Energy and Extractives Global Practice

SCALING UP TO PHASE DOWN:
Financing Energy Transitions in the Power Sector

The World Bank
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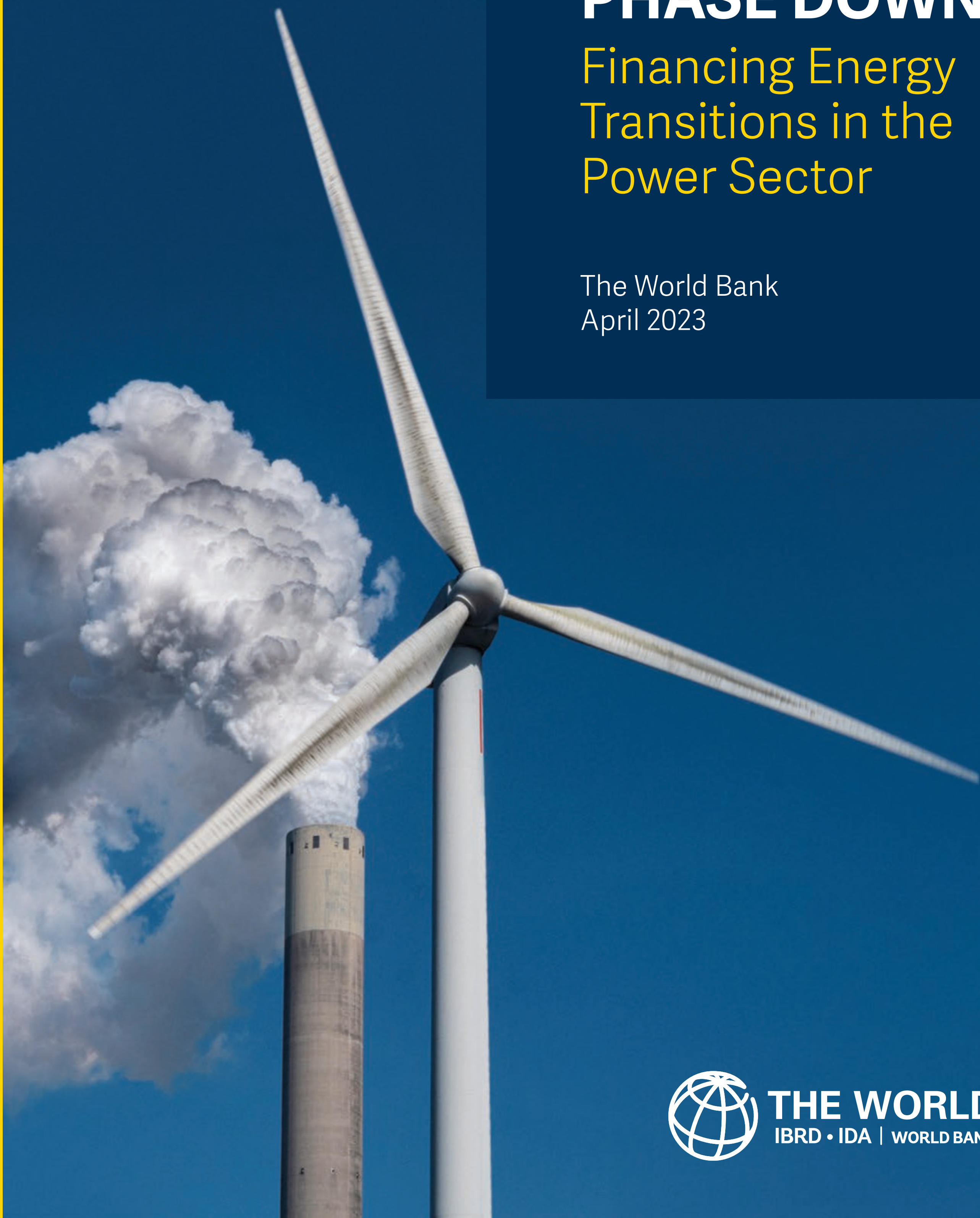

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Executive Summary

The energy transition in low- and middle-income countries (LICs and MICs) will entail an unprecedented expansion and transformation of power sector infrastructure. This transformation will require a massive scaling up of renewable energy and energy efficiency to meet rapidly growing demand, followed by a phasing down of coal-fired power generation. Analyses on decarbonizing the power sector carried out as part of the World Bank's 2021–22 Country Climate and Development Reports found that the pace of deployment of renewables-based electricity must accelerate considerably. The installation rate of solar photovoltaic (PV) capacity will have to double or triple in the next decade in Bangladesh, Ghana, Morocco, and Vietnam, compared with current development trajectories. Similar growth will be required in installations of onshore and offshore wind generation capacity, which will have to increase by 30 to 500 percent in the decarbonization scenarios of Bangladesh, Egypt, Jordan, Morocco, Türkiye, and Vietnam. Simultaneously, energy efficiency and demand-side management will need to be reemphasized to reduce capital requirements of the transition and buy time. In Türkiye, energy efficiency investments that could halve the rate of growth in demand would save $1.3 billion annually in new generation capacity, cutting the cost of decarbonization by 20 percent. Once adequate volumes of affordable and reliable renewable energy and energy efficiency materialize, LICs and MICs will also need to retire their coal-fired power plants. Presently, they collectively host 89 percent of the global coal power capacity that needs to be retired or repurposed before the end of its technical lifetime; this puts an estimated $1 trillion in capital costs at risk by 2040.

To finance a just transition that is consistent with both the goals of ensuring universal access to affordable, reliable, sustainable, and modern energy by 2030, and the 2015 Paris Agreement on Climate Change, developing countries will have to mobilize far more capital than they do today. Power sector investment in LICs and MICs, excluding China, must quadruple: from an average of $240 billion annually in 2016–20 to $1 trillion in 2030. This necessary volume of financing, already unprecedented, will grow as decarbonization deepens. In Morocco, for example, the additional capital expenditure required to advance the transition is estimated at $2.6 billion annually through 2030, rising to $17.4 billion annually by 2050. In Ghana, the figures are similar: $4.8 billion annually by 2030, and $22.6 billion by 2040. However, LICs and MICs, excluding China, are already spending close to $500 billion annually on fossil fuels for power generation (2019 prices), one-half of which is spent on coal and one-third on natural gas. These recurrent energy payments used to burn fossil fuels could go a long way if they were applied instead to bankable investments in clean energy. While current investment is misallocated and insufficient, the volumes needed to meet the Paris Agreement goals are small compared to the costs of inaction and the size of the global economy ($160 trillion in 2022). Nonetheless, in view of the inadequate scaling up in finance thus far, it is clear that new approaches are needed.

Insufficient attention has been paid to the barriers preventing LICs and MICs from mobilizing needed financing. Unless these barriers are removed, they are bound to hinder a just power sector transition. Despite accounting for two-thirds of the world's population, LICs and MICs receive only one-fifth of global investment in clean energy. Scaling investment in the transition for LICs and MICs is held back by:

a. ***Limited affordability*** in terms of the fiscal space needed to make catalytic public investments and consumers' ability to afford the cost of transitions. This barrier means that many countries are forced to settle for fossil fuel–based electricity generation, with its much lower (up-front) capital costs and pay-as-you-go fuel expenses. Many LICs and MICs are locked into costly and often poorly targeted public subsidies for energy that may preclude the strategic investments needed for transition of the power sector.

b. ***Limited access to private capital, and the high cost of capital*** owing to barriers at the country, sectoral, and project levels. Chief among the barriers are underdeveloped domestic financial markets; inadequate alignment with the standards of international financial markets; underdeveloped policy and regulatory frameworks; and institutions that lack adequate capacity. The average cost of capital typical of a high-income country (HIC) is substantially lower than that of a MIC, and the average capital cost of a MIC is substantially lower than that of a LIC.

> *Compounding crises in energy security, affordability, and resilience make it more urgent than ever to identify and address the barriers to accelerating transition of the power sector.*

LICs and MICs are caught in a poverty trap; they are unable to afford the high up-front costs of switching to clean energy, and thus are locked into higher costs and recurring payments for fossil fuels. Up-front capital accounts for a high proportion of the overall costs of renewable energy and energy efficiency, whereas coal and gas power have lower up-front capital requirements but incur higher fuel costs over their operating lifetimes. Combined with the higher cost of capital for LICs, the cost structure of renewables has a distorting effect on choices about how to build electricity generation capacity. In an illustrative country analysis without any carbon emission constraints, meeting the demand for electricity costs 25 percent more for a LIC than a HIC, purely as a result of the LIC having to pay more for the capital needed to build the network infrastructure and generation assets. Because of the higher cost of capital in a LIC and the up-front capital requirements of renewable generation relative to fossil fuels, LICs have less of an incentive to increase the share of renewables in their electricity mix. Continuing the same illustrative country analysis, if a carbon emission constraint is imposed, the incremental cost of achieving the same carbon target is 66 percent higher for a LIC than for a HIC. A LIC would also have to achieve the target using less renewable energy—which is inefficient and expensive. Therefore, LICs and MICs risk being locked out of economic projects for transitioning the power sector—and locked into fossil fuel–based electricity generation despite its high, and volatile, operating costs. This is a poverty trap applied to electricity.

Limited availability and the high cost of capital in LICs and MICs are stifling the formation of a pipeline of promising projects that could help meet development and climate objectives. Pipeline development receives inadequate attention because of limited financing and the holding back of capital by financiers who perceive risks associated with lack of track record and a weak enabling environment; this stalls progress. The fact that access and affordability of capital must be addressed simultaneously creates an opening for multilateral development banks to help LICs and MICs prepare bankable projects that match investors' risk-return expectations, while also preparing upstream studies and improving market conditions.

> *LICs and MICs are caught in a poverty trap, unable to afford the high up-front cost of switching to clean energy, and locked into higher costs and recurring payments for fossil fuels.*

The pathway to universal access to energy and net-zero emissions by mid-century is ambitious and narrow, but it is achievable if governments can foster a virtuous cycle of comprehensive and supportive policies and institutions capable of mobilizing financing that delivers access, security, and affordability while meeting global climate goals (See Figure ES1). To chart that path, governments would be responsible for:

a. **Setting policy directions and laying out roadmaps and targets** to implement the power sector transition, based on a least-cost combination of investment in renewable energy, energy efficiency, and flexibility, accompanied by retirement of existing fossil-fueled generation assets.

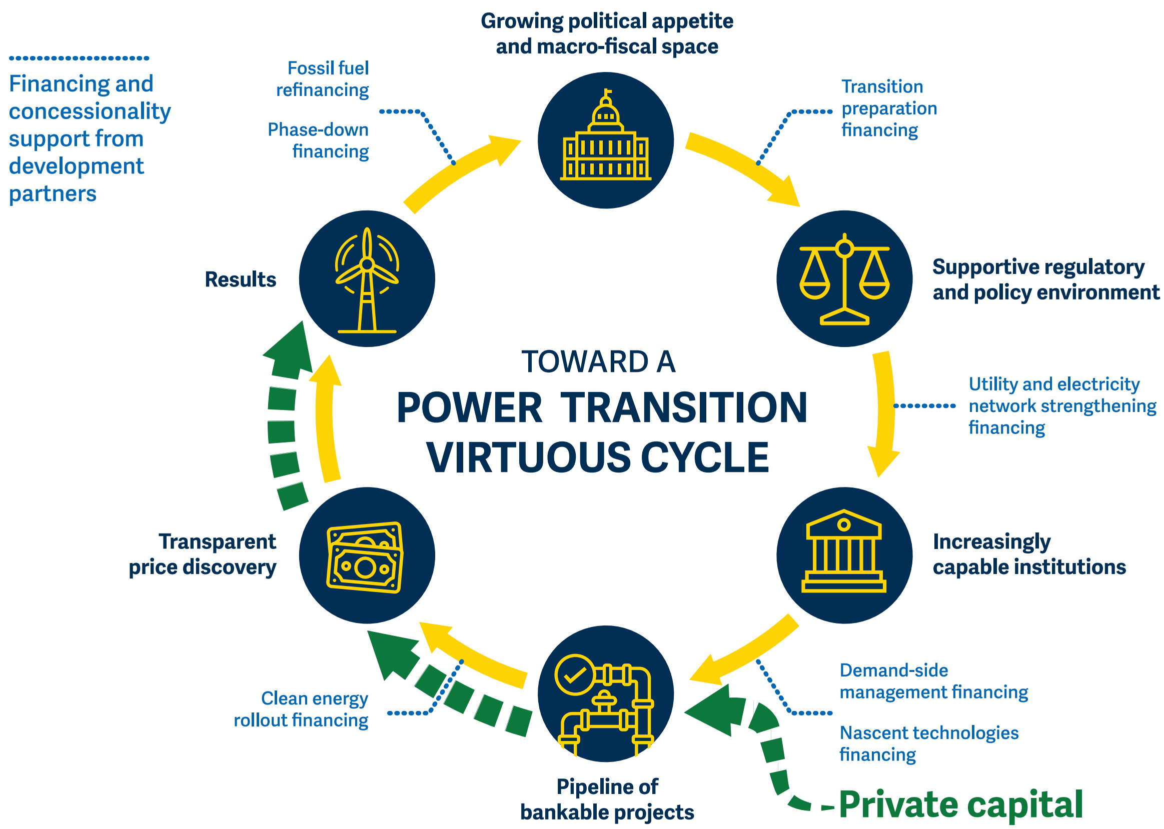
b. **Establishing regulatory frameworks and concrete long-term action plans** to guide transition of the power sector. Undertaking economy-wide or sector-wide reforms that strengthen the macroeconomic environment and governance at the country level can serve to improve the environment for private investment and enable governments to raise funds for catalytic investments. Over time, these reforms should also help lower the cost of capital and thus ease a major barrier to scaling up investment in clean energy. However, it should be noted that these interventions are complex and are not addressed holistically in this paper.

c. **Strengthening the institutions that design, operate, and regulate the power system.** These institutions must make sector plans, set expectations for future power market developments, help investors navigate the risks of stranded assets, and strengthen the transmission and distribution grids so they will not become a bottleneck for off-take of variable renewable energy.

d. **Allocating fiscal resources to prepare projects and mitigate the risks of early transition investments** to incentivize increased private sector participation, including through the adoption of robust carbon pricing and policies.

e. **Ensuring that results serve near-term imperatives such as energy security, energy affordability, and job creation.** Early results that successfully balance objectives related to development, distributional consequences for stakeholders, and transition objectives are likely to strengthen long-term political commitment to sustaining and deepening transition of the power sector. Government guidance and leadership are the critical first steps in laying down a foundation for minimizing risks, boosting market confidence, and ensuring that a growing share of the results will be achieved by private capital.

Figure ES.1 A virtuous cycle to propel the power sector transition, with financing approaches that can help to overcome barriers at each stage



Source: World Bank.

