reduced barriers to entry for foreign companies willing to invest. The design and implementation of such policies is often supported by DFIs, such as the World Bank Group Joint Capital Markets Program (J-CAP) (IFC, s.d.), which helps introduce policy and regulatory reforms to facilitate deeper capital markets.

Local currency swaps

Where the enabling conditions for capital market development are not in place and not likely for some time, a second avenue to secure local currency financing for the energy transition in EMDEs is to use cross-currency swaps where they are available. Pricing is often high and volumes limited, however, where domestic capital markets are underdeveloped.

DFIs are prominent among cross-border lenders and have limited options to provide local currency to borrowers. They can and do so via local currency issuance in domestic bond markets. But they more typically rely on cross-currency swaps where these are available from domestic banks and corporates and via special blended finance solutions using donor funds and hedging swaps with the local central banks. TCX (Box 4.2) continues to be a critical counterpart in frontier markets where counterparts are not readily available. Market-based swap costs can be very high, however, and availability limited, constraining how much cross-border capital can be passed through into local currency. Expanding TCX could be one important way to expand the volume of local currency forwards and swaps needed to channel cross-border funding from foreign currency investors into local currency financing for climate-focused projects in EMDEs.

Mobilising local currency through capital markets and syndication platforms

Coupled with using their own balance sheets, development banks can facilitate provision of local currency financing from local and international investors wherever possible. Solutions to mobilise local currency already exist in some areas, but will need to be dramatically expanded to meet current climate needs. DFIs can mobilise partners into local currency loans through a range of different approaches, including loans, swaps and synthetic structures for de-risking, as well as solutions that expand inclusion and access, such as microfinance and digital finance. While there are avenues to increase the pool of local currency available to development banks and international investors, nurturing local capital markets and expanding the ability of local investors to provide local currency to projects represent a more scalable solution. Efforts to mobilise more local currency for climate finance will need to build on DFIs' past success by upskilling more local lenders, increasing the supply of local savings available to invest, structuring good climate projects, and incentivising the use of funds in projects that will have positive climate results.

Appendix A: Voluntary carbon markets

Carbon finance is gaining momentum as more countries and private sector actors continue to explore options that generate additional revenue streams for climate mitigation projects and enable cost-efficient capital allocation. Revenue streams from carbon market mechanisms are considered by some to have large potential to accelerate private sector investment in mitigation action. Carbon finance may be a significant component of climate finance in the coming years if the private sector can capitalise on complementarities between climate funding and carbon finance.

Four common tools are associated with the pricing or trading of carbon:

- ***Carbon tax:*** a direct tax levied on the carbon emissions generated to produce goods and services (World Bank, 2022). Carbon taxes are fiscal instruments, but some countries such as South Africa, Colombia and Singapore allow the use of eligible carbon credits to comply with a portion of imposed carbon taxes.
- ***Compliance carbon market*** (e.g. cap-and-trade or baseline-and-credit): mandatory ETS, created and regulated by national or regional bodies. Jurisdictions that host regulated ETS and carbon markets include but are not limited to China, South Korea, Kazakhstan, New Zealand, the European Union, 10 US states (including California and New York), Québec and Tokyo. ETS may establish a "cap" on the GHGs that regulated companies can emit, allowing these allowances to be "traded" among companies that exceed their caps and those that have reduced emissions below them. Alternatively, ETS may also use benchmarks instead of a cap whereby the average intensity of key sectors and products is calculated and compared with that of individual emitters. For example, China implemented a benchmark based national ETS for its power sector.
- ***Voluntary carbon markets (VCMs):*** an international, self-regulated, voluntary regime that enables companies or other entities such as cities and regional authorities to buy and sell carbon credits to meet their voluntary decarbonisation objectives.
- ***"Article 6" of the Paris Agreement:*** Articles 6.2 and 6.4 of the Paris Agreement[20] are intended to allow countries to trade internationally transferred mitigation outcomes (ITMOs, i.e., authorised emission reductions and removals), with a view to achieving and going beyond the ambition of nationally determined contributions. The authorisation of ITMOs for use is an essential part of voluntary co-operation under Article 6 because it determines when mitigation outcomes become ITMOs, and therefore when a corresponding adjustment needs to be applied to the transfer (Ellis, Greiner and Lo Re, 2022).

[20] Article 6.2 allows countries to trade emission reductions and removals with one another through bilateral or multilateral agreements. Article 6.2 emissions reductions and removals can also be sold to and used by private companies, such as airlines to comply with CORSIA obligations. Article 6.4 will provides for a crediting mechanism overseen by a United Nations entity, issuing UN-recognised credits for projects authorised by host countries that can be bought by countries, companies or even individuals to meet their emission reduction goals.

