Report

Repurposing Power Markets

The Path to Sustainable and Affordable Energy for All

NOVEMBER 2024

International Finance Corporation
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IFC

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Acknowledgments

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The report benefitted from feedback from the following peer reviewers: Vivien Foster (Principal Research Fellow, Imperial College London), Alan F. Townsend (Principal Industry Specialist, IFC), David Loew (Senior Energy Economist, World Bank), and Tatyana Kramskaya (Senior Energy Specialist, World Bank).

Brian Beary and Irina Sarchenko (both IFC) were responsible, respectively, for editing and design.

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Foreword

Ensuring access to clean, affordable, and reliable energy—United Nations Sustainable Development Goal 7—is essential for growing our economies, reducing poverty levels, and improving living standards. While there is progress toward realizing this goal, it is not enough. To accelerate progress and meet the 2030 targets, unprecedented levels of private capital must be mobilized to complement public investment in the power sector. This report provides a comprehensive analysis of how countries can do so by repurposing existing power market designs and by tapping private capital channels more effectively and at greater scale.

Drawing on IFC's seven decades of experience working with the private sector under various and continually evolving power market structures, the report identifies strategies and shares best practices for engaging the private sector as the indispensable partner in achieving SDG7. The report recommends that policymakers, investors, and development finance institutions be guided by '6Is'—***Innovate, Integrate, Institutionalize, Incentivize, Invest, and Identify***—in ramping up their efforts to clean energy transition.

The recently announced partnership between the World Bank Group and the African Development Bank Group to connect 300 million people to electricity in Sub-Saharan Africa by 2030 is a good example of our commitment to reaching this goal. The partnership aims to halve the number of Africans without electricity. At IFC, we are committed to helping our clients and partners make the transition as seamless as possible. We will continue to provide innovative financial solutions, advisory services, and risk mitigation tools that mobilize private capital for the power sector in emerging markets and developing economies. Together, we can build a more sustainable, resilient, and inclusive energy future for all.

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Executive Summary

The electricity industry is undergoing a transformative evolution driven by three overarching trends: decentralization, digitalization, and decarbonization (3Ds). To ensure access to clean, affordable, and reliable energy for all by 2030—UN Sustainable Development Goal 7 (SDG7)—countries need to repurpose their power market designs to adapt to this transformation and unlock new opportunities. This report provides a fresh global perspective on how to leverage existing designs to effectively mobilize private capital at scale, complementing public investment to achieve SDG7. It draws on a new global database that tracks the evolution of power market structures in all 230 global economies over the past three decades. As countries strive to meet ambitious targets on sustainable energy and access, purposeful power market design will be critical to unlocking the investment needed to meet SDG7.

Evolving Power Market Structures

Alternatives to integrated power market monopolies—the traditional model—have been deployed by many countries since the 1990s. The general trend has been to allow greater private sector participation. Two key factors are driving this trend: the need to improve overall market performance and the imperative of finding additional funding sources given high growth in demand and tight fiscal space.

In 1989, when markets were on the cusp of major structural changes, the state-owned vertically integrated utility (VIU) model dominated, with 215 economies using it. Today, it is the second most used structure, operating in 72 countries. Those that have retained VIU have done so either as a policy choice or due to external factors (such as smaller economies and island states with limited market size) that constrain it from moving to a different model. However, even among those that retained it, many introduced some form of private management and ownership.

Increasingly, countries are adopting either a single buyer model (SBM) where the state authorizes private investors to operate power plants as independent power producers (IPPs), or various competitive wholesale and retail market structures (WRC) where public and private generation, distribution, and supply companies, and end users participate in the market. SBM, often viewed as an intermediary step toward full market liberalization, has become the most prevalent model, used by 89 countries. Meanwhile, WRC models are used by 69 countries and are more common in advanced economies.

Competition Is Associated with Better Sector Outcomes

The analysis reveals that transitioning to more competitive power market structures is associated with improved access to electricity, generation capacity, adoption of renewable energy, and private sector participation through IPPs. Countries with more competitive structures also tend to attract higher levels of private financing. However, the effectiveness of market reforms varies across regions and must be complemented by stable governance and policy environments for investments to have sustained impact.

Key findings from this report include:

Access and Generation Capacity: Transitioning from VIU to either SBM or WRC resulted in significant improvements in electricity access and generation capacity. Each additional year in SBM was associated with a 0.34 percentage point increase in overall electricity access and a similar increase in rural electricity access.

Renewable Energy Adoption: WRC performed best at accelerating the rate of adoption of renewable energy, with WRC countries seeing a significant increase in the share of renewables in their electricity mix compared to those operating under VIU. Each additional year a country spends in the WRC structure is associated with a 0.57 percentage point increase in the share of renewable energy.

Lowering Carbon Emissions: The analysis reveals that SBM-structured markets were historically associated with higher carbon emissions compared to VIU, with SBM countries seeing a significant increase in CO_2 emissions per capita. The WRC model scored better for lowering the carbon footprint. Each additional year in WRC was associated with a reduction of 1.95 metric tons of CO_2 per capita.

Private Sector Participation: Switching from VIU to either SBM or WRC significantly increases private sector participation in the power sector through IPPs. Each additional year a country spends outside VIU is associated with a 0.87-year increase in the number of years that have elapsed since the first IPP entered the market.

Private Financing Flows: Countries with more competitive power market structures tend to attract higher levels of private sector financing compared to countries that keep the VIU model. This correlation is particularly strong in the East Asia-Pacific region as well as in Latin America and the Caribbean, North America, and South Asia.