LICs and MICs need support—including low-cost ("concessional") financing—to overcome barriers at each stage of the virtuous cycle; initially to *scale up* clean energy development and to boost efficiency, and then to *phase down* the use of coal for power generation. Many LICs and MICs need the most support for the following barriers when scaling up:

a. **Sector reforms, integrated planning, and capacity building to mitigate the risks of investment in a clean energy supply.** This includes improving electricity pricing by strengthening electricity markets and reforming subsidies to better support policy goals. More comprehensive power sector planning is needed to guide development and minimize capital requirements for the power sector transition. The planning must reemphasize energy efficiency and demand-side management as central parts of capacity expansion. Planning must also coordinate the expansion and modernization of electricity grids as foundations for integrating larger volumes of renewable electricity and storage. Strengthening core sectoral institutions, particularly utilities, is needed to reduce developers' risks. These sector fundamentals are needed in order to systematically mitigate the risks and thus enable greater participation from the private sector in clean energy investment.

b. **Reduction of the up-front costs of clean technologies to enable cost-competitive, affordable, and reliable clean energy.** Projects must be delivered at the least cost to consumers, including through market competition and transparent auction approaches—these are necessary conditions for attracting concessional climate financing. Where risks and costs have been reduced to the extent possible, the adoption of promising emerging technologies can be accelerated using so-called viability gap funding until costs fall and markets mature.

Frameworks to phase down the use of coal-fired electricity are needed in order to manage the financial and societal challenges of power sector transition and reduce the risk and impact of stranded assets. These challenges include:

a. Ensuring that planning covers the risks of stranding new thermal generation plants, and the timeframe for retiring or repurposing existing plants;
b. Preparing just transition programs as coal-fired power plants are retired or repurposed to manage the social, environmental, and distributional impacts; and
c. Initiating policies and institutional reforms, and communicating strategies to retire and repurpose coal-fired generation at scale so stakeholders can prepare and minimize exposure to losses.

Because the majority of the financing needs of power sector transition must come from private sources, and because public and donor finance are so scarce, resources with a higher grant element—or concessionality—must be prioritized strategically across the virtuous cycle and deployed with a disciplined approach. The degree of concessionality should be sufficient to overcome well-identified and significant barriers to the transition, but should not be higher. Their use should reflect the transformational potential of a given intervention to sustain virtuous cycles until fiscal and end-user affordability is achieved. Such an approach will make it possible to accelerate the scale and speed of power sector transition before the enabling environment and other elements of the virtuous cycle are fully in place, and will no longer require as much concessional support, if any, as laid out in the World Bank's 2018 publication on the strategic use of concessional climate finance.

To create conditions for mobilizing the largest possible amounts of private capital, the use of concessional finance must be scaled up, sustained, coordinated, and carefully programmed. Existing schemes that optimize multiple sources of capital are reviewed in this report. They include (i) engagements that tailor needs to country contexts to support the virtuous cycle; and (ii) global technology demonstration partnerships. Country-based programmatic approaches leverage concessional and blended financing to mitigate risks at the country, sectoral, and project levels for the purpose of attracting private capital at the scale necessary for power sector transition. In this approach, financing sources are coordinated and applied toward a series of goals to advance needed policy and utility reforms; to de-risk and support renewable energy, energy efficiency, and investments in network reliability; and to retire coal-fired generation assets and ease the related social impacts. This approach will require many of the products of multilateral and regional development banks—notably loans and guarantees backed by technical assistance and analytics. Technology demonstration partnerships hold promise for mitigating the risks posed by nascent technologies particularly in frontier markets and thereby scaling up financing for those technologies and driving down costs. Such partnerships could serve as platforms for development and demonstration in developing country contexts, and be helpful in refining associated policies, regulations, and procurement processes.

Figures, Tables, Boxes

Introduction

The *Scaling Up to Phase Down* approach is a contribution by the World Bank to the ongoing debate on how to accelerate energy transition in low- and middle-income countries (LICs and MICs)—as called for by the 2015 Paris Agreement on climate change—while simultaneously widening access to the reliable and affordable energy that underpins countries' development goals. The approach is intended to be a bridge between the challenges facing World Bank clients who are seeking to transition their power sectors and the development partners supporting their efforts.

The energy transition is the process of shifting the global energy system away from the consumption of fossil fuels and toward low-carbon technologies in order to support international goals of limiting climate change. In the next decade, much of this transition will first occur in the power sector because solutions using newer technologies have the potential to become cost competitive with appropriate interventions, and also because the power sector is a powerful pathway for decarbonizing other sectors—most notably transport, buildings, and industry. The power sector is therefore the focus of this report.

The power sector transition will advance energy efficiency and decarbonize the energy supply by expanding renewable energy and strengthening electricity networks in order to integrate renewable energy, demand-side management, and end-use electrification. In LICs and MICs, this transition aims to meet the rapidly growing demand for energy in a way that supports inclusive development consistent with net-zero global emissions by mid-century, and builds resilience to the changing climate. A just transition in the power sector should address the needs of workers and communities who are affected by the shift away from fossil fuels; provide modern energy access to millions of people; and protect vulnerable customers from unaffordable energy prices.

For the first time, the World Bank has outlined a vision for how the international community can support LICs and MICs to overcome critical barriers that are paralyzing the power sector transition. Drawing on findings of the first set of Country Climate and Development Reports produced by the World Bank, and decades of engagement with energy sector development, this approach distills understanding of the unique challenges that LICs and MICs face in undertaking this transition at the scale and pace required to meet their development and climate needs. The approach may help both World Bank clients and development partners in preparing a roadmap to catalyze and sustain a virtuous cycle that unleashes urgently needed investment in power sector transition.

Chapter 1 explains that the capital-intensive nature of clean energy investments, combined with the lack of access to affordable capital, have a disproportionate and distorting effect on the power sector transitions of LICs and MICs. Even where renewable energy has the potential to provide a more affordable energy supply and improve energy security and health, the up-front capital costs that must be borne leave LICs and MICs locked into using costly fossil fuels.

Chapter 2 discusses additional barriers to the scaling up of clean energy and the concomitant phasing down of coal. The commitment of governments will be essential in order to foster the policies, regulations, and institutions needed to prepare a pipeline of projects that can attract private capital. This chapter argues that concessional finance is essential in order to overcome the barriers to investments of private capital at the necessary levels.

Chapter 3 discusses how public and concessional support must be deployed with a disciplined approach in order to scale up clean energy and energy efficiency.

Chapter 4 explains the need to phase down the use of unabated coal, and the instruments to do so in a manner that manages losses and protects the most vulnerable.

Chapter 5 concludes the paper with a discussion of how larger and sustained volumes of concessional capital could be more effectively structured within country-based programmatic approaches and technology demonstration partnerships in order to scale up the financial resources and political momentum for transitioning the power sector.

Chapter 1

The challenges of financing power sector transition in low- and middle-income countries

KEY TAKEAWAYS

- Power sector transition in LICs and MICs entails a massive scale-up of financing to meet rapidly growing demand, and to cover the incremental cost of decarbonization, particularly during the phasing down of coal-powered generation.
- The capital-intensive nature of clean energy, combined with the limited access of many LICs and MICs to affordable capital, is a major barrier to power sector transition.
- LICs and MICs face a triple penalty: despite tight budgets, they pay more for less clean energy. Without access to more and cheaper capital, LICs and MICs risk being locked out of otherwise economic solar, wind, and energy efficiency projects, which require relatively high up-front capital investment. At the same time they are being locked into fossil fuel generation despite its higher and volatile operating costs. This is a poverty trap applied to electricity.

Low- and middle- income countries (LICs and MICs) are demonstrating their political commitment to a just energy transition, in particular through their Nationally Determined Contributions (NDCs). Although many have yet to develop credible sector-level implementation plans for achieving their development ambitions while reducing emissions, through their national pledges they are explicitly or implicitly demonstrating their commitment to transition their power sector toward cleaner sources of energy. This transition aims to support the rising consumption associated with expanded access to energy and inclusive economic development, while also maintaining low emission levels consistent with the global goal of net-zero emissions by mid-century. The transition hinges on the advancement of energy efficiency, the expansion of renewable energy, and the strengthening of electricity network capacity to integrate variable renewable resources, improve resilience, and eventually replace fossil fuels. It also aims to accommodate the increased demand caused by expanded access and economic development, as well as by the progressive electrification of other end-use sectors. At the same time, the power sector transition must be "just." That is, it must attend to the needs of the workers and communities who are affected by the shift away from fossil fuels; provide modern energy services to all people; and protect vulnerable customers from unaffordable energy prices. Governments are more likely to formulate and execute politically sensitive just transition plans if they have confidence that they will be able to access financing on affordable terms.

The global economic and geopolitical situations have heightened uncertainty among governments and investors about the future of the power sector transition. Fuel supply faces the most visible cost pressures, but the cost of clean energy technologies such as solar panels and some wind turbines has also increased. About one-half of the capital invested globally in the energy sector in 2022 went to meet higher costs rather than to fund new infrastructure (IEA 2022). Compounding crises in energy security, affordability, and resilience make it more urgent than ever to identify and address the barriers to accelerating transition of the power sector.

Mobilizing sufficient capital and meeting the added costs of power sector transition

To finance a just power sector transition, LICs and MICs must mobilize far more capital than they do today. To be on track toward net-zero emissions globally by 2050, power sector investment in LICs and MICs, excluding China, must rise from an average of $240 billion annually in 2016–20 to $1 trillion in 2030 (IEA 2021a).[1] In particular, eight middle-income countries (China, India, Indonesia, Malaysia, the Philippines, South Africa, Türkiye, and Vietnam) will need to phase out more than 1,440 gigawatts (GW) of coal-fired generation by 2050 and replace it with new technologies, at a cost estimated to exceed $2,750 billion. LICs and MICs collectively host 89 percent of the estimated $1 trillion in global coal-fired power generation at risk of being stranded.[2] The volume of additional financing needed is substantial—but not relative to the size of the global economy ($160 trillion in 2022). The $130 trillion in financial assets under management by the 450 financial firms from 45 countries that have committed to aligning their operations and financing with the Paris Agreement could—in principle—readily supply the financing needed for transition of the power sector. Importantly, LICs and MICs are spending $345–446 billion annually on fossil fuels for power generation, one-half of which is spent on coal and one-third on natural gas.[3] Rather than burning through recurrent energy payments for fossil fuels, countries should be redirecting their funds over time to more productive investments in clean energy that will provide returns on their debt and equity capital.

> *Misallocated and insufficient: Power sector investment in LICs and MICs, excluding China, must rise from an average of $240 billion annually in 2016–20 to $1 trillion in 2030. Recurrent payments currently to burn fossil fuels could go a long way if applied instead to bankable investments in clean energy.*

Significant investment in generation capacity, storage, and grid expansion will be required to ensure reliable access, and to meet the increasing demand for electricity; transition of the power sector adds to these investment needs. The transition can be broken down into (i) investment to close the access gap and serve rising demand; and (ii) the additional cost of decarbonization. Meeting electricity demand in Bangladesh and Morocco, to take two examples, would require a doubling of annual power sector investment by 2033 and 2044, respectively. Decarbonization would imply additional costs to be borne by the consumers of electricity and taxpayers. According to the decarbonization analyses undertaken by the World Bank in several Country Climate and Development Reports, the addition of decarbonization to power system expansion increases the present value of total economic costs from 1 percent (in Iraq) to 10 percent (in Morocco and Ghana). Assuming these costs were transferred to electricity consumers, the average electricity generation in 2040 would increase between 10 percent (Morocco, Türkiye) and 30 percent (Bangladesh, Ghana). The benefits of decarbonization—increased economic and energy efficiency, lower energy imports, greater energy security, and improved resilience to climate shocks—far outweigh the costs, but the additional cost of decarbonization, particularly if it is reflected in power tariffs, represents a barrier that deters investment.

1 Numbers include emerging market and developing economies (EMDEs) in Africa, Europe, Latin America, the Middle East, and Asia, plus four Organisation for Economic Co-operation and Development (OECD) countries: Chile, Colombia, Costa Rica, and Mexico. China is excluded as a major outward investor in EMDEs.

2 World Bank Group analysis of World Electric Power Plants database, December 2019.

3 World Bank estimate, based on IEA World Energy Balance data and 2019 prices. Recent price escalations imply that this figure is underestimated.

The additional capital requirements of power sector transition increase as decarbonization deepens. In the early stages of renewable energy penetration, the existing system, particularly for larger power systems in MICs, will be able to provide most of the flexibility needed to accommodate variable renewable sources of generation, such as wind and solar. However, as decarbonization targets become stricter, it may be necessary to resort to more expensive renewable generation (owing to diminishing returns from the cheaper resources) and to deploy low-carbon sources of flexibility and firmness (for example, energy storage and thermal plants running on green hydrogen, or equipped with carbon capture and storage). All of these will raise costs. As an example, in the decarbonization scenario for Morocco, the additional overnight capital expenditure to initiate the power sector transition is $2.6 billion through 2030, escalating to $17.4 billion through 2050. In Ghana, similar figures are estimated to reach $4.8 billion by 2030 and $22.6 billion by 2040.[4] In Türkiye, electrifying buildings could double peak demand for electricity in 2040 unless major energy efficiency investments are implemented. Halving the rate of demand growth would save $1.3 billion annually in new generation capacity, cutting the cost of decarbonization by 20 percent—but only if incentives for improved efficiency were in place and capital for efficiency investments was available (World Bank 2022).

> *In Türkiye...major energy-efficiency investments [could cut] the cost of decarbonization by 20 percent—but only if incentives for improved efficiency were in place.*

LICs and MICs tend to be more vulnerable to the impacts of climate change; yet their ability to invest in more resilient energy systems is also constrained by limited planning capacity, access to capital, and affordability. While LICs contribute the least to global carbon emissions, they are disproportionately vulnerable to the negative impacts of climate change because of their weaker infrastructure and limited buffers to absorb shocks; this has repercussions for safeguarding development gains and security. The natural disaster–driven damage to critical infrastructure, including power generation, costs LICs and MICs about $18 billion per year, straining already tight fiscal space and lowering investment appetite in the power sector (World Bank 2019b). On top of the cost of damaged assets, disruptions in reliable service to households and firms add to the expense, with the estimated disruption cost ranging between $391 and $647 billion a year. While resilience investments in the power sector pay for themselves in the long run, as with mitigation investment, the up-front cost barrier is formidable for many LICs and MICs.

The higher transition barriers facing LICs and MICs

While the scale and urgency of the power sector transition are widely recognized, insufficient attention has been paid to the unique barriers crippling the ability of LICs and MICs to catalyze the needed financing. Although they account for two-thirds of the world's population, LICs and MICs receive only one-fifth of global investment in clean energy (IEA 2021a). Scaling transition investment in LICs and MICs is held back by (i) *limited affordability*, in terms of limited fiscal space to make catalytic public investments and limited consumer ability to pay for cost increases; and (ii) *limited access to private capital, and the high costs of capital,* owing to barriers such as underdeveloped domestic capital markets and inadequate alignment of policy and regulatory frameworks with the standards of international capital, as well as risks posed by an underdeveloped power sector policy and regulatory frameworks and institutions with inadequate capacity. Each of these barriers is discussed below.

4 World Bank estimates. These estimates account primarily for the incremental cost of increasing the share of renewables in electricity generation. The additional costs of ensuring a more resilient and modern electricity network are not included.