From the private sector perspective, carbon markets are a way for companies that are required to limit their GHG emissions to purchase carbon credits for emissions they are not currently able to reduce. Climate advocates stress that carbon credits should only be used as a last resort or as a temporary measure ahead of large decarbonisation projects, and not as a way to avoid reducing emissions. Companies in hard-to-abate sectors seek to offset their GHG emissions by purchasing carbon credits from third parties that have developed projects using accepted methodologies to reduce, avoid or remove GHGs from the atmosphere.[21]

Carbon credits are verified, transferable instruments of emission reductions or removals measured in units of t CO_2-eq – representing one tonne of CO_2 or equivalent GHGs that has been reduced, avoided or removed. They include:

- Reduction or avoidance credits, in which GHG emissions are reduced or avoided compared to a baseline scenario. Reductions are achieved by replacing high-emitting technologies with low-carbon technologies, consuming less carbon-intensive resources, or using more efficient processes. Examples include waste heat recovery or methane capture projects. Avoidance is achieved by preventing potential sources of stored GHG emissions from being emitted to the atmosphere, such as the non-exploitation of fossil fuel reserves, maintaining land use and agricultural practices that retain already-stored carbon, and avoiding deforestation (Lo Re, Jeudy-Hugo and Falduto, 2021).
- Removal credits, in which GHG emissions are captured from the atmosphere and stored. These can be nature-based, such as reforestation and afforestation, or technology-based, such as direct air capture projects.

Emissions are monitored and reported by the project developers and certified by a third-party independent reviewer that attests that these emissions have been effectively reduced, avoided or removed. Projects must meet specific criteria to issue carbon credits, defined under an approved methodology. Baseline methodologies and project documents are publicly available and subject to external comments before approval.[22]

VCM transaction volume has grown dramatically in recent years due to climate commitments made by private businesses, with demand increasing from 96 million t CO_2-eq issued and 47 million t CO_2-eq retired in 2017, to 282 million t CO_2-eq issued and 161 million t CO_2e-eq retired in 2021 (Macfarlane, 2022). Trading in 2021 totalled about USD 2 billion for a total of 493 million t CO_2-eq of transacted volume. Market potential is highly uncertain, however, with

[21] The terms "reduced" and "avoided" refer to decreasing CO_2 emissions that introduce new carbon to the atmosphere, while "removed" refers to capturing CO_2 from the atmosphere and storing it.

[22] The carbon asset of a qualifying project is typically developed in parallel with the project, according to the guidelines of the carbon standard used. Projects need to be assessed by qualified independent third parties called validation and verification bodies. Validations are double-checked by the carbon standard crediting programme to ensure standards are met and methodologies correctly applied before registry as a "carbon project." Verra, Gold Standard, Plan Vivo, American Carbon Registry, Climate Action Reserve and ART-TREES are the most accepted standards, with Verra and Gold Standard sharing most of the volume. A third-party audit is required initially at project registration and then upon every instance of credit issuance. The project registration can take between six months and two years.

estimates of its volume by McKinsey (2021), Morgan Stanley (2023) and others in 2030 ranging from USD 10 billion to USD 100 billion.

VCMs present several benefits:

- Properly functioning carbon markets can be a powerful climate tool by channelling funding to developing countries where they can use it to address hard-to-abate emissions.
- Carbon credit revenues can increase the bankability of projects and make them commercially and economically viable in sectors and emerging market countries that have a high cost of capital. This can help direct private sector financing to climate action projects that would not otherwise occur.
- Increased investment in projects generating carbon credits can boost flows into emerging economies.
- Many types of carbon credit-generating projects have additional SDG co-benefits, such as biodiversity protection, pollution prevention, public health improvements and job creation.
- In addition to emission reductions and removals, VCM credits can also support investment into innovation, lowering the cost of emerging climate technologies.

VCMs are a voluntary regime, not regulated by the Paris Agreement or any other state regulation. There are, however, initiatives to enhance both demand- and supply-side environmental integrity. Among these, the Voluntary Carbon Market Integrity Initiative (VCMI) aims to agree on a sensible way forward for corporate climate action claims that ensure the highest level of quality, integrity and impact. Through its provisional Claims Code of Practice, the VCMI aims to assure demand-side integrity by ensuring that carbon credits are underpinned by real action to reduce GHG emissions. The Integrity Council for the Voluntary Carbon Market (ICVCM) is an independent governance body for VCMs. The ICVCM aims to improve supply-side integrity by setting new threshold standards for high-quality carbon credits through its Core Carbon Principles and Assessment Framework. It aims to work with carbon credit registries and developers to operationalise Article 6 provisions. Both initiatives published guidelines for consultations and expect to finalise their work during 2023.

Barriers and issues

Removal versus avoidance, nature-based versus technology-based credits

Carbon reduction or avoidance credits are designed to incentivise the reduction or avoidance of carbon emissions and encourage the transition to a low-carbon economy, whereas carbon removals are designed to actively extract pre-existing carbon emissions from the atmosphere. Removals are considered by some as a cure to the problem since it focuses on reversing damage already done to the atmosphere.