What Are the Big Challenges and Opportunities?

The report identifies four main constraints—***cost***, ***complexity***, ***corruption***, and ***lack of cost recovery*** (the 4Cs)—that limit private sector engagement, especially in less-established markets. To address these constraints and repurpose power markets to meet SDG7, the report recommends that policymakers, investors, and development finance institutions follow the 6Is:

> ***Innovate*** by leveraging private sector financing and technological solutions such as smart grids, energy storage, and hybridization.

> ***Integrate*** renewables and unelectrified communities by utilizing distributed generation and off-grid solutions.

> ***Institutionalize*** investor-friendly practices, including transparent regulation and procurement, strengthened regulatory capacity, and enhanced creditworthiness of utilities.

> ***Incentivize*** private sector engagement through targeted procurement, predictable revenue streams, and risk mitigation tools.

> ***Invest*** alongside the private sector in critical infrastructure such as transmission networks and regional power markets.

> ***Identify*** opportunities for development finance institutions to provide technical advisory support, mobilize early-stage capital, and create investment platforms.

Tailored Recommendations

The report also provides recommendations tailored to each power market model to guide policymakers in repurposing markets. These include:

For VIU:

> Consider transitioning to more competitive structures given their potential to improve sector outcomes.

> Use renewable energy auctions or other transparent competitive bidding for IPP contracting to attract private sector financing at scale.

> Explore alternative forms of private sector engagement such as private management of VIUs or incentivizing private sector solutions in the off-grid segment.

For SBM:

> Utilize competitive auctions and market-driven procurement to scale up renewable capacity cost-effectively.

> Avoid locking power systems into high-carbon pathways through rigid long-term power purchase agreements with thermal generators.

> Scale up blended solar and storage power purchase agreements to ensure more continuous electricity supply from intermittent renewable energy sources.

For WRC:

- Implement clean energy standards, design new capacity market products, and develop ancillary services markets that better compensate renewable capacity attributes.
- Create appropriate revenue streams to commercialize evolving technologies such as variable renewable energy and battery energy storage systems.
- Accelerate the transition from feed-in-tariff structures to more market-based instruments, especially for utility-scale solar and onshore wind.

For investors, the report encourages them to adapt their business models to developing country contexts, explore innovative financing instruments, and actively engage with policymakers and development finance institutions to identify areas of potential support.

Development finance institutions can scale up their financial instruments and risk mitigation tools, work more systematically to support upstream reforms, and create bankable project pipelines. The report highlights the important contribution they can make in establishing platforms and mobilizing resources, such as the World Bank and African Development Bank's partnership on electricity access in Africa and the World Bank Group's new consolidated one-stop-shop guarantee platform.

Achieving SDG7 will require mobilizing private capital at unprecedented scale. Smart power market designs are crucial to unlocking that investment. This report presents pathways to reach SDG7, mindful that policymakers must continually adapt and be open to further repurposing of power market designs to meet the challenges and opportunities of the future.

1

Introduction

Developing countries are not on track to meet United Nations Sustainable Development Goal 7 (SDG7)—ensuring access to affordable, reliable, sustainable, and modern energy for all by 2030. Today, over 685 million people worldwide still live without electricity with the vast majority, some 600 million people, in Africa.[1]

Even where electricity is available, it is often unreliable and expensive. Due to successive crises including the COVID-19 pandemic and Russia's invasion of Ukraine, progress on SDG7 has slowed. These shocks have increased energy price volatility, exacerbating energy shortages and concerns over energy security, putting a further drag on progress. As things stand, none of the SDG7 targets are on course to be reached. The number of people globally without access to electricity is actually estimated to have increased by about 10 million in 2022. At the current rate, 660 million people will still have no access to electricity by 2030. For the world to reach SDG7, the annual growth rate on access needs to double, according to the International Energy Agency.

Renewable energy can be a big part of the solution, helping countries both to extend access and meet their goals in an environmentally responsible manner. Along with wind, solar has become one of the cheapest options to meet the growing demand for electricity.[2] Utility-scale solar energy is already the least costly option for new electricity generation in most countries worldwide.[3] The installed capacity of solar photovoltaic (PV) technology is expected to outpace coal by 2027, which when it happens will make solar the world's largest power source.[4] By 2030, solar mini-grids could bring high-quality uninterrupted power to 380 million people.[5] Connecting 490 million people to solar mini-grids could cut 1.2 billion tons of carbon dioxide (CO_2) emissions.[6]

2023 was a record-breaking year for deploying renewables globally, expanding by 473 gigawatts (GW) to hit a total capacity of 3.9 terawatts (TW).[7] However, despite this positive and accelerating growth, the UN's goal, pledged at its annual climate conference in 2023 (COP28), of tripling renewable power capacity by 2030 is still off track. To reach global climate targets, 1.1 TW (or 1,100 GW) of renewables a year is needed globally, more than double the current expansion rate. Growth in renewables is also overly concentrated in advanced economies and a few upper-middle-income countries,[8] particularly China, where the installed capacity of renewables surged by 63 percent in 2023 to reach almost 298 GW. In contrast, Africa experienced a much more modest increase of 4.6 percent, with total renewable capacity for the entire continent just 62 GW.[9] A glaring gap has opened, with the vast majority of developing countries falling behind on renewables, despite their massive economic and development needs.