Limited affordability. Governments in many LICs and MICs have severely limited fiscal space and therefore limited ability to afford the public expenditure needed to catalyze private investment in the transition of the power sector. The global economic crisis is exacerbating that challenge. The limited public resources available to LICs and MICs are focused on immediate economic and social issues, which, if they touch on the power sector at all, involve basic system development, such as expanding access to electricity or relieving immediate short-term challenges such as the unsustainable financing of electricity utilities. Many power sector utilities are not financially viable; this is often due to poor governance and management, and associated high costs and inefficiencies. Financial recovery of utilities is further complicated by the low incomes of consumers, who cannot afford higher electricity prices. The affordability barrier can starve utilities of cost-saving investment, leaving many countries to settle for fossil fuel–based electricity generation, with its much lower up-front capital costs and pay-as-you-go fuel expenses. Moreover, many LICs and MICs are politically locked into costly and often poorly targeted public subsidies for energy that may preclude the strategic investments needed for the transition.

Limited access to private capital, and the high cost of capital. Most LICs and MICs are unable to raise affordable capital because of their shallow and limited access to capital markets. Developing countries represent only 10 percent of the global outstanding issuances of international debt capital, with the majority occurring in just a few countries.[5] Developed countries—with $22 trillion in outstanding debt issuances by comparison—also have the benefit of more advanced local currency markets. The limited depth of local currency financing markets and the lack of robust hedging instruments for long-term, hard-currency financing pose a major challenge to financing the power sector transition in LICs and MICs. For instance, while advanced market structures in high-income countries have deep and efficient local currency bond markets offering long-term yield curves and price references, this success cannot be readily replicated in LICs and MICs. The causes are underdeveloped securitization and inadequate debt-capital innovations and instruments; local liquidity constraints; high transaction costs; a lack of robust environmental, social, and governance (ESG) frameworks; information asymmetry within markets; and weak institutional capacity. All are barriers to accessing capital on affordable terms. At the same time, some MICs are attractive to foreign investors due to their sizeable markets and creditworthy utilities, but they have policies favoring domestic state-owned enterprises over private investors for various reasons of political economy. In such cases, the barriers are self-imposed but are still politically challenging. A related problem is that domestic ESG standards may not be developed or aligned with international standards for sustainable investing. Macroeconomic stability, a robust legal and institutional environment, sector sustainability, and a certain level of development of the domestic financial sector are all important preconditions for mobilizing private capital.

> *Of 144 LICs and MICs, only 19 are investment grade-rated. High cost of capital could inhibit power-sector transition or compromise fiscal and end-user affordability.*

Raising affordable and long-tenor capital is also complicated by rising debt levels in most LICs and MICs. Economic growth that could lessen the burden of debt repayments has been held back by adverse macroeconomic shocks. Of 73 LICs that were eligible for the Debt Service Suspension Initiative in 2020–21, 41 are in debt distress exacerbated by macroeconomic stresses due to the COVID-19 pandemic and the ongoing war in Ukraine. The burden of existing sovereign debt weighs on the ability of governments to borrow further. International credit rating agencies downgraded more than 40 LICs and MICs between January 2020

5 Statistics from the Bank for International Settlement, Q3 2022.

and February 2021, stating that 17 were either in or at risk of default. The ongoing increase in interest rates to tame inflation will further increase the cost of borrowing—and therefore the cost of capital for transition investments—worldwide. Of 144 LICs and MICs, only 19 are investment grade–rated.[6] Unless countries are able to turn around the conditions that limit their robust and affordable access to long-term finance, they will be unable to contribute to the global public good of transitioning their power sectors toward clean energy and away from coal.

The consequences of these barriers for the transition

Where capital carries higher costs, projects require higher returns to be bankable; this can trigger affordability constraints and render projects nonviable. Taking a stylized country example, Table 1 illustrates the additional system costs and generation mix associated with decarbonizing the power system relative to a baseline where emissions reductions are not imposed. The results show the impact that capital costs typical of high-, middle-, and low-income countries would have on an illustrative model of power system decarbonization, all else being equal. In this illustrative country analysis, meeting electricity demand without any carbon emissions constraints costs 25 percent more for a LIC than for a high-income country (HIC), purely as a result of the LIC paying more for the capital needed to build the network infrastructure and generation assets. Continuing the same analysis, if a carbon emissions constraint is imposed, the incremental cost of achieving the *same carbon target* is 66 percent higher for a LIC (increment of 15) than for a HIC (increment of 9). With many consumers already finding electricity unaffordable, and the power sector transition raising system costs overall, the LICs appear bound to pay the most to achieve the same goals because of higher capital costs.

Table 1. Power System Cost and Contribution of Renewable Energy by the Typical Cost of Capital in High-, Middle-, and Low-Income Countries

Country type	Present value of system cost (normalized to 100)		Renewable energy in 2050 generation mix (%)	
	Baseline	Decarbonization	Baseline	Decarbonization
High income	100	109	70	89
Middle income	109	121	66	86
Low Income	125	140	59	83

Note: To illustrate the impact of different capital costs on the cost of decarbonization and the contribution of renewable energy, the World Bank's Electricity Planning Model was used to model a single, generic, mid-sized power system. In a baseline and decarbonization scenario, three different sets of assumptions were applied to reflect the different costs of debt and equity that are broadly typical of countries at a particular income level. These values are not an average across countries. Results could vary considerably among countries even within the same income group. For comparison, the present value of system cost has been normalized to 100 for the baseline in high-income countries.

Source: World Bank estimates.

Because of scarce and costly capital, LICs and MICs risk being locked out of economic projects related to transition of the power sector—and locked into fossil fuel generation of electricity despite its high and volatile operating costs. Critical transition technologies, such as wind and solar power and energy efficiency, face a disadvantage because of the cost structure of these technologies. Up-front capital accounts for a high proportion of the overall costs of solar and wind power, whereas coal and gas power have lower up-front capital requirements as a proportion of their overall costs, but they incur substantial fuel costs over their operating lifetimes. The levelized cost of energy of newly constructed solar and wind power plants (and of energy efficiency retrofits) is increasingly competitive, even with the marginal operating cost of existing coal- and

6 Botswana, Bulgaria, Chile, China, Croatia, India, Indonesia, Kazakhstan, Malaysia, Mauritius, Mexico, Panama, Peru, the Philippines, Poland, Romania, Thailand, Trinidad and Tobago, and Uruguay.

gas-fired generation (Lazard 2021).[7] However, Table 1 shows that the higher cost of capital in a LIC can make economic investments in solar and wind power plants unaffordable, such that LICs serve the same energy demands with lower levels of renewables. This is true in both the baseline and decarbonization scenarios. ***More economically viable options are available, but lower-income countries cannot afford to invest in them.***

> *About 10 percent of the total financing needed in both LICs and MICs would have to be on grant terms, but grant element is about 31 percent higher in LICs than in MICs.*

LICs and MICs are thus caught in a poverty trap, unable to afford the high up-front cost of switching to clean energy, and locked into higher costs and recurring payments for fossil fuels. Providing international funds with lower costs of capital to LICs and MICs can correct this penalty and offset the additional costs that LICs and MICs must pay to decarbonize. In the example from Table 1, a LIC could supply electricity in a decarbonization scenario at the same cost as in the baseline scenario only if it were able to lower its weighted average cost of capital by nearly 4 percent. To achieve the same goal, the MIC would need to lower that same cost by 3 percent. To ensure that electricity in a decarbonization scenario would cost the same as in the baseline scenario, about 10 percent of the total financing needed in both LICs and MICs would have to be on grant terms. ***However, it is important to note that this needed grant element—or the degree of concessionality of financial support—is about 31 percent higher in LICs than in MICs.*** In short, the cost of capital is a fundamental barrier that could inhibit power sector transition or compromise fiscal and end-user affordability. The chapters that follow discuss the importance of concessional financing to bring these costs down, both directly and by helping to address the fundamental barriers to power sector transition.

7 The levelized cost of energy (LCOE) annualizes the capital cost in the break-even price for selling electricity. The LCOE derived in the study is the levelized cost of energy ($/MWh) that would provide an after-tax internal rate of return on equity equal to an assumed hurdle rate.

Chapter 2

The foundations of power sector transitions—and concessionality as a catalyst

KEY TAKEAWAYS

- Government leadership on power sector transitions is translated into a supportive regulatory environment, increasingly capable institutions, and instruments to minimize risks, followed by transparent and competitive project allocation, which can deliver outcomes that serve immediate needs, including energy security, energy affordability, and jobs. These results enable governments to sustain and deepen commitment to power sector transition. Assessing barriers to the foundations of transition will help governments articulate needs for technical and financial support.
- Disciplined application of concessional finance removes the barriers to catalyzing and sustaining this "virtuous cycle" while protecting fiscal and end-user affordability during the transition. These resources are needed to help governments strengthen the enabling environment; build interest in a pipeline of bankable projects; procure affordable and reliable clean energy services; and support the phase down of coal.
- Concessional finance must be prioritized for investments that have the potential to transform the power sector by de-risking and attracting private capital on favorable terms; improving the cost-competitiveness of the newer technologies critical for the transition; and financing noncommercial investments and activities of significant social benefit.

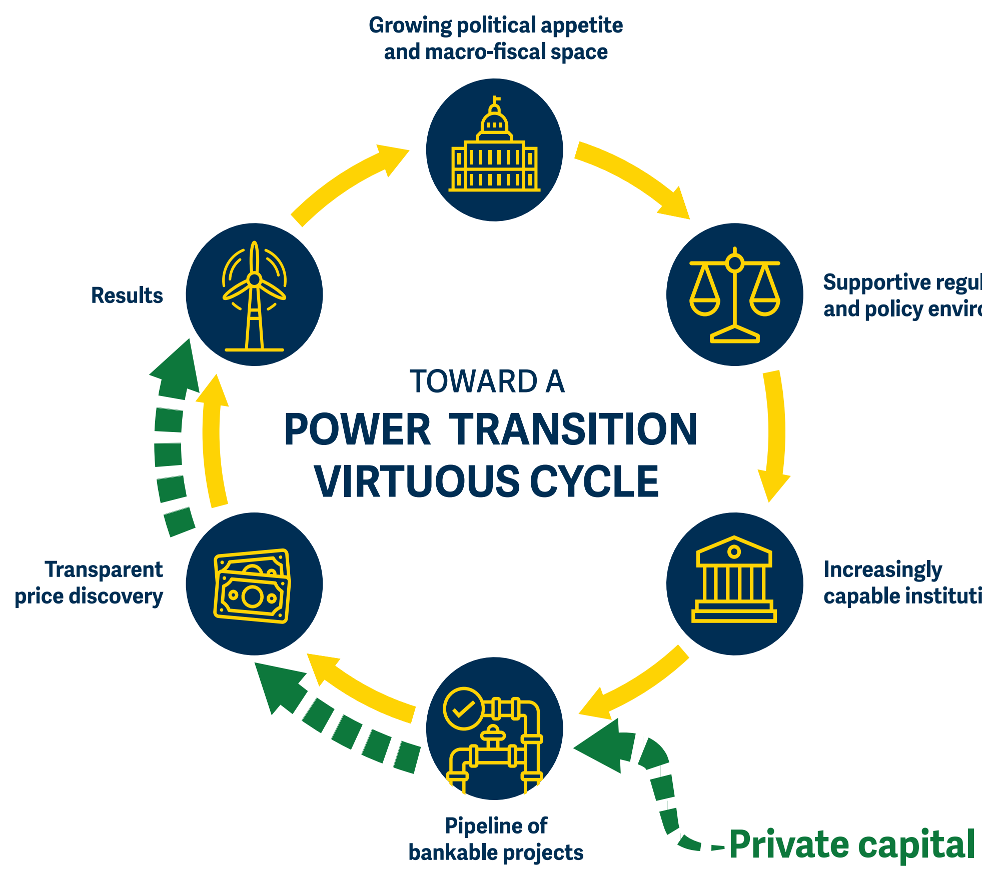
Responsibility for fostering a strong enabling environment at all levels to propel the power sector transition lies squarely with governments. Governments are responsible for (i) ***setting policy direction and implementation roadmaps*** for the transition; (ii) ***establishing regulatory frameworks and concrete long-term action plans*** to guide the transition; (iii) ***strengthening the power system institutions that must make informed sector plans,*** setting expectations for future market developments, and helping investors navigate the risks of stranded assets; (iv) ***allocating fiscal resources to mitigate the risks of early transition investments,*** and incentivizing private sector participation, eventually including robust carbon pricing; and (5) ***ensuring that early results serve near-term imperatives*** such as energy security, energy affordability, and job creation. Results that successfully balance the objectives of the transition with those related to development and distributional consequences for stakeholders, are likely to strengthen the long-term political commitment to sustain and deepen the transition. The essential message is that putting the foundations for power sector transition into place will reduce its costs and enable scaling up. The components of this foundation are discussed in the sections below.

> *A strong governmental commitment to transition of the power sector will reduce investors' risks and lower the risk premiums they expect.*

The policy foundations of a virtuous cycle for scaling power sector financing

Sound policy enables a *virtuous cycle* that catalyzes private capital for power sector transition. Figure 1 represents a cycle in which policy is translated into results. Each step reinforces the next, steadily building momentum for sustained and deepened action. Government involvement sets the foundation by minimizing risks and encouraging a growing share of the results to be achieved by private capital. While improving fundamental sector conditions can go a long way toward lowering costs and scaling up clean energy, scaling clean energy can also help to improve fundamental sector conditions. The steps illustrated in Figure 1 are described below.

Figure 1. A virtuous cycle to scale up financing for power sector transition



Source: World Bank.

Political appetite in support of the regulatory and policy environment

A strong governmental commitment to transition of the power sector will reduce investors' risks and lower the risk premiums they expect. That commitment can be expressed through policies with broad stakeholder buy-in, visible strategies to meet the country's Nationally Determined Contributions (NDCs), and measures to achieve long-term decarbonization and build resilience. Regulatory and policy frameworks in the financial and power sectors, including carbon pricing and policy, translate government commitment into implementation roles, targets, and direction. Strong institutions design and implement needed policy, regulatory, legal, market, and procurement frameworks to provide signals to the private sector that they can expand their businesses and should devise new business models aligned with the national plan for the transition.

Building increasingly capable institutions

Competent, credible, financially sustainable institutions are needed for effective planning in the power sector, and for the implementation of measures to reduce investor risk and deepen the pool of available capital. Well-functioning electricity sectors have a whole constellation of institutions—from transmission and distribution utilities to the entities responsible for so-called "soft" infrastructure—that is, market rules, grid codes, spatial planning, tariffs, and regulatory frameworks. Weak institutions raise the perception of risk in the private sector. Although the funds required to create solid institutions are minor compared with sector investment needs, the task of institutional strengthening often remains neglected—and this is a significant oversight. Redressing this deficiency should be a key priority for governments and providers of concessional climate finance.