Both types of carbon credit are important in mitigating climate change and can be used to offset carbon emissions from various sources. While most companies have recently come to prefer removal credits (where carbon is removed from the atmosphere) and are less interested in avoidance credits (where future emissions are avoided), removal credits account for only 4% of the total since 2010.

Guidance from the Science-Based Targets initiative (SBTi) is for carbon removal credits to account for no more than 10% of harder-to-abate carbon emissions that cannot be eliminated. From 2030 the SBTi will only recognise carbon credits generated from carbon removal activities as valid offsets. This emphasis has led some corporate buyers to highlight their preference for removal credits.

With carbon removals, historical emissions can be taken out of the atmosphere through nature-based or technology solutions and the carbon stored in trees, soil, the ocean, buildings, rocks or deep underground. Neither approach is without complication. Nature-based solutions require large amounts of land to achieve scale, while technological removals such as direct air capture require large amounts of energy and finance to scale up.

The State of Finance for Nature report of the UN Environmental Programme finds that USD 133 billion per year flows into nature-based solutions, with public funds accounting for 86%. It estimates that annual investment of USD 536 billion per year – four times the current level – are necessary to address the interlinked issues of climate, biodiversity, and land degradation. By augmenting revenues, VCMs can help to channel more private capital into projects that expand the supply of carbon credits, including nature-based ones.

Article 6: Avoiding double-counting through application of carbon adjustment and VCMs

The Paris Agreement requires all countries to enhance their mitigation ambition through climate strategies elaborated in their nationally determined contributions (NDCs). Countries have the option to enhance their mitigation ambition through international co-operation, which is allowed for under Article 6 of the Paris Agreement. Article 6 envisages trading carbon emission reduction and removal assets across borders, but this requires ensuring that emission reductions are not double-counted (in both the country of origin of the carbon offset or removal and the country purchasing the related mitigation outcome). The rules for Article 6.2 agreed at COP26 established a robust accounting system that avoids double-counting of emission reductions and removals through "corresponding adjustments". Such adjustments are triggered by the authorisation of ITMOs by the transferring country, and provide that when ITMOs are used, an equivalent amount of emissions is added to the host country's NDC accounting system, while it is deducted from the NDC count of the buyer country.[23]

[23] Governments can be buyers or sellers of carbon credits. This is important because NDC requirements may be increased by the amount of carbon credits transferred via these cross-border transactions. Mitigation costs that individual countries face in meeting their NDCs may also increase because they may have only limited
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While Article 6.2 bilateral co-operation has already begun, the full operationalisation of the Article 6.4 mechanism will require time. Article 6 implementation may also differ from one country to another. Seller countries will need to develop national accounting systems and decide which types of credit can be exported at what cost. Some countries such as Indonesia and Papua New Guinea have banned the export of VCM credits until they define what role VCMs can play and how they will reach their NDC target. The relationship between voluntary markets and Article 6 markets has yet to be defined. Countries looking to raise revenue for a carbon abatement activity may need to choose whether that activity will produce a unit under Article 6 or under VCMs.

Supply-side challenges

One of the main challenges of standards in VCMs is ensuring the credibility of carbon credits -that is, that one carbon credit will correspond to one tonne of CO_2-eq reduced or removed from the atmosphere. Buyers need to be confident that the carbon credits they purchase represent real, additional reductions in carbon emissions and beyond what would have occurred in a "business-as-usual" scenario.

Baseline setting, permanence, leakage, additionality, accurate measurement of GHG reduction or removal, and safeguards are the key points to ensure the quality of carbon credits. There are set standards and methodologies for different project types.

Some of the most recognised carbon standards are the Verified Carbon Standard (VCS) by VERRA, the Gold Standard (GS), the American Carbon Registry (ACR), the Climate Action Reserve (CAR), the Clean Development Mechanism (CDM), Plan Vivo,[24] VERRA for Climate, Community and Biodiversity Standard (CCBA), the REDD+ Environmental Excellence Standard (ART/TREES), the Sustainable Development Verified Impact Standard (SD VISta), the Gold Standard for the Global Goals (GS4GG), the Peatland Code, the Woodland Carbon Code, and ISO 14064-2.

The independent standard-setting bodies need to ensure that projects meet high environmental standards and follow accepted methodologies. The certification standards are important to ensure project quality, even as they continue to be improved. Current methodologies will need to be reviewed, revised or even made inactive on a regular basis to reflect best practices, scientific consensus, evolving market conditions and technical developments. There are also challenges with the robustness and quality of the validation and verification audits. Substandard work by validation and verification bodies can lead to

mitigation opportunities available, and some may have higher costs than those of carbon credits traded away. Proper planning will therefore be needed for countries to avoid having to rely on more expensive mitigation activities to meet their NDCs, with corresponding adjustment creating an obligation and an associated liability for the host country, the latter reflecting the marginal cost and the associated opportunity cost of meeting the NDC.