To plug existing gaps in electricity infrastructure and meet rising ambitions on climate, a major increase in investment is needed. This cannot be achieved by the public sector alone. Unprecedented mobilization of private capital channeled toward developing countries is imperative. The urgency of ramping up climate finance was highlighted at the UN's COP27 climate conference in 2022: the final agreement called for $4–6 trillion a year of investments in renewables until 2030 in order to arrive at net-zero CO_2 emissions by 2050. Annual investments in renewable energy generation need to surge from $570 billion in 2023 to $1.55 trillion on average between 2024 and 2030 globally—almost triple their current levels—to reach agreed climate targets.

However, private financing flows to the power sector in emerging markets fall far short of what is needed and pale in comparison to the boom in financing happening in advanced economies (Figure 1.1).[10] Between 2010 and 2023, an estimated $4.84 trillion flowed from the private sector into global power markets. Of this, approximately 80 percent was invested in advanced economies, with emerging markets receiving only 20 percent, or $966 billion. Even more concerning, the share of private financing in emerging markets' power sectors shrunk from 36 percent to just 12 percent of total private sector financing during this period. There is an urgent need for a large ramp-up in private investments in emerging power markets.

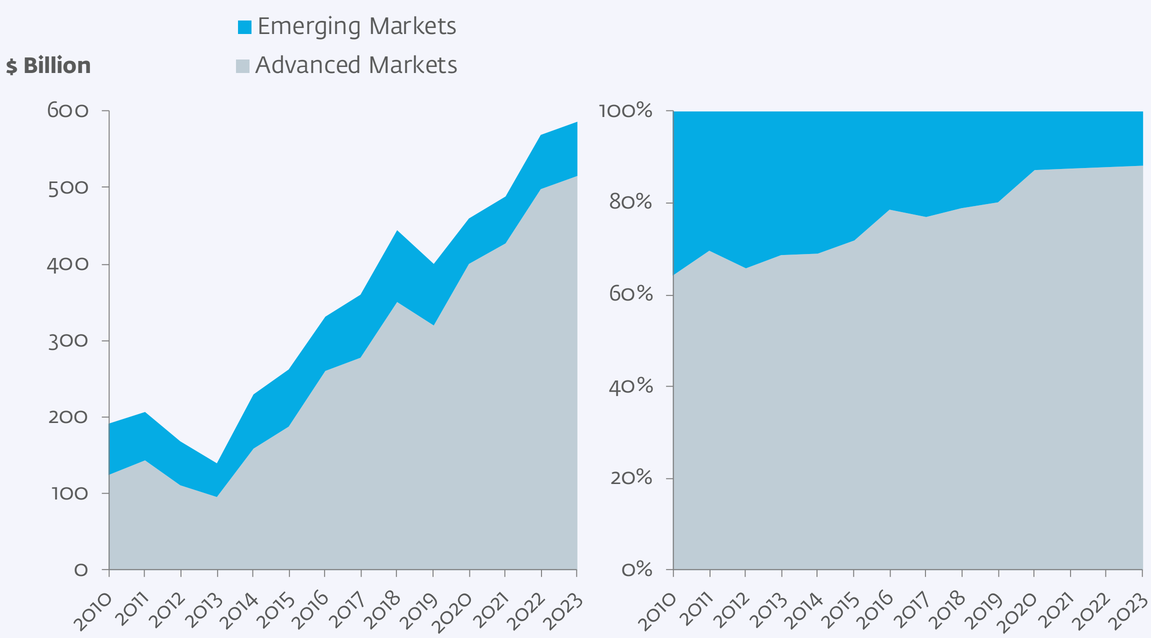
Since 2010, private capital flows have increasingly supported renewable energy projects while flows to networks and thermal generation have declined. Sustainable finance instruments, such as green bonds—fixed-income instruments with proceeds earmarked exclusively for projects with a positive environmental impact—have meanwhile gained in prominence. Green bonds and loans are increasingly used in the power sector, with $198 billion issued in 2023, although down from $283 billion in 2021.[11] Cumulative issuance from 2010 to 2023 reached a total of $1.48 trillion.[12] However, similar to the trend in total private investment flows, emerging markets received just 16 percent of all sustainable financing flows during this timeframe. This gap has widened in recent years, with emerging markets receiving just 9 percent of total financing in 2023.

Development finance institutions increasingly play a crucial role in plugging power infrastructure development gaps in emerging markets. Between 2010 and 2023, their total annual financing for the power sector grew from $42 billion to $73 billion, or approximately $709 billion over the entire period. Renewables' share of the total grew from 27 percent to 66 percent, reflecting the prioritization of clean energy projects.

FIGURE 1.1

Emerging Markets Greatly Lag Advanced Economies on Private Investment

Investment flows into the power sector—advanced versus emerging markets



Source: IFC based on IJGlobal (2023). Data includes project and corporate finance transactions with at least one private sector financing source.

Despite this investment bump, developing countries are not on track to meet SDG7. Small island states, least-developed countries, and landlocked developing countries are especially lagging.[13] Moreover, the clean energy transition is looking more uncertain amid soaring prices and shortages of critical raw materials required for renewable technologies. Rising material costs led to a 25 percent increase in prices for PV modules (solar panels) between 2020 and 2022.[14]

The latest projections through 2030 suggest that urgent policy interventions are needed, including in how power markets are designed.[15]

Aim of the Report

A repurposing of global power markets is essential to reach SDG7. As new clean energy technologies emerge on both the supply (renewable energy, battery storage) and demand (electric vehicles, distributed generation such as rooftop solar) side, it creates complex design challenges for many countries.[16] Well-designed power markets can incentivize the kind of investments that ensure renewable energy gets integrated at a scale that will substantially increase rates of access to clean, affordable, and reliable electricity.