> *Because power sector transition can be only as successful as its weakest link, strengthening the financial and operational performance of transmission and distribution utilities must be a priority for governments and their partners.*

At the national level, improving the enabling environment for mobilizing domestic and international private capital requires a robust legal and institutional infrastructure, sector sustainability, and a certain level of development of the domestic financial sector. Debt distress and limited fiscal space for transitioning the power sector create a chicken–egg challenge, with the rewards being cost-saving investments and elimination of the need for subsidies. But alternate sources of long-term financing are also needed to ease pressure on public finances. Governments can engage their central banks and other domestic development institutions to provide incentives—including special facilities and financing options—to induce financial markets to lend for energy transition projects. Addressing additional regulatory constraints in the banking sector, shortfalls in institutional capacity, and high transaction costs could help to raise domestic capital for power sector transition. The necessary steps include (i) ***ensuring that capital market policy, and regulatory and institutional conditions support long-term infrastructure investments*** (for example, through prudential and investment regulations); (ii) ***developing the investor base through pension and insurance market reforms,*** and building capacity to help these markets diversify into infrastructure and related asset classes; (iii) ***developing innovative and scalable financing solutions and instruments*** such as co-investment vehicles, including de-risking instruments and facilities to address the risk concerns of investors; and (iv) ***reducing information asymmetry and standardizing taxonomies and frameworks.*** But financial sector regulatory architectures and taxonomies must be aligned with international standards if they are to attract international investors. Unlocking regulatory frameworks can bring in capital from central and development banks, including thematic instruments (green bonds), transition bonds, and sustainability-linked instruments in line with international standards, as well as co-investment platforms and funds (energy transition funds, debt funds, and private equity) and de-risking facilities or guarantee funds.

Critical policy and regulatory institutions in many LICs and MICs have inadequate resources, capacity, and independence to serve the interests of government and consumers. Funding is needed to equip ministries, regulators, and sector planners with the people and tools they need to conduct consultations, engage technical experts, set and enforce targets, formulate regulations, steer markets, and manage procurement.

Electricity transmission and distribution utilities are linchpins for managing and financing power sector transition in this decade, but their role is often underappreciated. Utilities are responsible for essential functions, including building the electricity network; they also serve as off-takers of electricity and are the interface with consumers. They must raise capital at affordable rates in order to expand and modernize networks so they can integrate clean and distributed energy resources, while ensuring a reliable supply of electricity. However, many utilities, especially in LICs, are financially unviable, usually due to a combination of high costs and low revenues. In Sub-Saharan Africa, only about one-third of utilities fully recover their costs. Of the 45 utilities that do not recover their operating and debt service costs, 35 fail to do so despite being subsidized (Balabanyan et al. 2021). A range of issues, including regulated tariffs that are set below the cost of service; unsustainable debt levels; the high cost of electricity generation because of poor planning and procurement practices; and operational inefficiencies (including high losses) raises costs for utilities that often are not covered by the government and cannot be passed onto consumers. In many LICs and MICs, the lack of a sector regulator with enough independence and authority to set and review tariffs goes hand-in-hand with the weak financial health of utilities. Large unrecovered costs start a chain reaction that erodes the utilities' financial positions. Noncreditworthy utilities require sovereign guarantees for liquidity that are sometimes unavailable, risking defaults that can ricochet across the power sector. In MICs with investment-grade ratings, electricity utilities may also be at investment grade and thus in a better financial position to mobilize commercial sources of capital. However, regulatory incentives are often insufficient to induce these utilities to invest in clean energy and phase down their exposure to fossil fuel–powered generating assets.

Because power sector transition can be only as successful as its weakest link, strengthening the financial and operational performance of transmission and distribution utilities must be a priority for governments and their partners. Many measures under the government's or regulators' control can bring utility costs in line with revenues. Chief among these are ***better planning for network investments,*** and procurement practices that minimize the cost of electricity; ***consistent enforcement of tariff-setting regulations,*** including automatic adjustments for the costs of generation; ***mitigation measures to protect poor households; payment discipline*** throughout the supply chain, including mechanisms to ensure timely payment of electricity bills by public institutions; ***improved operational performance of utilities*** through investments in both hard and soft infrastructure (management information systems); ***stronger utility governance and accountability;*** and ***balance sheet restructuring*** to repay arrears and refinance debt to restore the ability of utilities to borrow at a reasonable cost.

> *To avoid bottlenecks for integrating renewable and distributed energy resources, transmission must be properly considered within power-system planning.*

Beyond utilities, national and sectoral institutions need to provide critical direction through analytics that translate political commitments into robust sectoral plans. Ambitious long-term targets for renewable energy and energy efficiency send a signal to the private sector to invest. If the targets are too low or too short-sighted, a vigorous market will not form. Targets should embody a phased approach with clear milestones to signal the path forward and encourage the private sector to engage. Planning should include decarbonization modeling that deals with critical uncertainties about technology maturity, demand, resource availability, commodity market dynamics, and the cost of capital. To avoid bottlenecks for integrating renewable and distributed energy resources, transmission must be properly considered within power system planning—rather than separately, as is frequently the case. Some transmission projects can take as long as 15 to 20 years to complete; this requires lengthy and broad stakeholder engagement for land acquisition and compensation, as well as close coordination with load growth and new sources of electricity generation. Fully integrated planning will increase the accuracy of cost estimates, reduce the risk of stranded assets, and keep risk premiums to a minimum. This process is instrumental in the conception and early preparation of potential projects, and in the creation of an investment pipeline that will be interesting to investors, as discussed below.

Fostering an investment pipeline consistent with the stated policy and regulatory direction

Market signals for energy efficiency and renewable energy are distorted or weak in many developing countries, which reduces incentives for the private sector to invest. The private sector—which consists of commercial developers, engineering firms, and financiers—needs clear signals about demand and incentives if they are to bring their human and financial resources in line with power sector objectives. However, few LICs and MICs have well-developed markets for basic energy services that can signal demand and induce private capital to mobilize. Energy prices, which are often regulated in LICs and MICs, do not reflect the full cost of energy services, including financial costs. Where electricity markets do operate, they commonly co-exist with bilateral contracts that tend to make dispatch in the power system less efficient. Prices that reflect the full costs of energy—and possibly also of energy's carbon externalities—would allow clean energy options to compete fairly and encourage greater investment in energy efficiency, storage, and network strengthening. In the meantime, governments need the capacity to create and enforce codes and standards of efficiency that can build a pipeline of investment and strengthen firms whose business models are being built around energy efficiency.

Governments have a key role to play in supporting the origination and development of initial renewable energy and energy efficiency investments, and sustaining market activity, until market confidence is sufficient to attract private involvement. Public efforts to originate a pipeline of projects and to de-risk investment can kick-start the power sector transition. But the lack of a track record, coupled with technology risks, means that seed capital may be needed to (i) substantially improve the cost-competitiveness of the newer technologies that are required to scale up clean energy, and (ii) sufficiently de-risk investments to attract the private sector. Seed capital supports project preparation activities and encourages financial institutions to initiate lending programs in new subsectors and for a more diverse set of end borrowers. Institutions need early risk capital to carry out upstream studies and to prepare bankable projects that match investors' risk–return expectations. Concessional funds are essential in order to undertake the project preparation activities that are needed to create a robust pipeline.

Developing institutional mechanisms to elicit carbon credits from voluntary or compliance markets can also help generate interest in project origination. Carbon credits for emission reductions—whether provided through voluntary carbon markets or markets established under Article 6 of the Paris Agreement—could complement sources of capital and increase returns, and thus the affordability, of investments in the power sector transition. While some countries have initiated the procurement of credits under Article 6, most LICs and MICs will need dedicated assistance in order to establish the necessary institutional mechanisms and processes to take advantage of carbon markets.

Transparency and competition to deliver results at affordable prices

Transparent, competitive, and predictable procurement processes can help attract more investment, particularly from the private sector. Such processes have been successful in scaling up low-cost renewable energy investments in several international settings, as described in Box 1. Some governments have orchestrated successful programs to bundle energy efficiency projects at public facilities such as schools and hospitals, creating an attractive procurement opportunity for private players. A fair risk allocation between the private and public stakeholders—translated into clear contractual arrangements—will allow governments to drive down the costs of energy services.

Box 1. Two examples of a systematic approach to power sector transition

Morocco's Solar Expansion

Morocco's gradual expansion in solar energy over a decade illustrates the transformative role that concessional financing can play when embedded within a systematic policy vision. In the case of Morocco, the vision included the creation of MASEN, a dedicated state-owned agency responsible for procuring large-scale renewable independent power producers, thus building on the procurement experience of Morocco's electricity utility, ONEE, in the early 2000s.

In the mid-2000s, Morocco explored scaling up solar investments in order to reduce its dependence on imported oil, coal, and gas, and its exposure to the volatile prices of those commodities, as well as to expand its global leadership in climate change mitigation. At the time, because solar energy was not a least-cost option for power, even with Morocco's excellent solar resources, scaling up solar energy required concessional financing, without which the impact of solar power on consumer energy prices would have been politically unviable. Moroccan consumers or taxpayers would not have had the incentive to bear the full additional cost of providing the global public good associated with a lower emissions development pathway.

The Clean Technology Fund (CTF) is part of the Clean Investment Fund, one of the world's largest and most ambitious multilateral climate finance mechanisms for developing countries that are seeking to shift to low-carbon and climate-resilient development, and to accelerate climate action. Launched in 2008[a] the CTF was an essential part of the solution in Morocco. The World Bank helped Morocco mobilize CTF financing on concessional terms (equivalent to those offered by the International Development Association), along with lending from the International Bank for Reconstruction and Development (IBRD), to anchor a package of bilateral and multilateral financing involving multiple donors, and a blend of concessional and nonconcessional resources. The initial result was a 20 percent reduction in the tariff bid by the private investors in the first solar public-private partnerships. The private sector subsequently invested in hundreds of megawatts of solar power generation in Morocco, and the program has had significant regional and global demonstration impacts.

Box 1. Two examples of a systematic approach to power sector transition (*continued*)

India's Solar Parks

India has made renewables—solar energy in particular—central to its efforts to tackle air pollution and climate change, while meeting growing demand for energy and expanding access to it. The creation in 1987 of the Indian Renewable Energy Development Agency was a first step toward enabling financing for clean energy. The Global Environment Fund supported activities from 1993 to 2002 to commercialize renewable projects and attract private financial institutions. Ambition was significantly elevated in 2010 when India committed to establishing 20 gigawatts (GW) of solar power capacity by 2022, which was subsequently raised to 100 GW. By 2015 only about 2 GW had been added, bringing total solar capacity to less than 4 GW. Although solar plants could be profitable, investors were discouraged by inadequate infrastructure, difficulties with access to land, and a lack of familiarity with the sector.

In 2016, India's first Nationally Determined Contribution under the Paris Agreement pledged that approximately 40 percent of the country's installed electric power capacity would be based on non-fossil-fuel–based resources by 2030 with the help of transfers of technology and low-cost international finance. At the time, this pledge was estimated to require $150 billion in funding, much of which would come from private sources following improvements to the investment environment (regulatory reforms and new transmission infrastructure). From 2015, the World Bank Group began supporting the government's efforts to achieve its goal by providing $100 million in concessional finance: a $75 million loan from IBRD, a $23 million loan from CTF, and a $2 million technical assistance grant from CTF. The financing is helping to establish large solar parks in Madhya Pradesh and develop the infrastructure to connect them to the grid and distribute power to consumers.

Along with this, the government worked on improving the regulatory and fiscal environment, as well as establishing fair and binding arrangements among state and national agencies, state-owned enterprises, and private energy producers. One measure has been to double the portion of energy that large-scale consumers must source from renewables, and another to raise the tax levied on coal-derived energy, from less than 3 percent in 2016 to more than 17 percent in 2019. A major outcome was the establishment of a bankable solar project for both domestic and international investors.

Competitively procured, the Rewa Solar Park established a record low tariff for renewable energy—less than 3 rupees (4.4 U.S. cents) per kilowatt hour. Competitive with power produced from nonrenewable sources, the tariff made new investments in coal plants far less attractive and encouraged the Indian government to redouble its ambition to advance solar energy investments in the country—a clear example of the virtuous cycle at work. The World Bank's $18 million dedicated to infrastructure for Rewa leveraged almost 32 times that amount in private investment ($575 million), with International Finance Corporation (IFC) providing advisory services for structuring the transaction and a package of $437 million in commercial financing.

Under the SolaRISING India program, the World Bank Group is working to replicate the success of Rewa by establishing at least three more parks, representing a combined 1.5 GW of capacity. Solar parks built and operated by the private sector are expected to contribute 40 percent of the government's 100 GW target for solar capacity by 2023.

Concessional finance as the catalyst for the virtuous cycle

While governments are responsible for creating conditions for the virtuous cycle, barriers to doing so can be substantial in some countries as a result of weak governance, poorly targeted subsidies, and inadequate capacity and planning, to name a few. As a consequence, power sector transition can be paralyzed, despite its potential to alleviate some of the sector challenges. For instance, utilities could significantly lower their energy supply costs and shield themselves from fuel price fluctuations if clean energy could be scaled up in an affordable manner. Inefficient energy subsidies can be very challenging to remove because of political economy issues, but the scaling up of affordable clean energy can reduce the need for fuel subsidies. ***Given the scale and the pace of transition required to meet the goals of the Paris Agreement, the world cannot afford to wait until LICs and MICs address all of the macro-sectoral issues involved in gaining access to affordable capital, and only then scaling up clean energy.*** Instead, development partners can help LICs and MICs scale up clean energy now as governments demonstrate leadership and commitment to power sector transition, and embark on setting the required policy, regulatory, and institutional framework for it.

Adequate flows of international concessional finance are essential for removing the barriers to catalyzing and sustaining the virtuous cycle, while *protecting fiscal and end-user affordability amidst the transition of the power sector.* Any concessional finance should be used with a disciplined approach in order to accelerate affordable transition. The degree of concessionality—or the size of the grant element blended with other sources of finance—should be sufficient to overcome significant, well-defined barriers to transition, *but not be higher.* ***The key consideration for the use of concessional resources should be the transformational potential of a given intervention to strengthen and accelerate the virtuous cycle by dismantling barriers, so that subsequent cycles will need less, or no, concessional support*** (World Bank 2018).[8] Because the majority of financing needs for the transition must come from private sources, transformational potential is considered as the ability to scale up private finance by catalyzing the virtuous cycle, eventually making markets sustainable without the further use of concessional finance.

> *Concessional finance is not a substitute for the fundamental reforms needed to propel the virtuous cycle. However, concessional support can help to facilitate and support fundamental reforms, yielding benefits for the sector's health, decarbonization, and affordability.*

As governments demonstrate leadership and commitment to transition the power sector and assess their progress on each of the six steps in the virtuous cycle, international support provided through concessional finance may be needed to inform policy and regulation, strengthen sector institutions, and populate the investment pipeline. A periodic reassessment of progress in establishing these foundations can be used to adjust the targeting of technical and financial support. Concessional finance is not a substitute for the fundamental reforms needed to propel the virtuous cycle. However, concessional support can help facilitate and support fundamental reforms, yielding benefits for the sector's health, decarbonization, and affordability.