[24] Plan Vivo is an offset project standard for forestry, agriculture, and other land-use projects, with a focus on promoting sustainable development and improving rural livelihoods and ecosystem services. It has specific requirements for community projects in the Global South.

inconsistencies between projects and between the certification standards themselves, with adverse consequences for the quality of the credits and the credibility of the carbon market.

The lack of full standardisation in VCMs creates confusion and inefficiencies. There are many different types of carbon credits and offsets, and they can vary in terms of quality, additionality and verifiability. The large variety of standards gives rise to cheap, low-quality projects (e.g. with low additionality) alongside high-integrity and high-quality projects, making it difficult for buyers to compare different options and make informed decisions. Buyers are required to do their own thorough due diligence for each project. Verifying the authenticity and quality of carbon credits can be a complex and costly process. Smaller buyers may not have the capacity to check technical issues such as verification of the baseline using spatial analysis, legal rights of the land used or operational costs of the project. Rating agencies such as Sylvera, Calyx, Carbon Plan and BeZero Carbon provide independent ratings and insights on the quality of carbon projects to allow buyers to compare projects with respect to different quality dimensions.

Market players have taken initiative through ICVCM to develop core carbon principles and set independent thresholds that comply with them to define high-quality credit and crediting programmes. Creating overarching quality standards will reduce information asymmetries between sellers and buyers and help to improve the overall quality of projects.

Demand-side challenges

As mentioned above, VCMs need to deliver real and additional GHG reduction and removal benefits and help accelerate the transition to ambitious, economy-wide climate actions. However, the credibility of the "offsetting claim" is as important as the credibility of the carbon credit. The voluntary use of carbon credits must augment rather than substitute for corporates' decarbonisation efforts.

VCMI was established to propose guidelines for demand-side integrity by answering two key questions:

- When, and under what circumstances, can companies and other non-state actors credibly make voluntary use of carbon credits?
- What claims can they credibly make about this use?

The Claims Code (VCMI, 2022) imposes prerequisites and claims requirements to keep companies from purchasing carbon credits to offset their emissions without making meaningful efforts to reduce their GHG emissions. The purchase of carbon credits by a private sector entity can give the appearance of contributing to climate action without addressing the root causes of emissions by the entity. Concerns about greenwashing[25] can undermine the credibility of the entire market. It is important to verify the validity of a

[25] Greenwashing is a marketing strategy that some companies may use to portray themselves as climate friendly without actually taking meaningful action to reduce their climate impact. This can include the use of vague, misleading language or making unsubstantiated claims on net zero targets.

company's claims and to look for third-party certifications or independent audits that verify whether the company's practices are in line with their net zero pledges. Transparency and disclosure are critical components of effective carbon markets. By requiring companies to disclose their emissions and offsetting activities, carbon markets can provide greater accountability and help prevent greenwashing.

At the same time, many buyers are concerned that the carbon offsets they purchase may not be as effective as advertised, leading to accusations of greenwashing. This perception can discourage private sector actors from participating in VCMs. The reputational risk can cause reluctance by corporates and prevent their meaningful engagement in carbon markets. Buyers need to have confidence in the transparency and accountability of VCMs. This requires clear reporting and tracking mechanisms, as well as robust governance structures to prevent fraud and ensure the integrity of the markets.

A reputable monitoring, reporting and verification framework is a key criterion for issuing credible carbon credits. As the spotlight on carbon offsetting grows, buyers will want to ensure that the credits they buy have impact that is easy to prove and defensible against claims of greenwashing. Improving project integrity is needed to spur growth and investment (Porsborg-Smith et al., 2023). Both project developers and carbon-credit buyers need to provide guidance on the regulations and tools needed to create universally accepted attributes for what constitutes a quality carbon credit and apply these. Work by VCMI and ICVCM should be finalised quickly, and the adaption of guidelines and principles should be encouraged by all actors.

In addition, the price of carbon credits should also be transparent and reflect the true value of emission reductions. The development of clear price signals will help incentivise investment in low-carbon technologies and provide a more accurate reflection of the cost of carbon emissions.

Finally, carbon market transactions should be structured in a way where a share of proceeds flows to communities or project owners implementing the project. Earnings from the sale of carbon credits should be shared equitably between project developers and the communities involved.

Future actions

Market participants are unclear on the impact of Article 6 and corresponding adjustments to VCMs. Policy risks can affect carbon projects in VCMs. COP28 and the Article 6.4 Supervisory Body can provide guidance.

To help companies achieve their climate neutrality goals, it will be imperative to make sure that all types of carbon credits are valued. Relying solely on carbon removal will not address the problem of GHGs currently being released into the atmosphere. Corporate buyers should not dismiss reduction and avoidance projects, since limiting current emissions will reduce the need for removals in the future and many avoidance projects have significant co-benefits.