The private sector has a critical role to play, in particular in helping markets evolve in a way that furthers sustainability and access goals. The public sector will continue playing an important role too, especially in designing markets and regulations, coordination and planning, providing incentives, and ensuring a level playing field for private sector participants and value for money. In developing designs for the future, lessons can be learned from their more than three decades of experience with power sector reforms.[17]

This report presents a fresh view of how to fully leverage the various power market designs to mobilize private capital in a way that it complements public investment so that their collective efforts work toward reaching SDG7. Based on IFC's decades of experience working with the private sector in a wide array of power market structures, the report provides insight on how best to tap the private sector for investment, innovation, and expertise. It identifies deployable strategies for countries seeking to redesign their power markets with an eye to unleashing the power of the private sector to usher in more sustainable, affordable electricity.

Three major trends—***decentralization***, ***digitalization***, and ***decarbonization*** (the '3Ds')—are shaping the electricity sector's current evolution. These overarching trends demand a major rethink of how power markets are structured. Alongside the 3Ds, four major constraints continue to hinder progress on SDG7—***cost***, ***complexity***, ***corruption***, and ***lack of cost recovery***—the '4Cs.' These constraints are disincentivizing the private sector from engaging in the power sector, especially in less-established markets. In the face of these trends and constraints, policymakers, private investors, and development finance institutions need to do six things: ***innovate***, ***integrate***, ***institutionalize***, ***incentivize***, ***invest***, and ***identify***—the '6Is.' Only if they take action on all six fronts will they succeed in making electricity more sustainable, accessible, and affordable (Figure 1.2).

The report details avenues for private sector participation across the power sector value chain, from generation to transmission and distribution/supply, and identifies opportunities for private sector involvement across various power market designs. It assesses progress being made on the access and sustainability goals of SDG7 and offers recommendations for enhancing the private sector's role in advancing on both fronts. The report also touches on SDG7's energy efficiency objectives, although this is not the primary focus.

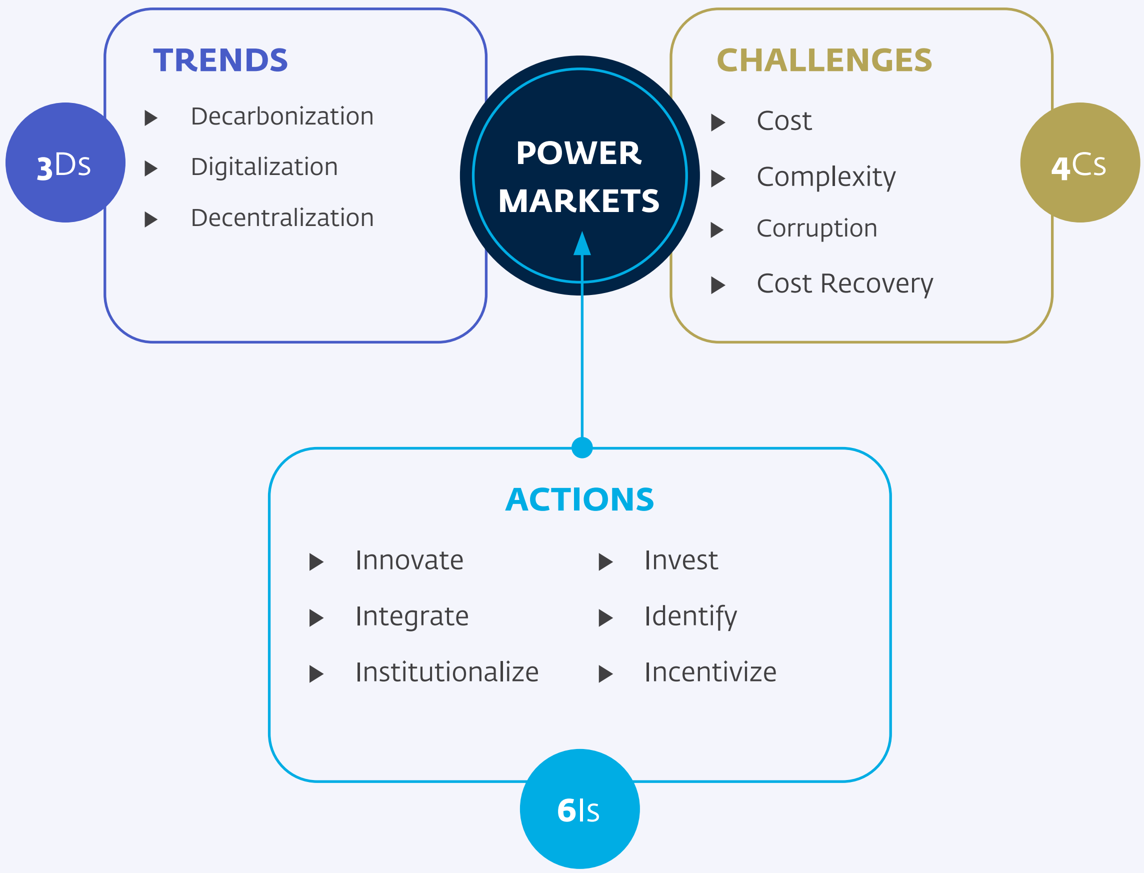
Report Structure

Chapter 2 provides an overview of global power market structures and models and trends in private investment over the past three decades. The chapter includes original analysis of what impact adopting a different power market structure tends to have on key metrics such as improved electricity access

FIGURE 1.2

Global Power Markets: Trends, Challenges, Actions

A framework for delivering SDG7



Source: IFC

rates, growth in renewable-based power generation, and future private investment flows. It shows how different market designs have performed historically in improving access and sustainability and how current trends (notably the 3Ds) might impact future performance.