Once the government articulates its commitment to transition the power sector and sets policy and regulatory direction for removing barriers to it, concessional finance may continue to play a role in helping LIC and MIC governments deliver results that keep the virtuous cycle moving. Governments need support

8 This framing of barriers and transformational potential draws on World Bank (2018) "Strategic Use of Climate Finance to Maximize Climate Action: A Guiding Framework." This framework includes "ambition" as a consideration for prioritizing concessional finance, alongside transformational potential, though the framing of this paper presumes *all candidate power sector transition activities are "ambitious" because they orient the country toward a net-zero pathway.*

in order to address the residual regulatory, financial, and technology risks related to unfinished reforms, or to make effective use of new technologies. Such risks may be at the country, sector, or project level.
The degree of concessionality appropriate for each risk will differ depending on the country context, utility creditworthiness, investment bankability, fossil fuel capacity, and domestic capital market depth and liquidity, among other factors.

For many LICs and MICs, concessional finance may be needed for certain near-term activities. For example:

a. **Integrated planning and capacity building to mitigate the risks of investment in a clean energy supply, as previously discussed.** In LICs and many MICs, public and concessional finance are critical to transmission and distribution investments, particularly those made to expand access to electricity or upgrade networks to increase their efficiency and their ability to integrate variable renewable energy. Concessional finance may also be used by utilities as credit enhancements for de-risking and mobilizing commercial finance, as long as reforms are putting utilities on track toward sustainable operational and financial performance.
b. **Cost reduction of clean technologies to enable cost-competitive, affordable, and reliable clean energy.** Market competition and transparent auctions are the best ways to ensure that projects are delivered at the least cost to consumers, and should be necessary conditions for awards of concessional financing. Where risks and costs have been reduced to the extent possible, the adoption of promising emerging technologies can be accelerated with viability gap funding to make technologies cost competitive, affordable, and reliable until markets mature. The de-risking of nascent technology is needed for battery and long duration storage, offshore wind, and green hydrogen, among other things, to make early projects bankable.
c. **Fossil fuel phase-down activities that ease the financial impact of early retirements on the economies of LICs and MICs, and prepare societies to adjust successfully to the energy transition.** Governments in LICs and MICs face the daunting challenge of facilitating the early or accelerated retirement of coal-fired power plants. Concessional resources to refinance existing plant debts make it possible to advance the retirement date, and financial instruments can amortize early retirement costs into the future. Many governments will also need help to ensure responsible physical decommissioning and environmental remediation at coal plants that are being retired and prepare holistic development programs to support the communities most affected by phase-down activities.

Chapter 3

Catalyzing capital for clean energy deployment: toward a comprehensive approach

KEY TAKEAWAYS

Development programs supported by concessional finance can contribute to the following key priorities for scaling up clean energy supply:

- Sector planning, electricity pricing, and subsidy reform to clarify policy goals; systematizing the identification of market barriers, and mobilizing public and private capital
- Strengthening utilities, with a particular focus on expanding their capacity to identify and procure clean energy investment, and to design and develop flexible grids as a backbone of a power system dominated by clean energy.
- Systematically mitigating the risks associated with sources of renewable energy
- Emphasizing energy efficiency and demand-side management to tame the growth of costs
- Devoting systematic attention to emerging technologies to reduce technology risks, improve cost competitiveness, and expand markets.

An unprecedented scale-up of clean energy will be needed in order to achieve countries' development objectives and meet the temperature goals of the Paris Agreement. The decarbonization analysis carried out by the World Bank as part of its 2021–22 Country Climate and Development Reports found that the pace of deployment of renewables-based electricity must accelerate, even in countries that have already made considerable progress. For example, the installation rate of solar photovoltaic (PV) capacity will have to double (and in many cases, triple) compared with the baseline scenario within the next decade in Bangladesh, Ghana, Morocco, and Vietnam. Similar growth will be required in onshore and offshore wind generation capacity, which will have to rise by 30 to 500 percent in the decarbonization scenarios of Bangladesh, Egypt, Jordan, Morocco, Türkiye, and Vietnam.

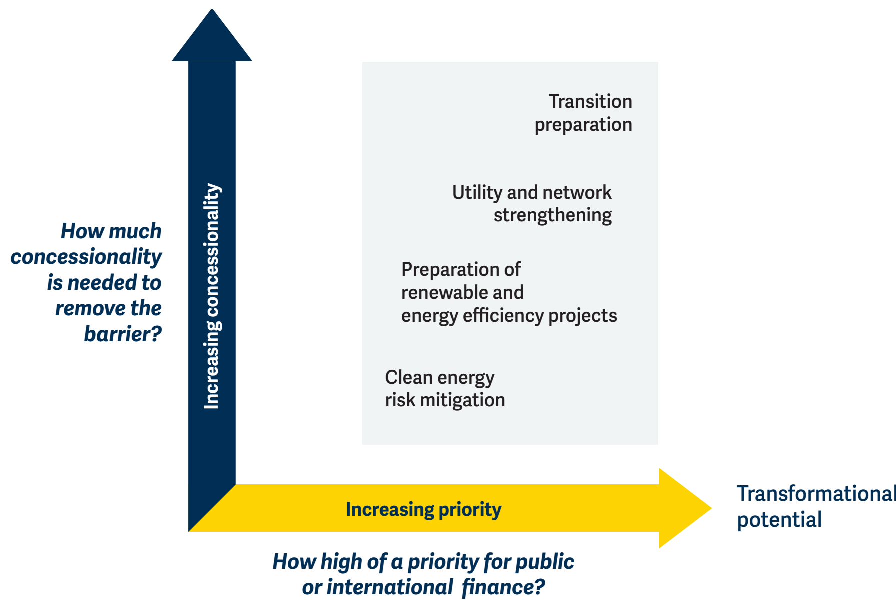
Barriers at each stage of the virtuous cycle interfere with the cycle's momentum and can block clean energy investments, slowing the pace of the transition. These barriers exist at the country, sectoral, and project levels. This chapter identifies five areas where interventions will be needed if most LICs and MICs are to overcome critical barriers. The areas are:

- **Transition preparation activities,** such as sector planning, electricity pricing, and subsidy reform to clarify policy goals; systematize the identification of market barriers; and mobilize public and private capital;
- **Strengthening transmission and distribution utilities,** with a particular focus on their creditworthiness and the capacity of power grids to integrate renewable electricity;

- **Emphasizing energy efficiency and demand-side management** to tame the growth of costs;
- **Systematically mitigating the risks** associated with sources of renewable energy; and
- **Devoting systematic attention to emerging technologies** to improve affordability, reduce technology risks, and expand markets.

Each area calls for a different degree of concessional and commercial finance, as illustrated in Figure 2.

Figure 2. Use concessionality to remove barriers to the virtuous cycle, leading to more private finance for clean energy deployment



Source: World Bank.

Financing to prepare for the transition

Governmental political commitment and leadership are necessary conditions for catalyzing investment in energy transition. Sustaining and deepening the transition requires that ambitions translate into detailed implementation roadmaps that are supported by planning, and adequate policy and regulatory frameworks. LIC and MIC governments commonly need assistance to create this enabling environment.

Power sector planning consistent with stated policy is critical for scaling up clean energy and managing the risks of transition. Power system planning should reflect countries' development and climate change goals as well as uncertainties about the evolution of technology and fossil fuel prices, among other factors. Resilience of the power system and sector assets to future climate shifts requires planning around climate change over several decades using downscaling and the interpretation of climate models (see Box 2). Multilateral technical assistance for such planning will play an important role in informing governments and investors about transition pathways in the medium to long term, and in building a consistent near-term investment pipeline. Planning is also important for identifying and managing the risk of stranded assets.

Preexisting energy price subsidies undercut the positive potential of carbon pricing

Regulatory and policy frameworks must provide credible sectoral direction to reduce investor uncertainty, assign implementation roles across the government and the economy, and allocate resources to protect the vulnerable. Working with multilateral development banks, governments can devise whole-of-economy solutions to optimize the use of limited public finance and identify essential sectoral reforms. Concessional finance will be needed to acquire the personnel and tools to implement targets, make regulations, foster markets, and design procurement processes as expressed in government policy frameworks. For many countries, phasing out fossil fuel subsidies (both explicit and implicit) provides an opportunity to redirect public resources to more productive activities while realigning incentives toward decarbonization. Concessional finance can play an important role in energy subsidy reform by funding technical, analytical, and advisory support to set up and apply a transparent tariff-setting methodology; strengthen social safety nets; and conduct communication campaigns while energy subsidies are being reformed. Governments will also need technical assistance in preparing to use instruments such as carbon pricing embedded in the national decarbonization strategy. These instruments can generate revenues once investment appetite accelerates and institutions are in place.

Box 2. Incorporating resilience in plans for power sector transition

Ensuring that the power sector is resilient against emerging risks, particularly looming climate threats, is a priority in transition of the power sector. Faster and more ambitious decarbonization of the sector can reduce the burden of adaptation, but given its current pace and scale, planning and financing for resilience needs to grow, especially for those LICs and MICs that are on the front line of the climate crisis. Enhancing climate resilience comes with multiple socioeconomic benefits: in LICs and MICs, the average net benefit of investing in more resilient infrastructure can be up to $4.2 trillion, with every one dollar invested yielding four dollars of benefits.[a]

Despite the high return on investment, financing for resilience in the countries that are most vulnerable to the impacts of climate change has not been forthcoming. What makes financing for adaptation, and more broadly for resilience, particularly challenging is the difficulty of defining the financing needs as well as measuring and tracking delivery in the absence of standardized and transparent data and reporting systems. By the best estimates, the average financing flows tagged to adaptation in LICs and MICs in 2019-20 were about $41 billion, less than 10 percent of the total climate finance flows. The majority of the adaptation finance tracked to LICs and MICs was provided by public and international actors, such as national development finance institutions (36 percent) and multilateral development banks (36 percent).

In LICs and MICs, each year of delay in the adoption of resilience–enhancing policies in infrastructure, including the power sector, could cost an additional $100 billion in otherwise avoidable disaster impacts. Hence, it is critical that financing for resilience be accompanied by technical assistance geared toward improving institutional capacity to measure climate risks and take them into account in power sector planning and management, as well as for emergency response and recovery mechanisms.

Box 2. Incorporating resilience in plans for power sector transition (*continued*)

Optimal financing for climate resilience layers three dimensions of public, international, and private finance into early investment that can increase fiscal space. Specifically, public finance can be channeled through budget reallocation and reserve funds while multilateral development banks provide deferred drawdown or equivalent instruments for rapid response assistance in case of disasters. Private sector financing for resilience typically involves catastrophe bonds and other instruments in the insurance and capital markets. Public-private partnerships for climate resilience insurance can help crowd in more private sector capital.

The World Bank Group is committed to scaling up climate adaptation and resilience finance to protect and benefit the most vulnerable. In addition to the continuous provision of contingent financing instruments, such as the Contingent Emergency Response Components, the Bank is exploring instruments to enhance the access of small and medium enterprises to finance using a portfolio credit guarantee scheme that can cover the disaster risks of utilities and system operators. At the upstream level, capacity-building support will be strengthened to enhance data and methodologies for climate risk assessment, and the development of systematic policies and strategies to identify and implement climate resilience measures in a timely manner.

Source: World Bank. 2019. "Lifelines: The Resilient Infrastructure Opportunity". All figures are World Bank estimates.
a. Climate resilience is the ability to anticipate, absorb, accommodate, and recover from the effects of a potentially hazardous event related to climate change (IEA 2020).

Jumpstarting the investment pipeline requires seed capital to prepare promising projects in line with sector plans. Pre-feasibility studies can identify and characterize the technical and financial merits of promising early entry points for project development. Governments can also draw in private interest to pursue projects through schemes to explicitly eliminate known sector risks. For instance, India's solar park scheme (described in Box 1) brought in private investors by having the public sector manage the land risk, including assuring the availability, permitting, and environmental and social aspects of the project. The private sector's ability to lead in identifying and preparing promising projects is increased when governments and development partners share data on physical resource characterizations such as wind profiles and land surveys, power system network maps, and clearly defined and credible plans for further system development.

Financing to strengthen utilities, energy efficiency, and demand-side management

Transition of the power sector will need to occur in parallel with efforts to restore utilities' creditworthiness and strengthen network infrastructure. *Government support can keep utilities functioning effectively as transition of the sector accelerates.* Utilities should be given the technical assistance and financial support they need to strengthen, upgrade, and digitize network infrastructure to meet growing demand, reduce losses, and achieve much greater flexibility in order to accommodate growing shares of variable renewable and distributed energy. They will also need support to build capacity and reengineer their business processes to improve their operational and financial performance and manage an increasingly complex network infrastructure.

Utilities cannot discharge these functions if they are financially unsustainable. A 2018 World Bank market sounding identified weak creditworthiness of utilities—and the prospect that this would make the utilities unreliable off-takers of electricity—as the most important risk that is limiting private sector investment (World Bank 2019a). For utilities that are on track to achieve operational and financial sustainability, risk mitigation guarantees from multilateral development banks and other international donors can ease fears of payment delays, defaults, and termination risks, and thus make the establishment of independent power producers more attractive. But such instruments only have a lasting impact if complemented by efforts to improve utilities' creditworthiness over time. Such products will help the private sector access long-term financing and enable countries to benefit from low-cost renewable energy.

Government efforts to create demand for energy efficiency through policy frameworks, regulatory obligations, and price signals must be accompanied by measures designed to overcome financial risks and technical and institutional obstacles. At the heart of the financial and technical challenges of financing for energy efficiency is the perceived risk of whether the costs saved through greater efficiency will be enough to repay the underlying investments. The technical challenges of (i) establishing proper baselines through energy audits, and (ii) verifying the accrued savings and other system benefits, can lead to higher perceived risks and transaction costs. This in turn reduces investment, undermining the enormous potential represented by energy efficiency and demand-side management.

> *In LICs and many MICs, public and concessional finance is critical to transmission and distribution investments.*

Measures to mitigate the risks associated with energy efficiency investments are too often applied as isolated pilots or short-term fixes. Three strategies can lower the barriers to energy efficiency financing: (i) ***direct financial support*** such as targeted credit lines and specialized funds complementing rebates and subsidies initiated by the government; (ii) ***risk-mitigating mechanisms*** such as guarantees or insurance; and (iii) ***technical facilitation*** from energy service companies or equipment lessors. These measures, individually or in combination, have proven effective in many countries. However, few projects, even those that have met their objectives, have been replicated or scaled up. Because it takes time to create a commercial finance ecosystem, concessional support must be sustained while the market compiles a sufficient track record and assembles a solid pipeline of projects in energy efficiency and demand-side management.

Building a critical mass of demonstration projects will build the case for energy efficiency and catalyze a scale-up in energy efficiency financing. Accrediting a larger pool of equipment and energy service providers will enhance trust and confidence in the energy efficiency market. With concessional finance and technical assistance, businesses can be encouraged to enter the market, test approaches and technologies, and develop their capabilities. In the process, they will discover best practices and find ways to reduce risks and costs. Together, their efforts will build the business case for energy efficiency. Engaging a wider range of stakeholders, particularly those in the private sector, in more long-term, national-scale energy efficiency programs with clear targets and strong training components would help to create a sustainable market that could continue to grow as concessional support is phased out.