All project types are essential to achieving a neutral carbon balance. Preventing emissions from entering the atmosphere in the first place – by substituting lower-emitting technologies for high-emitting ones (e.g. clean cookstoves) – or absorbing more of those that do – by preserving forests that would otherwise have been felled – will both be important in preventing an exacerbation of the problem. By 2030 and 2050, however, the market is expected to largely be dominated by removal credits.

There should be no contradiction between a corporate, institution or individual cutting its own emissions and using high-quality, high-integrity carbon credits to compensate for the residual emissions. Decarbonisation for all should start with reducing emissions, and carbon credits are not a substitute for emission reductions. Industry bodies, public acceptance and societal pressure shape the narrative for VCMs. What constitutes a legitimate credit and what is the valid use of credits should be made clear to private sector players.

MDBs can play a critical role in advancing the development of the market. Among the most important is promoting a clearer path on the convergence of standards and monitoring, reporting and verification practices. Useful contributions in this context include:

- The World Bank Climate Warehouse Initiative, which aims to develop end-to-end digital infrastructure for carbon markets.
- The World Bank Partnership for Market Implementation (PMI), World Bank Partnership for Market Implementation (PMI), which supports countries trying to roll out carbon pricing instruments aligned with their development priorities.
- The Transformative Carbon Asset Facility, Transformative Carbon Asset Facility, which supports countries' efforts to implement market-based carbon pricing and to create conditions for private sector investment in low-carbon technologies.
- IFC's Forest Bond, which channels funding to a private sector project that creates viable alternatives to deforestation by using carbon markets.

MDBs can work as system integrators, providing trusted platforms for high-integrity buyers trying to achieve genuine net zero targets and climate action goals, connecting them with sellers that have development projects generating high-quality, high-integrity offsets. Early finalisation of the ongoing work of ICVCM and VCMI should help accelerate the adoption of harmonised guidelines and principles benefiting both buyers and sellers.

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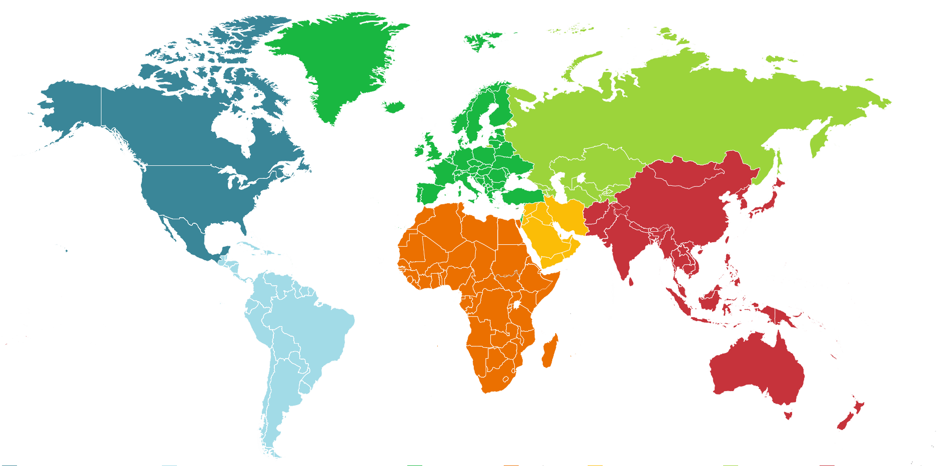
Regional and country groupings

Advanced economies: Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Cyprus[1,2],Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Türkiye, United Kingdom and United States.

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.

Figure 1 ▹ 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, China, India, Japan, Korea, Democratic People's Republic of 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), Brazil, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, Bolivarian Republic of Venezuela (Venezuela), 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

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

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

European Union: Austria, Belgium, Bulgaria, Croatia, Cyprus[1,2], Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain and Sweden.

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

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

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.

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

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

North America: Canada, Mexico and 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, United Kingdom and United States.

OPEC (Organisation of the Petroleum Exporting Countries): Algeria, Angola, Republic of the Congo (Congo), Equatorial Guinea, Gabon, the Islamic Republic of Iran (Iran), Iraq, Kuwait, Libya, Nigeria, Saudi Arabia, United Arab Emirates and Bolivarian Republic of Venezuela (Venezuela).

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).

A

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

Country notes

[1] Note by 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. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey 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 and 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, British Virgin Islands, Cayman Islands, Dominica, Falkland Islands (Malvinas), French Guiana, Grenada, Guadeloupe, Guyana, Martinique, Montserrat, Saba, Saint Eustatius, Saint Kitts and Nevis, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and Grenadines, Saint Maarten, 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, Kingdom of Eswatini, Gambia, Guinea, Guinea-Bissau, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Réunion, Rwanda, Sao Tome and Principe, Seychelles, Sierra Leone, Somalia and Uganda.