Chapter 3 presents emerging opportunities for countries to leverage the private sector to meet access, sustainability, and other key sector objectives. The chapter provides an overview of the key issues policymakers need to consider in redesigning existing power market structures to accommodate the transformations brought about by decentralization, digitalization, and decarbonization. It showcases examples of how the private sector can be an effective and crucial partner. Recommendations, both cross-cutting and stakeholder-tailored, are provided for each power market structure.

Chapter 4 highlights a range of policies that the public sector can pursue as they rethink power market structures to make the private sector a valued partner in meeting SDG7 goals. It discusses actions that governments can take to institutionalize investor-friendly practices, incentivize private sector participation, and address current bottlenecks to private investment. Again, both cross-cutting and tailored recommendations are provided by power market structure.

Chapter 5 concludes the report by synthesizing the key recommendations for policymakers, investors, and development finance institutions.

The **Appendices** consolidate the policy recommendations, organized by market structure, and offer a primer on how electricity systems and markets work.

2

Structuring Power Markets

KEY INSIGHTS

Over the past four decades, alternatives to integrated power market monopolies—the traditional model—have been deployed by many countries. The general trend has been to allow greater private sector participation in power markets. Two key factors are driving this: the need to improve overall market performance and the imperative of finding additional funding sources in the face of high growth in demand and tight fiscal space.

In 1989, when markets were on the cusp of some major structural changes, the state-owned vertically integrated utility (VIU) model dominated, with 215 economies using it. Today, VIU is the second most used structure, its popularity having declined greatly, being used now in only 72 economies. Those that have retained VIU have done so either as a policy choice or due to external factors that constrain it from moving to a different model. VIU tends to be the preferred structure notably of smaller economies and of island states. However, even among those that have retained this overall model, many have introduced some form of private management and ownership.

Increasingly, countries are adopting the single buyer model (SBM) in which the state authorizes private investors to operate power plants as independent power producers (IPPs), and various forms of competitive wholesale and retail market structures which allow active participation in the market of public and private generation companies, distribution and supply companies, and end users. SBM, often viewed as an intermediary step in market liberalization, has become the most prevalent model, used by 89 countries. Wholesale-retail competition models are less widespread, used by 69 countries, and are more common in advanced economies.

IFC's econometric analysis of global power market structures, based a panel dataset[18] developed in-house and which uses an array of power sector indicators, finds that:

- More competitive market structures have a positive and significant effect on energy access, installed generation capacity, adoption of renewables, and participation of IPPs.
- Private investment flows are positively correlated with competitive market structures, though regional disparities exist.

Designing power markets that deliver clear, correct signals that encourage private sector entry takes time. Whatever market structure countries choose, they should adapt their design to address the dual challenges of meeting both their sustainability goals and other public policy goals, notably on energy access, affordability, and reliability.

How a power market is designed determines how the sector can address complex economic, social, environmental, and engineering challenges to deliver sustainable and reliable electricity at the least cost to consumers. This is no simple task as supply and demand must be balanced every second, multiple resource and network constraints satisfied, and the market must send the correct price signals to stimulate efficient generation and investment over time. Electricity market designs differ significantly globally. This is a sector where there is no 'one-size-fits-all' model that works for every market. For any design to function well, a country's geographic, political, and economic context needs to be considered. And experimentation is essential.

This chapter reviews global trends in adoption of different designs. It draws from a unique new Global Power Market Structures Database[19] that captures the market's evolution in 230 economies from 1989 to 2024.[i] It provides insight into the most promising design options available to countries aiming to reach UN Sustainable Development Goal 7. IFC's analysis indicates that market structures that enable private sector entry are associated with several improved outcomes for the sector.

Types of Power Market Structures

Forty years ago, the power sector was widely regarded as a public utility function. The state-owned VIU model dominated globally. Since then, a wide variety of countries—small and large, advanced and emerging economies—have deployed alternatives to integrated monopolies. The dominant overarching trend has been the adoption of market designs that, to varying degrees, expand the role of the private sector.

According to the aforementioned database, 135 countries have transitioned from the traditionally publicly owned VIU model to introduce a degree of private sector engagement since 1989 (Figure 2.1). This has generally been in the power generation segment, but there are also cases of private sector participation in the networks. Since 1989, 152 economies have allowed private independent power producers, or IPPs, into the generation segment.[20] In this section, we provide a short overview of each power market structure and share some insights based on over three decades of experience in their deployment.[21]