Financing for clean energy rollouts

Clean energy rollout financing is needed to mitigate the residual risks of renewable energy investments. Affordable power networks, robust institutions, and even affordable capital are not enough to pivot investment toward renewable energy in all countries. Other instruments will be needed to cover foreign exchange risks, demand risks (for mini-grids), and, in some cases, guarantees to make long-term contracts more affordable while off-takers continue moving toward financial viability. Multilateral development banks and international donors should expand their portfolios of risk mitigation instruments, which could be developed and tested with concessional climate finance to address these issues in developing countries, particularly those posing the highest risks.

Market competition and transparency in clean energy procurement can help drive down costs and protect fiscal and consumer affordability. Auctions are an accepted mechanism for efficient price discovery and can be combined with bulk procurement by the government to aggregate contracts and drive costs down further. India's Energy Efficiency Services Limited has used this approach to purchase low-cost LED lights as part of a World Bank–supported energy efficiency campaign. Governments can also work with development partners to standardize contracts, drawing on international experience to reduce transaction costs and mitigate investor uncertainty about how to protect their investments. Bankable project structures, along with transparent procurement processes and balanced risk allocation, are essential elements in attracting private investors. Development partners can also help governments to structure public first-loss guarantees to reduce real and perceived residual risks for investors, drawing private capital to critical investment areas. Various financing models, such as corporate finance, cash flow–based project finance, and other innovative financing models (for example, asset-backed securitization), are used by both public and private investors. Corporate finance may be based on the strength of the underlying balance sheet and the debt raising capacity of sponsors, whether they are state-owned utilities or private concerns. Project finance may be considered for specific projects in order to enable private sponsors and state-owned utilities to mobilize more capital (through dedicated special purpose vehicles) by leveraging the underlying project cash flow.

Financing for new technology

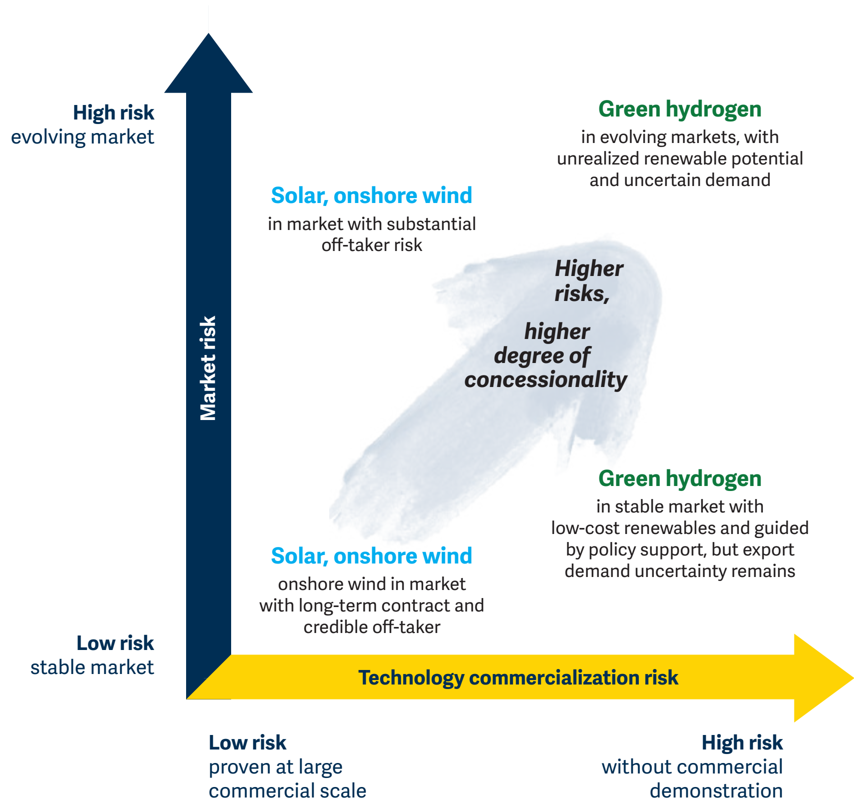
Capital on concessional terms will be needed in order to make early commercial technologies affordable, and to reduce or spread out the risks associated with them. LICs and MICs will need to be fast adopters of new technologies in order to support transition of the power sector. As the transition deepens, new technologies will move from pilots to commercial applications, or from commercial operations in developed markets to large-scale deployment at affordable prices in frontier markets of LICs and MICs (offshore wind is a good example of this). But financing projects with technology that is novel in a given market may require mitigation of the residual technology risk, which is present in first-of-a-kind deployments in any new market or in a new regulatory or environmental context, even if it has been commercially deployed in other markets. Concessional capital may be used to make technologies financeable and affordable in developing countries by de-risking projects through first-loss seed capital, and contingent liquidity to kick-start sustainable lending programs. In addition, some technologies may require significant cost reductions through instruments like viability gap funding for large-scale deployment without adversely affecting financial sustainability; for example, battery storage solutions for more robust and flexible networks. Without concessional support to make capital accessible and affordable until market confidence improves and costs come down, technologies in frontier markets will diffuse only very slowly—if at all—while the lock-in risks of fossil fuels will grow.

Technology commercialization and market risk determine the appropriate level of concessionality for newer technologies, as illustrated in Figure 3. The figure does not address whether the project is worth pursuing; one may assume it has been assessed and determined to have transformational potential. Some examples of World Bank Group initiatives to scale up clean energy technologies are described in Box 3.

Commercial technologies in mature markets require little or no concessional finance. Projects of this sort fall into the lower-left quadrant of the Figure 3. They include well-prepared solar and onshore wind projects in MICs; these are projects that may be financed with private capital at market rates. Some energy efficiency projects—for example, industrial modernization and equipment upgrades in creditworthy countries, LEDs in buildings, and brownfield geothermal projects backed by long-term sales agreements—may be financed in similar ways. Possible sources of finance include commercial banks, the private sector arms of multilateral development banks, export credit agencies, and investment funds.

Concessional finance still has a role in leveraging private capital for mature technologies in LICs. Here affordability may be a concern, and sectoral risks such as the inability of off-takers to pay may require concessional financing to help bring down project costs. Projects of this type fall into the upper-left quadrant. Other possible sources of finance would include, again, commercial banks, the private sector arms of multilateral lenders, export credit agencies, and investment funds.

Figure 3. The degree of concessionality appropriate for the deployment of clean energy technologies increases with market and commercialization risks



Source: World Bank.

Lenders may require large risk premiums to finance frontier technologies, such as long-duration energy storage, carbon capture and sequestration, and low-carbon hydrogen. Projects with high levels of commercialization risk fall in the upper-right and lower-right quadrants. While the costs of such technologies are dropping, projects that include them will continue to rely on equity (corporate balance sheets), some bank debt, and concessional funding from public funds or international institutions to make them affordable. Where the market risks are also significant (upper-right quadrant), the need for concessionality will be even higher. Deployment of these technologies may rely on strategic investment (for technology development, or industry cluster development), private equity, and grant support.

Box 3. Selected World Bank Group initiatives to scale up financing for clean energy technologies

Solar

The World Bank's **Sustainable Renewables Risk Mitigation Initiative (SRMI)** is a comprehensive approach to risk mitigation based on global lessons. It builds on the importance of a tailored and holistic approach to electricity systems that is focused on reducing all regulatory and grid-integration risks to support the mobilization of commercial capital and the procurement of larger volumes of renewables-based energy than would be possible in an approach focused exclusively on isolated investments. SRMI brings together experts in capacity building; investments that complement electricity generation; technical assistance for electricity system planning and project development; and tailored de-risking instruments. Launched at COP24 in Katowice (2018) by the World Bank Group, the *Agence Française de Développement* (AFD), and the International Renewable Energy Agency, SRMI is currently being implemented in 11 countries, with support from the Green Climate Fund. It plans to mobilize $1 billion of concessional finance to unlock 14 GWs of renewable energy capacity in 20 countries by 2025.

Wind

Although one-fourth of the world's offshore wind potential is found in the waters of LICs and MICs, the development of offshore wind power has been far below its potential. The **Offshore Wind Development Program** was created by the Energy Sector Management Assistance Program (ESMAP) and the International Finance Corporation (IFC) to accelerate the uptake of offshore wind by advocating its inclusion in countries' energy policies, and supporting the preparatory work needed to build a pipeline of bankable projects. The World Bank Group is working with the governments of Azerbaijan, Brazil, Colombia, India, the Philippines, Sri Lanka, Türkiye, and Vietnam to prime a cycle of policy design and regulatory improvements. The effort will identify specific investments to be supported by both commercial and public sources of capital.

Geothermal

The **Global Geothermal Development Plan (GGDP)** was initiated by ESMAP in 2013 to shift global support for geothermal energy from downstream to upstream stages of development. The goal of the shift was to reduce the high cost and risk intrinsic to geothermal exploratory drilling and accelerate the expansion of this source of energy. Drilling risks have long prevented private developers of geothermal energy from gaining access to commercial capital. The GGDP initially mobilized donors to contribute $6.7 million,

Box 3. Selected World Bank Group initiatives to scale up financing for clean energy technologies *(continued)*

which helped build an investment pipeline that raised $235 million through the Clean Technology Fund by 2015. In turn, this helped leverage $1 billion in World Bank lending for upstream geothermal development and twice that amount in downstream development, crowding in private capital in Chile, Indonesia, Kenya, Mexico, and Türkiye. Commissioned projects are leading to the deployment of more than a gigawatt of geothermal power capacity, which will reduce CO_2 emissions by an estimated 6.2 million tons per year.

Energy storage

The batteries used in power systems are expensive, and most projects are concentrated in developed countries. The **Accelerating Battery Storage for Development** program was launched in 2018 by the World Bank Group to facilitate financing of storage projects for utility-scale solar parks and off-grid systems, as well as stand-alone batteries to enable grids to absorb increasing amounts of renewable energy. (The Bank's support for this initiative is further described in Box 6.)

IFC is also engaged in battery storage initiatives, including an upstream multiyear platform, **Accelerating Battery Energy Storage Systems.** Approved in 2021, this platform includes multiple components, ranging from developing a framework for risk allocation in bankable projects that can be used across countries, to developing individual opportunities at the country level, including hybridized systems of renewable energy and battery storage in **Samoa** and the **Philippines.** The IFC is also considering financing a stand-alone battery storage project to improve transmission infrastructure in **Colombia.**

Chapter 4

Managing the costs of phasing down coal-fired generation

KEY TAKEAWAYS

- Phasing down coal-fired generation requires significant preparatory efforts, starting with electricity system planning and the establishment of policy and regulatory frameworks for the retirement, repurposing, and replacement of coal generators. Also needed are comprehensive and detailed environmental studies and remediation plans to minimize community impacts.
- Various strategies can be applied to manage the financial liabilities associated with phasing down coal power plants. Their costs can be shared by plant owners, investors, off-takers, government, and rate payers, depending on the regulatory regime in place when the plant was commissioned, and contractual obligations. Regardless of the strategy chosen, concessional finance will have an important role in limiting these costs and making sure they are affordable for different stakeholders.
- It is critical to ensure that the coal phase-down is just, which will involve a high degree of government support. Transition assistance must be made available to communities affected by the phase-down. Investments in new economic opportunities will often be required.

Even though the transition to clean energy tends to have net economic benefits and improve both energy security and health, the phasing down and eventual elimination of unabated coal-fired power incurs significant economic and financial costs. The retirement or repurposing of coal power plants, whether they are privately owned or state-owned, requires expenditures—for decommissioning, retirement, and the just transition—that are additional to the cost of scaling up clean energy to replace coal-fired generation. These costs can be high and need to be managed, and support is needed to also address other barriers, including the challenging political economy of the coal sector in many countries.

> *The social transition associated with phasing down coal tend to have significant economic costs and must be driven by governments.*

The scale of the challenge is daunting and highly concentrated. Eliminating emissions from today's 2,153 GW coal fleet[9] by 2040 would require more than 100 GW of coal capacity to be retired each year for the next 20 years—roughly one coal unit every day until 2040. While the average economic lifetime of a coal plant is 40 years, 60 percent of the existing fleet is less than 20 years old. Either the operating global coal power plants will be left to emit 100 $GtCO_2$ and thus exhaust one-fourth of the planet's remaining carbon budget, or

9 In December 2019, coal-fired power plants in operation and under construction represented 2,153 GW globally. The International Energy Agency (IEA) estimates that only 10 percent of the existing coal fleet could be economically retrofitted for carbon capture or biomass co-firing.

approximately $1 trillion in coal-fired assets will have to be retired or repurposed. LICs and MICs account for 89 percent of the global capital in coal-fired power plants that is at risk of being stranded. ***To meet growing demand and make up for the generation capacity lost by retiring coal-fired plants, deployment of renewable power generation and energy efficiency must far outpace the phasing out of the coal fleet in LICs and MICs.***[10]

Managing the risks of stranded assets and avoiding legacy costs

Stranded capital in coal power plants could present systemic risks to LICs and MICs. The public sector at the national and subnational levels owns more than one-half of the capital at risk of being stranded, mostly in MICs. Nearly all (99 percent) of the $555 billion of public capital invested in coal-fired power plants at risk of being stranded is in MICs, and 89 percent of that is in China and India alone. Stranded capital at risk in LICs constituted 1.9 percent of their 2019 gross domestic product (GDP), with this share being well above 5 percent in several countries. In MICs (excluding China and India), at-risk capital was 1.3 percent of the 2019 GDP.

Continued expansion of coal power capacity will further complicate the challenge of stranded assets. At the start of 2020, more than 400 GW of coal power plants were either under construction or being planned. One-half of the remaining pipeline in developing countries is outside of China and India, spread across 58 countries. Twenty of these countries have never had a coal power plant before, including 13 countries in Africa.[11] Commissioning these plants could add $0.5 trillion in stranded costs under a 1.5°C pathway (Edwards, et al. 2022).

Gas-fired power plants are also at risk of stranding, which will require additional planning efforts (Box 4). Globally, the role of natural gas in the electricity mix will continue to fall. In mid-century global net-zero emissions scenarios, it is estimated that by 2050, unabated natural gas power generation will shrink by 90 percent from the 2020 level (IEA 2021b). However, the role of natural gas as a transition fuel will vary greatly by country. While countries considering the deployment of natural gas for electricity generation as an alternative to coal may seek help with navigating the market and stranding risks, an increasing number of countries will seek support to phase out or even leapfrog natural gas, particularly if adequate concessional financing is available to help scale up clean energy.

Box 4. How governments can avoid the risks of stranded gas-fired assets

Natural gas–fired power generation is one important source of flexibility in the electricity systems of many developing countries. Flexible electricity resources are those that can help system operators cope with the variability and uncertainty that solar and wind generation introduce, thus avoiding power curtailments and reliably meeting the demand for energy. Flexible resources are essential in order to complement high levels of renewable energy.

10 A little less than $1 trillion of new investments in Official Development Assistance (ODA) countries before 2030 is estimated to be required in the power sector alone to achieve a full transition to net zero by 2050. (IEA 2021b).

11 Côte d'Ivoire, Egypt, Eswatini, Ghana, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Niger, Nigeria, Senegal, and Tanzania. World Bank staff estimates according to the World Electric Power Plants database (version December 2019).