Abbreviations, units and acronyms

APS	Announced Pledges Scenario
ASEAN	Association of Southeast Asian Nations
BESS	battery energy storage systems
CAF	Capital Adequacy Frameworks
CBI	Climate Bonds Initiative
CCUS	carbon capture, utilisation and storage
CIF	Climate Investment Funds
DACCS	direct air capture with carbon storage
DFI	development finance institution
EMDE	emerging market and developing economy
ESG	environmental, social and governance

ETS	emissions trading schemes
EV	electric vehicle
GCF	Green Climate Fund
GEAPP	Global Energy Alliance for People and Planet
GHG	greenhouse gas
GSSS	green, social, sustainable and sustainability-linked
FDI	foreign direct investment
FID	final investment decision
FIT	feed-in tariff
FY	fiscal year
FX	foreign exchange
GFANZ	Glasgow Financial Alliance for Net Zero
GSSS	green, social, sustainable and sustainability-linked
ICMA	International Capital Markets Association
ICVCM	Integrity Council for the Voluntary Carbon Market
IDA	International Development Association
IEA	International Energy Agency
IFC	International Finance Corporation
IPP	independent power producer
IPPC	Intergovernmental Panel on Climate Change
ITMO	Internationally Transferred Mitigation Outcome
J-CAP	Joint Capital Markets Program
JETP	Just Energy Transition Partnerships
LC	letter of credit
LCOE	levelized cost of electricity
MCPP	Managed Co-lending Portfolio Program
MDB	multilateral development bank
NDC	nationally determined contribution
NZE Scenario	Net Zero Emissions by 2050 Scenario
OECD	Organisation for Economic Co-operation and Development
PayGo	pay-as-you-go
PBI	performance-based incentive
PFI	private finance initiative
PLI	production linked incentive
PPA	power purchase agreement
PPP	public-private partnership
PSW	Private Sector Window
PV	photovoltaic
RPO	renewable purchase obligation
RSF	risk-sharing facility
SBTi	Science-Based Targets initiative
SDG	Sustainable Development Goal
SDS	Sustainable Development Scenario
SECI	Solar Energy Corporation of India
SME	small and medium-sized enterprise
SOE	state-owned enterprises

STEPS	Stated Policies Scenario
TCX	The Currency Exchange Fund
VCM	voluntary carbon market
VCMI	Voluntary Carbon Market Integrity Initiative
VGF	viability gap funding

Units of measure

GJ	gigajoule
Gt	gigatonne
GW	gigawatt
GWh	gigawatt hour
kg	kilogramme
km	kilometre
kWh	kilowatt hour
Mt	million tonnes
Mtoe	million tonnes of oil equivalent
MW	megawatt
m^2	square metre
t CO_2-eq	tonne of carbon dioxide-equivalent

Glossary

Advanced biofuels: Sustainable fuels produced from non-food crop feedstocks, which are capable of delivering significant lifecycle greenhouse gas emissions savings compared with fossil fuel alternatives, and which do not directly compete with food and feed crops for agricultural land or cause adverse sustainability impacts. This definition differs from the one used for "advanced biofuels" in the US legislation, which is based on a minimum 50% lifecycle greenhouse gas reduction and which, therefore, includes sugar cane ethanol.

Advanced economies: OECD regional grouping and Bulgaria, Croatia, Cyprus, Malta and Romania.

Balance sheet finance: Involves the explicit financing of assets on a company's balance sheet using retained earnings from business activities, including those with regulated revenues, as well as corporate debt and equity issuance in capital markets. To some extent, it measures the degree to which a company self-finances its assets, though balance sheets also serve as intermediaries for raising capital from external sources. Corporate finance is also described as on balance sheet financing.

Blended finance: A broad category of development finance arrangements that blend relatively small amounts of concessional donor funds into investments, in order to mitigate specific investment risks. This can catalyse important investments that would otherwise be unable to proceed under conventional commercial terms. These arrangements can be structured as debt, equity, risk-sharing or guarantee products. Specific terms of these arrangements, such as interest rates, tenor, security or rank, can vary across scenarios.

Borrowing costs: Borrowing cost are the costs incurred by a company resulting from the borrowing of funds e.g. interest.

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

Capital costs: Costs to develop and construct a fixed asset such as a power plant and grid infrastructure or execute a project, excluding financing costs. For power generation assets, capital costs include refurbishment and decommissioning costs.

Capital structure: Capital structure is the particular combination of debt and equity used by a company to finance its overall operations and growth.

Coal: Includes both primary coal (including lignite, coking and steam coal) and derived fuels (including 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.

Concessional financing: Resources extended at terms more favourable than those available in the market. This can be achieved through one or a combination of the following factors: interest rates below those available on the market; maturity, grace period, security, rank or back-weighted repayment profile that would not be accepted/extended by a commercial financial institution; and/or by providing financing to the recipient otherwise not served by commercial financing.