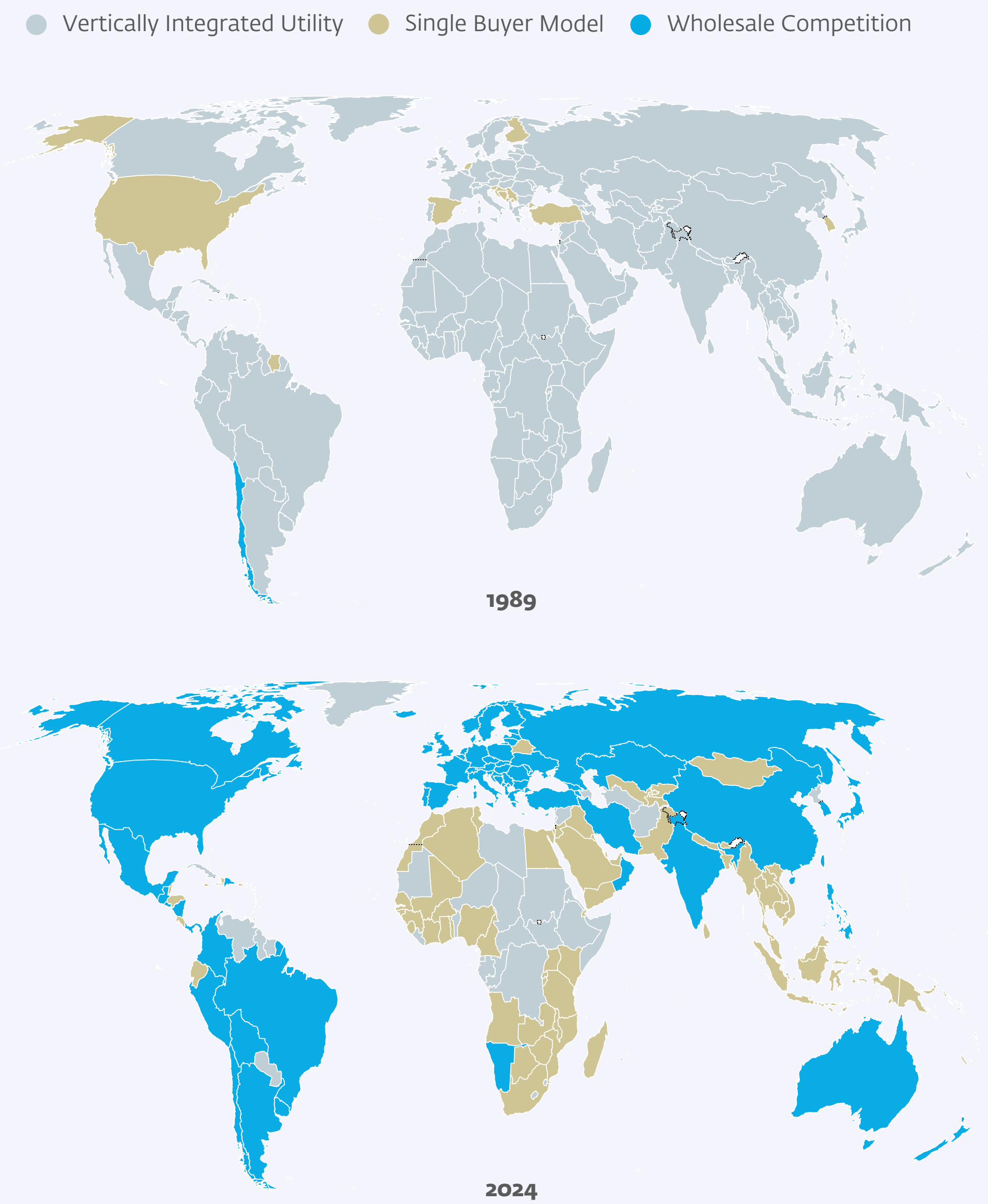
Vertically integrated utility (VIU)

The oldest market structure among models currently utilized is the VIU. Under this model, a single entity carries out all functions in the electricity sector, including generation, transmission, distribution, and retail supply (Figure 2.2). In 1989, it was by far the dominant model, with 215 economies using it, providing electricity to 92 percent of the world's population. By 2024, just 72 countries and territories, accounting for 7 percent of the world's population, were operating VIU. It is currently the second

i The database covers all 193 countries recognized by the United Nations as well as 37 additional economies which includes countries' overseas territories (e.g. French Guiana). 1989 was selected as the base year to capture the market structures in place before the dissolution of the Soviet Union and Yugoslavia. Their breakup triggered the emergence of new electricity markets out of successor countries and an overall gradual trend toward market liberalization. See https://datacatalog.worldbank.org/search/dataset/0065245/global_power_market_structures_database.

FIGURE 2.1

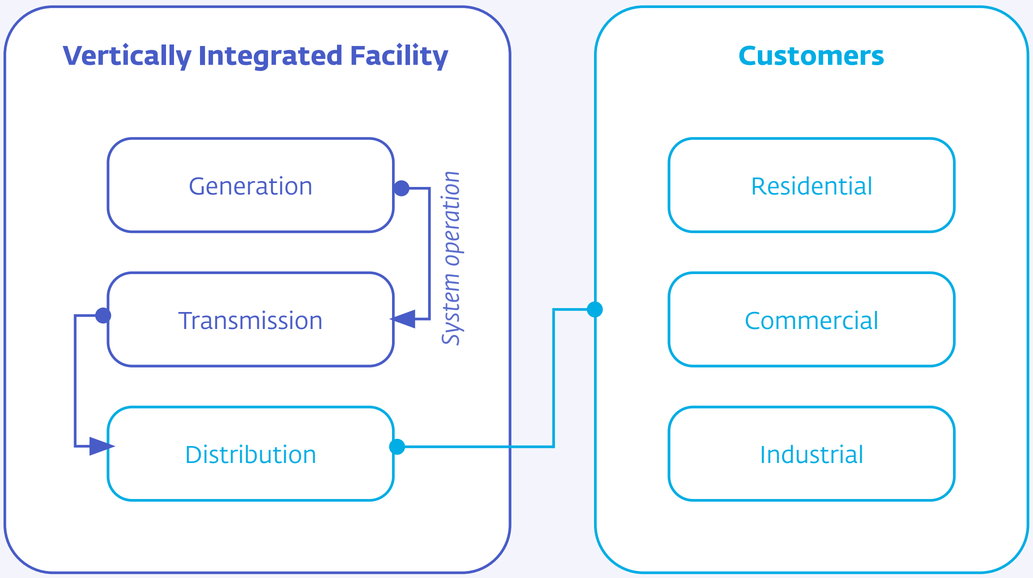
Evolving Power Markets: A Global Overview



Source: Akcura, 2024.