Box 4. How governments can avoid the risks of stranded gas-fired assets *(continued)*

However, as many countries are starting to consider phasing out natural gas, there is a need to step up efforts to develop and deploy workable, sustainable, and cost-effective alternatives for managing the need for flexibility of power grids. Such alternatives could be provided by (i) technologies that are highly capital-intensive but have low variable costs (for example, some forms of hydropower, some forms of long-duration energy storage, and demand-side responses); (ii) technologies with low capital costs and high variable costs (for example, biogas); or (iii) technologies with moderate capital and variable costs (for example, natural gas accompanied by carbon capture and storage [CCS]). In a decarbonized power system, each of these technologies would operate in a particular way to meet the demand for electricity at the lowest cost. (Baik et al. 2021).

In the future, in addition to the cost of fuel and other variable operational costs, variable costs in gas-fired power generation may include the uncertain costs of carbon pricing, and the capture, transport, and storage of carbon dioxide. According to the Sixth Assessment Report from the Intergovernmental Panel on Climate Change, models that limit global warming to 1.5°C by the end of the century suggest global declines in gas use of 21 to 61 percent (interquartile range) below 2020 levels by 2050. The equivalent interquartile range for limiting warming to 2°C is a decline by 2050 (from 2020 levels) of between –13 percent (that is, an increase of 13 percent) and 36 percent, subject to a more precise quantification of methane leakage, which undermines the emissions benefits of gas and accounts for 4 to 8 percent of global greenhouse gas emissions. The timely commercial viability of CCS technologies is uncertain, and the availability of geological sequestration in LICs and MICs is not well characterized. In an emission-constrained world, unabated natural gas could continue to be used to provide a firm supply of energy during infrequent shortfalls of renewable energy or very high demand because the emissions impact would be relatively small. However, unabated natural gas–fired power plants operating often and for long periods will increasingly conflict with emission reduction targets unless CCS technologies are used. If the variable costs of gas-fired generation are high, either because of volatile global fuel prices or high carbon prices, or if there are high variable costs of CCS, gas-fired generation may have a more limited role to play in meeting electricity demand at the lowest cost.

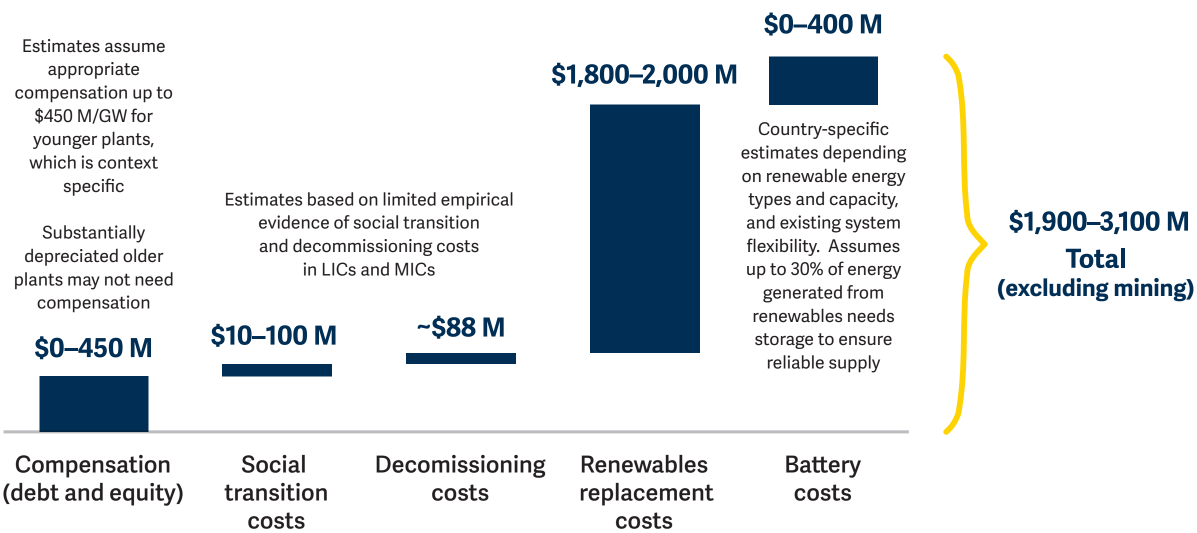
Governments and financiers can protect themselves from the costs of stranding, and from unexpected shortfalls in revenue, by entering into contracts and financial arrangements that build in the risk that the role of a natural gas plant may change over its lifetime. The stranding risks of natural gas–fired power plants are less severe than those of coal-fired power plants because the lower up-front capital cost of the plant reduces the value that may be stranded before the asset is depreciated. Nevertheless, careful sectoral planning and consideration of uncertainty should inform decisions about new investments in natural gas power generation. The contracts and financing arrangements associated with new plants should reflect their lower level of use, or early retirement, consistent with mid-century net-zero emissions.

Stranded costs that do arise from retiring coal power plants before the end of their expected lifetime will impose a loss of net financial value for asset owners, which will then need to be distributed to investors, ratepayers, or taxpayers. Stranded cost is the nondepreciated capital expenditure that cannot be recovered through future market revenues. There is an important distinction between the assessment of stranded costs and the separate but related assessment of potential compensation to asset owners. If compensation is paid to asset owners for the stranded value of a coal generator resulting from a change in government policy, these financial costs affect public finances and/or electricity prices. The compensation amount may be substantially higher if state-owned generators break long-term fuel supply agreements, or if asset owners seek compensation for the loss of the expected future revenues if the generator had continued operating. Asset owners may seek compensation, particularly when state-owned utilities had long-term power purchase agreements with coal power plant owners. The design of any compensation program must avoid creating incentives for generators to delay retirement in hopes of receiving a payout (that is, a moral hazard). This makes determining a fair level of compensation challenging, and no single methodology has been used globally. Compensation schemes will have to be tailored to each country's sectoral, legal, regulatory, and contractual context. While compensation can be costly, the potential for uncompensated stranded costs or contentious litigation to harm the already fragile investment environments of LICs and MICs must also be considered. A sample analysis of the capital needed to replace 1 GW of operational coal-fired power with clean energy appears in Figure 4.

Financing the phase-down of coal

The social transition associated with phasing down coal tends to have significant economic costs and must be driven by governments. Managing the social impacts of closing coal power plants and mines in the developing world will cost an estimated $50 billion a year between now and 2040. Judicious policy and investment measures are critical to support economic diversification and mitigate the socioeconomic impacts of job losses in coal-related activities through direct compensation and reskilling. In countries heavily dependent on coal power generation, many local economies are closely interwoven with the coal industry. Closing coal-fired power plants poses a significant challenge for governments to plan and provide alternative economic opportunities for local populations and businesses. A justtransition initiative surrounding the decommissioning of South Africa's Komati power station is described in Box 5.

Figure 4. Investment required to decommission and replace 1 GW of coal-fired generation with clean energy, by component



Note: The figure does not include costs related to mine closures and the associated social expenses. Compensation to plant owners is estimated based on the remaining asset value, which is calculated using two approaches: (i) net book value, which uses the remaining asset value on the accounting book as a proxy for the plant's value; and (ii) net present value, which arrives at the plant's asset value by discounting future cash flow for the asset's remaining life. Social transition costs are based on an internal World Bank review of social transition programs associated with the closures of coal mines and power plants. Decommissioning expenses are based on an average of US and Indian coal markets (Raimi 2017; ESMAP 2021). Numbers may not add up to the total, due to rounding off.
Source: World Bank estimates.

Governments and/or state-owned energy enterprises may undertake these associated expenses and amortize the costs through tariff surcharges to the extent that such surcharges are affordable for electricity consumers. Carbon credits and concessional finance can defray the impact of these costs on budgets and consumers.

(Re)financing to phase down

Refinancing existing expensive liabilities under more attractive terms could be a powerful tool to incentivize early retirement of fossil fuel generation assets. Financing facilities could be created to refinance the existing debt of fossil fuel generation assets on more favorable terms to advance the date by which capital expenditures are recovered. For privately owned fossil fuel assets, refinancing could help minimize expensive compensation in the form of termination payments made by off-takers to fossil fuel asset developers. For publicly owned assets, refinancing existing debt could reduce debt service liabilities and facilitate earlier retirement.

> *The transition away from coal-fired generation can exacerbate internal political divisions and result in stalemate, if not managed carefully.*

Approaches to retirement and compensation may be used in tandem. Targeted buyouts through negotiation or market-based auction mechanisms can be used to compensate plant owners. Plants can also be purchased directly and decommissioned; this often requires special financing to supplement public budgets. A repurposing strategy allows the land and relevant equipment of the closed plant to be used for renewable energy, energy storage, and ancillary services. Financing is typically needed for decommissioning and for developing the new alternative energy assets. Regulators may reduce closure costs by revising tariffs to compress the recovery period of the repurposing investments, resulting in higher tariffs for customers, unless they are offset with concessional finance. There are several mechanisms to swap a coal power purchase obligation with a renewable energy purchase obligation. The incumbent coal power purchase agreement can be used to refinance a renewable energy asset, packaging the liability of payment for solar power plant output together with the repayment for purchasing and decommissioning the coal plant.

Box 5. First among thousands: A just transition away from coal at South Africa's Komati power station

To support the South African government's commitment to a clean energy transition that ensures reliable, affordable, and sustainable energy for all, the World Bank has approved $497 million in financing to decommission and repurpose the 60-year-old Komati coal-fired power plant with 150 MW of solar power, 70 MW of wind power, and 150 MW of battery energy storage.[a] The decommissioning of the Komati plant will lower carbon emissions and improve local air quality. Its repurposing will also enhance energy security by improving the quality of the electricity supply and grid stability. A containerized micro-grid assembly factory has already been established on the site.

Box 5. First among thousands: A just transition away from coal at South Africa's Komati power station *(continued)*

The project is aligned with the country's Just Transition Framework, which aims to minimize the socioeconomic impacts of energy transition; improve the livelihoods of those most affected; and capitalize on the opportunities stemming from the transition. A portion of project financing will be devoted to creating economic opportunities for local communities, an initiative that is expected to benefit approximately 15,000 people. No employees of the public electrical utility, Eskom, will lose their jobs; the majority of the employees of the power station have already been transferred to support and augment skills in other power stations. Community-driven projects, skills training, incubation support, and business development services for new and existing micro, small, and medium enterprises are expected to create jobs in agriculture, local manufacturing, and digital technology. Activities will be carried out in coordination with the local government, civil society organizations, and the private sector.

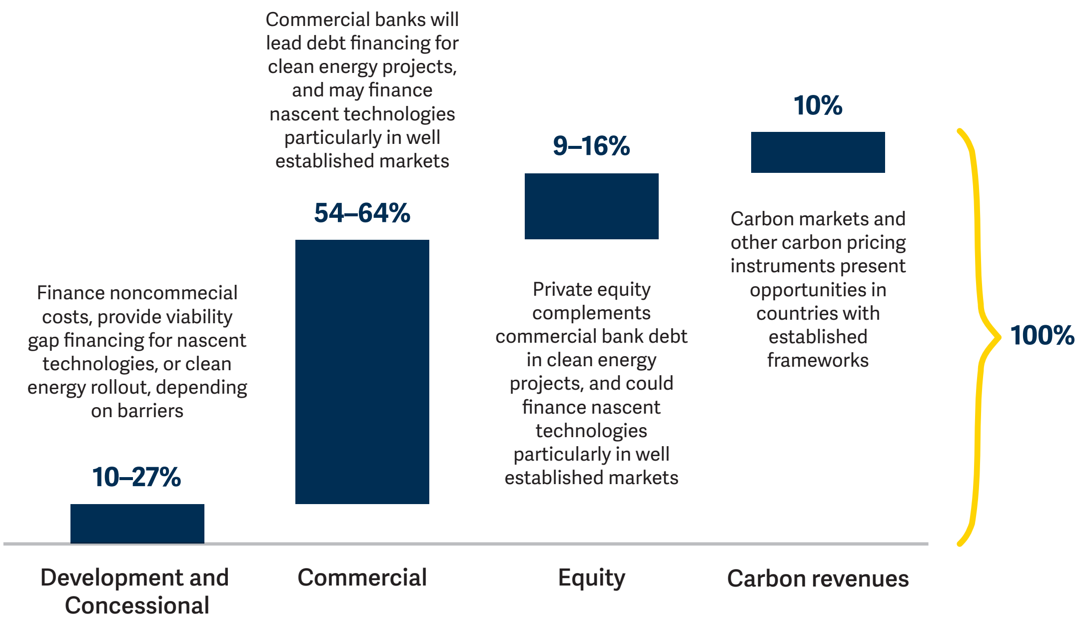
The decommissioning of Komati marks the beginning of the transition to a new, clean energy era in South Africa. It is part of the country's Integrated Resource Plan 2019 to gradually retire 12 GW of the inefficient coal-fired power fleet by 2030 and scale up 18 GW of private sector–led renewables during the same period.

As one of the largest global efforts to decommission and repurpose a coal-fired power plant, the Komati project will serve as a global reference on how to transition fossil fuel assets. It also demonstrates the World Bank's holistic approach to setting the virtuous cycle in motion by providing financing at affordable terms and realizing results for both renewable reinvestment and transition support for impacted stakeholders and communities.

Concessional finance has an important role in ensuring that the transition from coal, regardless of the chosen retirement approach, is just and affordable. The Climate Investment Fund's Accelerating Coal Transition (ACT) program is a source of concessional finance that supports activities such as identifying coal plants that could be retired; designing options packages; assessing economic, financial, and environmental impacts; and identifying projects that deal with social protection, jobs, education, and reskilling. The sources of finance and extent of the concessional component will depend on the country and sectoral contexts. The ACT program has begun well, but demand for its funds from the outset has been so high as to suggest that expansion will be necessary. Figure 5 suggests a plausible mix of concessional, commercial, and carbon financing sources to implement transition activities for a 1 GW coal-fired power plant.

The transition away from coal-fired generation can exacerbate internal political divisions and result in stalemate, if not managed carefully. By reducing the costs of decommissioning, well-designed policy and concessional finance can maximize net domestic benefits from the coal transition and make those benefits more visible. Operations that can be successfully concluded using concessional finance may reduce the perception of risk and sustain political commitment for later efforts.

Figure 5. Illustrative sources of financing for transitioning 1 GW of coal-fired generation



Note: If it is not feasible to raise financing through carbon markets, concessional financing would have to fill the financing gap. The above costing does not take into account power system planning, feasibility studies, capacity building, and/or assessment of the financial sustainability and creditworthiness of state-owned enterprises. These would be financed primarily through concessional funds (that is, grants, and assistance from the project preparation facilities of multilateral development banks).
Source: World Bank estimates.

Chapter 5

Holistic approaches to catalyzing and sustaining the virtuous cycle

KEY TAKEAWAYS

- New country programs are needed to deepen and sustain capital mobilization and systematize allocation of more highly concessional capital, consistent with Nationally Determined Contributions and energy sector planning.
- New global and regional technology-focused initiatives are needed to systematically reduce technology and deployment risks in developing country contexts.
- The coordinated support of the international community is needed to make finance with a high degree of concessionality available and transformational. If deployed systematically to address the barriers identified throughout this paper, the application of such finance can scale up the use of clean energy and reduce the use of coal in line with the Paris Agreement.