Corporate venture capital: Equity investments in start-ups that are developing a new technology or service by companies whose primary business is not venture capital nor other equity investments. In addition to playing the traditional role of a venture capital investor, corporate venture capital investors often provide support to the start-ups via access to their customer base, R&D laboratories and other corporate resources. Corporate venture capital is used by companies as part of their energy innovation strategies to enter new technology areas or learn about technologies more quickly than developing them in-house.

Debt:	Bonds or loans issued or taken out by a company to finance its growth and operations.
Dispatchable power generation:	Refers to technologies whose power output can be readily controlled – increased to maximum rated capacity or decreased to zero – in order to match supply with demand.
District heating:	An insulated network that delivers hot water or steam from co-generation (the combined production of heat and power) or heat-only sources via pipelines to space heating or hot water users in buildings.
Early-stage venture capital:	Generally the first three venture capital fundraising rounds involving external investors in a start-up, referred to as seed, series A and series B. These investments accept a significant share of of technology risk and are a major source of risk capital that support innovation in many clean energy technologies. The values generally increase from up to USD 2 million for a seed round, to USD 10 million or more for a series B round, but can be smaller or much larger.
Electrolyser:	Refers to water electrolysers designed for the production of hydrogen via electrolysis using electricity and water inputs.
Emerging market and developing economies (EMDEs):	For the purpose of the WEI and FCET report, this group includes all emerging market and developing economies except for OECD member countries Chile, Colombia and Mexico, and excluding China, as the dynamics of investment in China are quite distinctive and is also a major outward investor in EMDEs.
End-use investment:	End-use investment includes investment in three categories on the demand side: energy efficiency, end-use renewables and other end-use.
End-use renewable investment:	Capital spending on bioenergy, geothermal and thermal solar, which are directly consumed by residential and service buildings and industry.
Energy efficiency investment:	The incremental spending on new energy-efficient equipment or the full cost of refurbishments that reduce energy use. The intention is to capture spending that leads to reduced energy consumption. Under conventional accounting, part of this is categorised as consumption rather than investment.
Equity:	Common stock, preferred stock, or retained earnings that a company uses to finance its growth and operations.
Green bond:	A green bond is a type of fixed-income instrument created to fund projects that have positive environmental and/or climate benefits.

Hydropower: The energy content of the electricity produced in hydropower plants, assuming 100% efficiency. It excludes output from pumped storage and marine (tide and wave) plants.

Internal rate of return (IRR): The discount rate that makes the present value of investment cost (cash outflow) equal to that of benefits (cash inflow), whereby making the net present value of the project equal to 0.

Investment: In WEI 2021 and this report, all investment data and projections reflect actual spending across the life cycle of a project, i.e. the capital spent is assigned to the year when it is incurred. Investments for oil, gas and coal include production, transformation and transportation; those for the power sector include refurbishments, uprates, new builds and replacements for all fuels and technologies for on-grid, mini-grid and off-grid generation, as well as investment in transmission and distribution, and battery storage. Investment data are presented in real terms in year 2022 US dollars unless otherwise stated.

Note that the definition was effective beginning in 2019. Previously, the investment data reflected "overnight investment", i.e. the capital spent is generally assigned to the year production (or trade) is started, rather than the year when it is incurred.

Lead times: The amount of time from the start of a project to its commissioning. Lead times refer to the time between the final investment decision and the start-up for oil and gas projects and construction time for power generation assets.

Light-duty vehicles: A light-duty vehicle is a road vehicle with at least four wheels and with a kerb weight below 3.5 tonnes. This broadly covers the UN categories of M1 and N1.

Liquidity: The availability of liquid (cash) assets.

Long-term debt: Long-term debt, also called non-current liabilities, are a company's financial obligations will mature after a year.

Low-emission power: Low-emission power comes from methods that produce substantially less carbon (or carbon equivalent) emissions than fossil fuel power generations. Low-emission power includes power generation from wind, solar, hydro, nuclear, geothermal, marine, bioenergy, and fossil fuel with CCUS.

Net Zero Emissions Scenario (NZE) The Net-Zero Emissions by 2050 Scenario (NZE): An IEA Scenario that shows what is needed for the global energy sector to achieve net-zero CO2 emissions by 2050. It also aims to minimise methane emissions from the energy sector and it contains concrete action on the energy-related United Nations Sustainable Development Goals. The NZE does not rely on action in areas other than the energy sector to achieve net-zero emissions, but with corresponding reductions in emissions from outside the energy sector, it is consistent with limiting the global temperature rise to 1.5 °C without a temperature overshoot (with a 50% probability).

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Nominal (terms): Nominal (value or terms) is a financial and economic term that indicates the statistic in question is measured in actual prices that exist at the time. nominal value of any economic statistic means the statistic is measured in terms of actual prices that exist at the time.

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

Other end-use investment: Capital spending on transport electrification and industry CCUS.

Paris Agreement: An agreement with the United Nations Framework Convention on Climate Change ratified by almost 190 countries to tackle climate change. It aims to strengthen the global response to keep a global temperature rise this century well below 2 °C above pre-industrial levels. All Parties to the Agreement are required to put forward their best efforts through Nationally Determined Contributions and to strengthen the efforts in the years ahead.