FIGURE 2.2

Vertically Integrated Utility



Source: IFC

most prevalent market structure and is especially common in Sub-Saharan Africa.

As of July 2024, 84 percent of VIUs are state-owned companies. Only 11 economies have private VIUs without any IPP presence. These are mostly either small, island states, or fragile and conflict-affected states such as Somalia, where private energy service suppliers primarily provide electricity through mini-grids. The unique context of these countries, including major issues with their sector's financial sustainability, constrains the scope for private sector entry. Private VIUs can improve operational performance but they rely on effective regulation to mitigate abuse of market power and ensure that the private monopoly has the right incentives. Restrictions on market entry could also perpetuate concentration of market power, even when economic and technological changes support new entrants.[22]

The technical and financial performance of VIUs has been mixed. Some markets leveraged the model to better coordinate investment decisions and operations—thereby improving cost efficiency and lowering risks—and to achieve energy security and social objectives such as rural electrification. However, some economies operating VIUs have performed more poorly, with investment lags, lack of competition, weak financial performance, low efficiency, and high losses. This is because the VIU model typically creates less incentive to innovate and improve performance, especially for state-owned entities that have standing fiscal support available. In addition, this market structure can be subject to government interventions such as on bill collection, tariffs, and fuel procurement that are driven more by short-term political goals and which tend to adversely impact VIU operations. The countries that have succeeded at maintaining high performance using VIU structures have found ways to alleviate these risks—for example, through corporatization or public listings of state utilities.

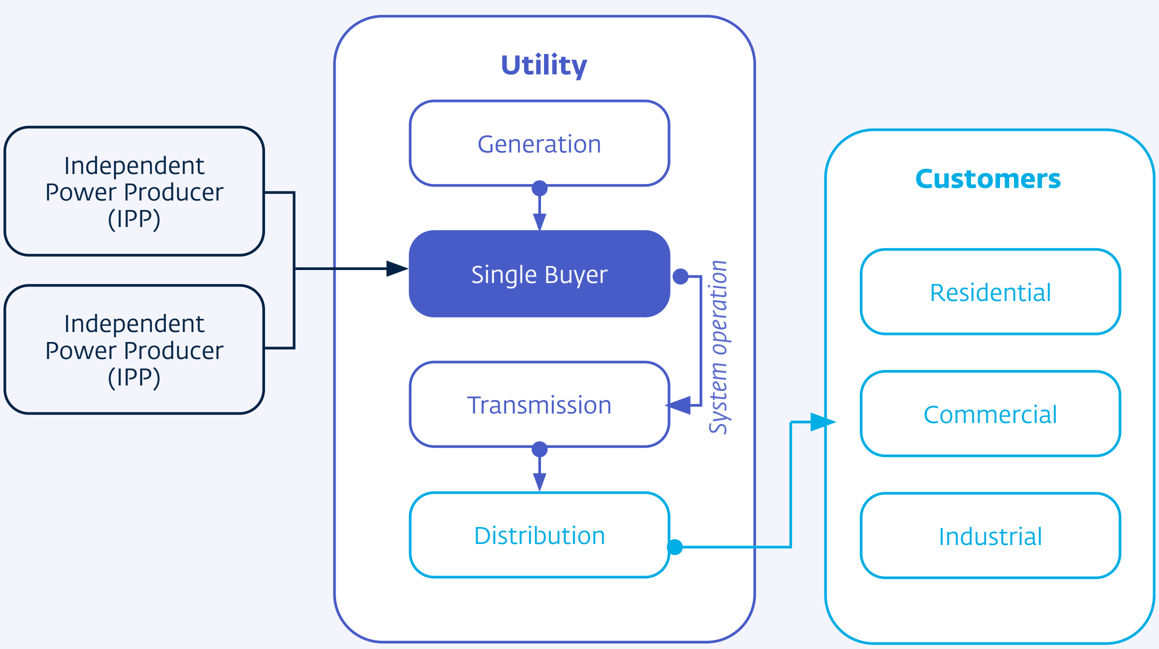
Single buyer model (SBM)

The SBM is the most utilized power market structure, with 89 countries and territories operating it, covering 29 percent of the world's population. Under SBM, the state authorizes private investors to operate power plants as IPPs which generate electricity and sell it to a single buyer, typically the national power company or a wholesale purchasing agency (Figure 2.3). IPPs usually sell their output to a single buyer through long-term power purchase agreements, or PPAs. Under this model, decision-making on whether to add capacity and expand power systems is centralized. This model allows system operators to maintain a unified wholesale price and simplifies price regulation.

While this model has several design variations, one common feature is the presence of some

FIGURE 2.3

Single Buyer Model



Source: IFC

arrangement for centralized purchasing. The diverse designs stem from differences in objectives pursued, the power sector conditions, and political and institutional contexts. A single buyer could, for example, retain ownership and control over generation assets (and other functions such as distribution) or be detached from other functions. The design that involves the least structural change allows IPPs to sell power to the VIU that has not been unbundled or privatized. This design allows limited competition, whereby private generators compete to supply power to the VIUs via contracts.