All forms of public, private, and international capital will have to be mobilized to achieve transition of the power sector at the scale and pace needed. To mobilize the necessary funds, concessional finance will have to be allocated in a coordinated and well-targeted manner. This chapter first explores ways to expand the available pools of capital. It then proposes two holistic tools—a country-based approach and technology demonstration partnerships—to maximize and coordinate available capital and ensure the most cost-effective use of concessional finance.

Expanding the pools of public, private, and international capital

Every form of capital has unique advantages that should be part of a holistic approach to mobilize the financial resources needed for transition of the power sector. Concessional financing from philanthropies and international donors can complement scarce public finance to strengthen planning, procurement, and regulatory institutions, and establish the legal and regulatory frameworks needed to attract private investment. Philanthropies and international donors can also help meet the costs of accelerating the transition away from fossil fuels in line with the principles of social and climate justice. Multilateral development banks and climate funds can provide additional concessional finance on terms that are aligned with capital-intensive, long-lived investments, long-term power sector reform, and risk mitigation for immediate investment needs. Concessional climate finance can build a bridge to sources of domestic and international private capital. But blending private and concessional capital requires the involvement of a broad range of stakeholders—in government, multilateral institutions, and the private sector—all united to develop a sustainable holistic approach to the transition, while avoiding information asymmetry, lack of transparency, and mismatched objectives (Choi and Seiger 2020).

Domestic capital markets can provide both private capital and local knowledge, and are important for leveraging concessional financing to draw in private capital. The participation of domestic investors can attract international capital by providing a better understanding of the local market and regulations. Globally, three-fourths of climate finance in 2017–18 was sourced domestically, and mostly privately (Climate Policy Initiative 2019). Domestic investments are not exposed to the same risks as international investments and therefore have a different risk–reward profile. MICs, especially those that are rated investment grade, have considerably more financing accessible to them because of their higher incomes, better sovereign credit ratings, more developed local currency markets, lower debt-to-GDP ratios, and generally larger and more resilient economies. Yet two-thirds of private investment in developing countries flows to just a few countries: chiefly China, India, Indonesia, Mexico, and Türkiye. With the right enabling environment, public and concessional funds may be used to boost the supply of nonconcessional financing in LICs and MICs.

Addressing regulatory constraints in the banking sector, insufficient institutional capacity, and high transaction costs could raise the amount of domestic capital available for transitioning the power sector. The necessary steps include (i) ensuring that the policy, regulatory, and institutional aspects of capital markets support long-term infrastructure investments through prudential and investment regulations; (ii) developing the investor base through pension and insurance reforms, and building capacity to help them diversify into infrastructure and related asset classes; (iii) developing innovative and scalable financing instruments and co-investment vehicles, including de-risking instruments, and facilities to address investors' risk concerns; and (iv) reducing information asymmetry and ensuring standardization of taxonomies and frameworks. Attracting local investors' support will require governments to align fiscal, economic, and sectoral policies to reduce the costs of the transition and improve its business case.

> *A more pronounced role for local currency instruments in the power sector transition would help LICs and MICs to mitigate foreign-exchange risks, which are likely to be heightened by expectations of increases in interest rates across developed markets.*

Alternative sources of long-term financing in local currency are needed to reduce the pressure on public finances. A more pronounced role for local currency instruments in the power sector transition would help LICs and MICs to mitigate foreign exchange risks, which are likely to be heightened by expectations of increases in interest rates across developed markets. Developing country governments could involve their central banks and other domestic development institutions to provide incentives to domestic capital markets for financing energy transition projects, including special facilities and financing options. To cite three examples, the Bank of Japan has launched a new scheme to lend at zero percent interest to financial institutions for investments or loans related to climate change; the Bank of England has incorporated climate change criteria into its corporate bond purchase programs as one of its measures to support the transition to a net-zero economy; and the European Central Bank has included climate change considerations in its monetary policy strategy, its due diligence for corporate sector asset purchases, and its monetary policy portfolios.

Carbon markets, green bonds, and other environmental, social, and governance (ESG) investments will need to expand and mature to promote clean investments over fossil fuel investments. Subject to debt sustainability constraints, governments could benefit from tapping long-maturity ESG loans and bonds, ideally in local currency, to finance the transition of the power sector. Payments for emission reductions through international carbon credits could reduce the cost of implementing the transition through voluntary or compliance carbon markets established under Article 6 of the Paris Agreement (see Box 6). For example, an estimated 4 to 10 percent of costs for coal transition could be met through payments for emission reductions achieved through early retirement of coal-fired power plants. Such additional capital could help reduce the pressure on sovereign balance sheets and attract new sources of carbon-focused investors, providing incentives for undertaking transition investments.

Box 6. Carbon credits to improve project viability

Domestic and international carbon markets have the potential to reduce the costs of climate action and raise revenue for climate policies and energy transition projects. For example, renewable energy projects generate carbon credits by avoiding emissions and may benefit from carbon revenues generated by the sale of these credits. Mature carbon markets with consistent price signals can improve commercial viability and affordability that scales up financing for renewable energy and energy efficiency at the sector level.

Voluntary and compliance markets are expected to increase in value in the coming years. Depending on the scenario, the value of the Article 6 (compliance) market could rise to $300 billion per year in 2030 and to $1 trillion per year by 2050 (IETA 2021). In parallel, 2021 saw voluntary carbon markets grow to nearly $2 billion, quadrupling in value from 2020, driven by corporate demand (Ecosystem Marketplace 2022). Many corporations are planning to buy carbon credits to offset emissions as part of their near-term transition to net-zero, using carbon removals thereafter. However, barriers must be addressed if carbon markets are to scale up successfully. For example, preexisting energy price subsidies undercut the positive potential of carbon pricing. Also, carbon markets remain fragmented and underdeveloped, with low carbon price levels, a limited supply of quality credits, and evolving rules and guidance under the Paris Agreement.

LICs and MICs need to establish the domestic institutional frameworks necessary to permit participation in carbon markets under the Paris Agreement and take advantage of opportunities to sell credits related to the transition of their power sectors. Through its Scaling Climate Action by Lowering Emissions (SCALE) facility, the World Bank will provide results-based climate finance against emission reduction results achieved by investment programs. Results-based climate finance can play an important role in improving the attractiveness of climate mitigation investments for investors by providing a consistent stream of additional cash flow.

LICs and MICs need support in developing the necessary instruments and policies to unlock capital. On the financial regulations side, there is a need to implement international financial regulatory standards in LICs and MICs to attract international investors and direct local capital to sustainable investments. Climate-related transition risks can have material impacts on the financial sector, but many LICs and MICs lack the methodologies and frameworks to quantify financial risk related to the climate transition. Regulatory frameworks are needed to develop instruments and reporting frameworks for green, transition, and sustainability-linked bonds in line with international standards. Co-investment platforms and funds (for example, energy transition funds, private equity, and debt funds) and de-risking facilities or guarantee funds could be structured as support mechanisms or blended finance facilities. While some countries have initiated the procurement of credits under Article 6, most LICs and MICs will need dedicated assistance to establish the necessary institutional mechanisms and processes to take advantage of carbon markets.

A programmatic country-based approach

Translating policy into results will require a financing approach that matches the phases of the transition with the right type of financing. The initial phases of the virtuous cycle described in Chapter 2 are likely to require a greater proportion of higher concessionality financing to kick-start transition activities. As barriers at the country, sector, and project levels are addressed over the course of the virtuous cycle and results materialize to benefit consumers and the economy, less concessionality will be needed, and commercial and private sources of capital will lead the transition. In this context, it is essential to plan sequenced power transition investments, and match them to appropriate financing sources over the medium to long term.

Aggregating multiple sources of capital in an optimal way will require a country-based approach. Such an approach leverages concessional and blended financing to mitigate risks at the country, sectoral, and project levels, and in so doing can attract private capital at volumes necessary for transition of the power sector. In this approach, financing sources are coordinated and applied toward a series of goals: (i) to advance needed policy and utility reforms; (ii) to support investments in network reliability; (iii) to de-risk renewable energy and energy efficiency projects using appropriate risk mitigation instruments; and (iv) to facilitate the retirement of fossil fuels and the associated social adjustments. The approach will require many of the products of multilateral development banks—notably lending, grants, and guarantees backed by technical assistance and analytics. Figure 6 provides a schematic view of a country-based approach that dismantles barriers to the transition at each stage of the virtuous cycle.

Five forms of financing will have to be tailored to support power sector transitions in each country. As discussed in Chapter 3 and summarized in Figure 6, these are (i) financing for transition preparation; (ii) financing to strengthen utilities; (iii) financing for energy efficiency and demand-side management; (iv) financing for nascent technologies; and (v) financing for clean energy rollouts. Concessional finance, including grants, can provide technical assistance and capacity building for reforms, institution building, and long-term planning. While deep sectoral problems may take years to remedy, concessional finance can be used for urgent investments (in transmission, storage, and new technologies) to deal with the immediate pressure to meet demand, avoid carbon lock-in, and to lower emissions.

In countries that need to transition away from fossil fuel–based generation of electricity, concessional financing will be required to phase down coal plants in a way that ensures a just transition and prevents the transition from straining government balance sheets and imperiling debt sustainability. Financing can support governments in creating just transition policies that establish a pathway for incumbent industries, including for re-skilling workers, decommissioning retiring fossil fuel capacity, and creating alternative livelihoods for disadvantaged communities.

> *To create the conditions for mobilizing the largest possible amounts of private capital, the use of concessional finance must be scaled up, sustained, coordinated, and carefully programmed*

Without the strong signal of a programmatic approach to financing the transition, governments are unlikely to be able to attract the volume of capital needed to carry out a complex, long-term agenda. A sequence of isolated energy sector interventions may have a positive impact on the climate yet fail to achieve the necessary speed and scale of transition. The fragmented deployment of concessional funds can neglect addressing important barriers that prevent the virtuous cycle from gathering momentum. Recent windows of the Climate

Figure 6. A financing approach that overcomes barriers at each stage of the virtuous cycle

	Transition Preparation Financing	Utility Strengthening Financing	Demand side Management (DSM) Financing	Nascent Technology Financing	Clean Energy Rollout Financing	Fossil Fuel Refinancing	Phase-Down Financing
Borrower	Technical assistance grant funding to governments or state-owned enterprises	Private special purpose vehicle or state-owned enterprise, depending on ownership	Private special purpose vehicle or state-owned enterprise, depending on ownership	Private special purpose vehicle or state-owned enterprise, depending on ownership	Private special purpose vehicle or state-owned enterprise, depending on ownership	Energy state-owned enterprises	State-owned enterprises or government
Potential sources	Climate trust funds (ESMAP, PPIAF, GIIF, etc.), MDB project preparation facilities	MDB credit enhancements, guarantees, concessional loans	Climate trust funds, MDB guarantees, local currency commercial banks	Commercial banks, carbon revenues, climate trust funds, MDB loans and guarantees	Commercial banks and bond investors (ESG, green, etc.), private equity and MDB credit enhancements	Local or international project finance banks, donor funds, and MDBs as credit enhancement	Commercial banks, bond investors (ESG), carbon credits, climate trust funds, and MDB loans
Potential uses	Policy and regulation, power sector planning and strategy, capacity building	Mitigate off-taker risks, fund transmis-sion, modernization, and loss reduction initiatives	Partial risk sharing facilities for energy efficiency investments	Finances country-wide nascent technology adoption at scale	Complements existing financing for clean energy generation, including large hydropower	Refinance outstanding debt of younger fossil fuel assets to retire early	Finance expenses for decommissioning fossil fuel assets and social transition
Recovery of investment	Not expected to be repaid since it is a grant	Loss reduction, improved revenue collection, tariffs that reflect costs	Revenues from energy service agreements	Based on application, through contracts, or merchant operations	Revenues from power purchase agreements or electricity market revenue	Reduced operations of coal assets toward retirement	Through surcharges on consumer tariffs and carbon revenues
Risk of investment	Careful consideration needs to be given to design of technical assistance program	Political risks, commissioning risks, technology risks	Market risks, creditworthiness	Substantial market & technology risk	Regulatory risks, grid integration risks of variable renewables, market risks, creditworthiness	Rewarding risky investments ("moral hazard"), potential for over-compensation	Residual environmen-tal and social risks and economic disruption

Note: MDB = Multilateral Development Bank; ESMAP = Energy Sector Management Assistance Program; PPIAF = Public-Private Infrastructure Advisory Facility; GIIF = Global Index Insurance Facility; ESG = Environment, Social, and Governance.
Source: World Bank.

Investment Funds demonstrated the value of developing a project as part of a long-term plan. However, with limited resources, those windows can finance only near-term actions. The country-based financing approach should be designed to take in concessional and public contributions for a sustained period—commensurate with the 10-year intervals of Nationally Determined Contributions.

Technology demonstration partnerships

While each country will need its own tailored approach to the power sector transition, there are commonalities among countries that could benefit from global partnerships, especially for technology demonstrations. The unique requirements of LICs and MICs are not yet fully considered in the development of innovative technologies for the energy transition—even though these countries may offer significant potential for their use. By connecting public and private stakeholders and sharing international experiences with energy transition technologies, new technological, regulatory, and business models can be developed and shared. The early demonstration of new technologies in developing country contexts may lead to technological improvements and accelerated cost reductions over time, expanding the global market with concomitant economies of scale. A model global technology partnership for energy storage is described in Box 7.

Technology demonstration partnerships could help scale up financing for nascent technology, mitigating residual technology risk. The partnerships could explore applications and integration in particular contexts and help refine policies, regulations, and procurement processes. Several domains are ripe for this type of cooperation, chief among them long-duration energy storage; low-carbon hydrogen; pathways for long-term low-carbon development; energy efficiency and demand-side management; and information systems technology for power networks. Examples of the latter include systems for supervisory control, data acquisition, and forecasting of variable renewable energy.

Box 7. The Energy Storage Partnership

The Energy Storage Partnership (ESP) was created in support of the World Bank's Accelerating Battery Storage for Development initiative, a $1 billion World Bank Group program announced in September 2018 to accelerate investments in battery storage for energy systems in low- and middle-income countries. Working together, the 40 ESP partners are developing a knowledge base in energy storage solutions tailored to the needs of developing countries. By connecting stakeholders and sharing experiences in deploying energy storage and advancements in storage technologies, the ESP helps bring new technological and regulatory solutions to developing countries, and helps in developing new business models that can leverage the full range of services that storage can provide.

The ESP is supporting active projects with a battery capacity of 4.7 GWh and a pipeline of 2.4 GWh in more than 15 client countries. Contracts of approximately 900 MWh in South Africa, India, and the Central African Republic have been awarded. Some of the key knowledge outputs include reports focusing on (i) reuse and recycling of lithium-ion battery energy storage systems; (ii) warranties for energy storage systems in developing countries; and (iii) policy and regulatory considerations for the deployment of storage for power systems.

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