Payback period: Refers to the period of time required to recover the amount invested in a project from its benefits (cash inflows).

Pooled vehicle: A pooled (investment) vehicle is a fund created from capital aggregated from many individual investors that are used to secure full payment for investment.

Power generation: Refers to fuel use in electricity plants, heat plants and combined heat and power (CHP) plants. Both main activity producer plants and small plants that produce fuel for their own use (auto-producers) are included.

Power purchase agreement (PPA): A power purchase agreement is a legal contract between an electricity generator (provider) and a power purchaser (user).

Project finance: Involves external lenders – including commercial banks, development banks and infrastructure funds – sharing risks with the sponsor of the project. It can also involve fundraising from the debt capital markets with asset-backed project bonds. They often involve non-recourse or limited-recourse loans where lenders provide funding on a project's future cash flow and have no or limited recourse to liability of the project parent companies.

Real (terms): Real (value or terms) is a financial and economic term that indicates the statistic in questionhas been adjusted to take into account the effect of inflation.

Renewable power: Power derived from bioenergy, geothermal, hydropower, solar photovoltaic (PV), concentrating solar power (CSP), wind and marine (tide and wave) energy for electricity and heat generation.

Revenue: Revenue is the income a business derives, usually from the sale of goods and services to customers.

Securitisation: Creating tradeable securities by pooling assets into interest-bearing securities.

Short-term debt: Short-term debt, also called current liabilities, are a company's financial obligations that are due to be paid within a year.

Stated Policies Scenario (STEPS): An IEA scenario that reflects the impact of existing policy frameworks and today's announced policy intentions. The aim is to hold up a mirror to the plans of today's policy makers and illustrate their consequences for energy use, emissions and energy security. The aim of the Stated Policies Scenario is to provide a detailed sense of the direction in which existing policy frameworks and today's policy ambitions would take the energy sector out to 2050. Previously known as the New Policies Scenario, it has been renamed in WEO 2019 to underline that it considers only specific policy initiatives that have already been announced.

Sustainable Development Scenario (SDS): An IEA scenario that outlines a major transformation of the global energy system, showing how the world can change course to deliver on the three main energy-related SDGs simultaneously. SDS shows how the energy sector can achieve the objectives of the UN Sustainable Development Goals (SDGs) most closely related to energy, namely, those goals related to energy access, air pollution emissions and climate change (SDGs 3, 6, 7, and 13). It is aligned with the Paris Agreement's goal holding the increase in the global average temperature to well below 2 °C.

Sustainable debt instruments

Loan instruments or debt structures (e.g guarantee lines, letters of credit) that embed environmental, social and governance related performance indicators, in order to incentivize issuers to achieve progress in non-financial impact areas. There are a variety of sustainability-linked debt instruments:

- Green Bonds: A share of proceeds are used to fund green projects
- Social Impact Bonds: The rate of the coupon (interest rate) or of the bond repayment itself is linked to the achievement, by the issuer, of pre-agreed social targets (e.g. gender equality)
- Sustainability-linked Bonds: The rate of the coupon (interest rate) or of the bond repayment itself is linked to the achievement, by the issuer, of pre-agreed sustainability targets (e.g. GHG reductions)
- Transition Bonds: The rate of the coupon (interest rate) or of the bond repayment itself is linked to the achievement, by the issuer, of pre-agreed targets related to the transition (e.g. coal plants closures).

The borrower's sustainability performance can be measured against external ratings or equivalent metrics to measure improvements in the borrower's profile.

Transition bond: A transition bond is a type of sustainability, fixed-income instrument that is to be used to fund projects to improve environmental performance for fossil-fuel or high-carbon emission projects.

Transport: Fuels and electricity used in the transport of goods or persons 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.

Weighted-average cost of capital (WACC): The weighted average cost of capital is expressed in nominal terms and measures the company's required return on equity and the after-tax cost of debt issuance, weighted according to its capital structure.

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Scaling up Private Finance for Clean Energy in Emerging and Developing Economies

A massive scaling up of investment is essential in emerging and developing economies to sustainably meet rising demand for energy, as well as to ensure that climate targets are met. Getting on track for net zero emissions by 2050 will require clean energy spending in emerging and developing economies to more than triple by 2030 – far beyond the capacity of public financing alone and therefore demanding an unprecedented mobilization of private capital.

This special report by the International Energy Agency (IEA) and International Finance Corporation (IFC) examines how to scale up private finance for clean energy transitions by quantifying the investments required in different regions and sectors to build modern, clean energy systems, including achieving universal access. The new global energy economy represents a huge opportunity for growth and employment in emerging and developing economies. This report's analysis identifies key barriers and how to remove them – and sets out the policy actions and financial instruments that can deliver a major acceleration in private capital flows for the energy transition.