The SBM is relatively easy to implement and tailor to country contexts. Faced with public financing constraints, countries can use IPPs to significantly increase generation capacity. However, the model also brings considerable risks. SBM can, for instance, lock in poorly designed and negotiated long-term PPAs, which could be detrimental to the sector's financial sustainability or hinder a transition to more competitive structures.[23] Sub-optimal sector outcomes can result if the single buyer is financially weak and unable to honor the terms of PPAs.

Organized wholesale power markets

A third power market model, one embraced by countries interested in introducing more competition, encourages active participation of public and private generation companies, distribution and supply companies, and end users. Allowing the market to set prices reveals the true cost of electricity and provides clear signals for where investments are needed, while competition in wholesale and retail segments creates opportunities for the private sector.[24] There are a variety of wholesale and retail competition market design options.

Sixty-nine countries, covering 63 percent of the world's population, have some form of competition in their wholesale markets. Most of these countries allow generators and large energy consumers (distribution companies and industrial consumers) to conclude bilateral energy contracts. Most countries complement bilateral contracting with a type of organized spot market in which short-term trades are conducted either a day in advance (day-ahead market) or within a day of (intra-day market) actual delivery of power (Figure 2.4).

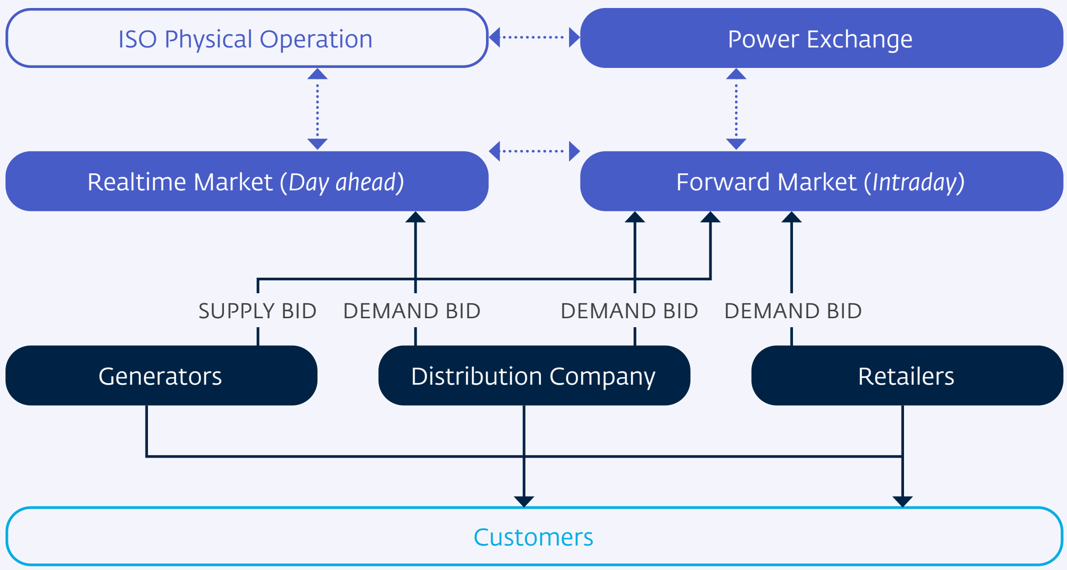
There are several types of spot market. They can be designed as 'power exchange/net pool' settlement which involves double auctions where power generators submit bid prices and quantities to sell, and buyers (distribution/supply companies, traders, and large consumers) submit offers to purchase. The generators' bids are then stacked in increasing order of price offered, and the demand bids are stacked in decreasing order of their prices, with market-clearing price determined by where the two sets intersect. Forty-two countries have adopted this structure. An alternative spot market design is the 'power pool/gross pool' settlement, which involves a single auction where only the generators offer bids, and the price is determined by the highest accepted generator's sell bid that intersects with forecasted demand. Eight countries operate this wholesale structure.

Thirteen countries, primarily in Latin America, have adopted a cost-based structure in designing their wholesale markets. This design shares

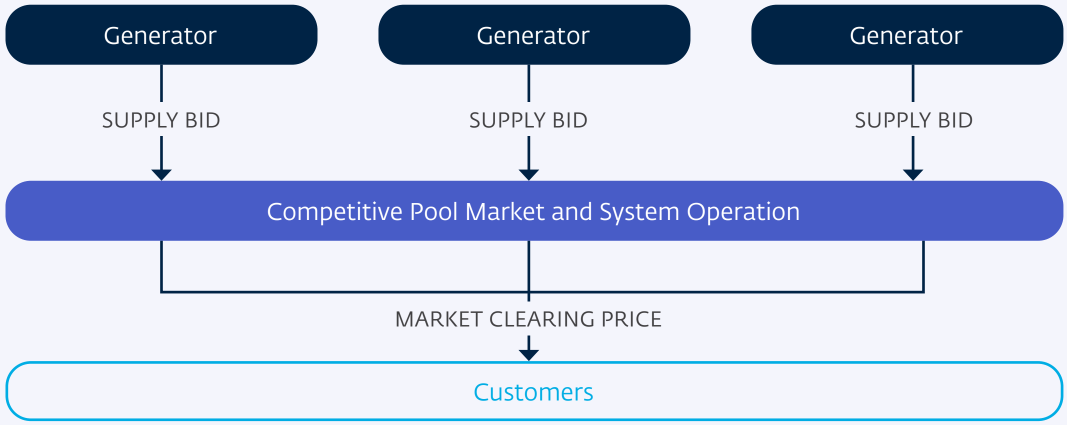
FIGURE 2.4

Bid-Based Wholesale Market Models

Power Exchange (Net Pool)



Power Pool (Gross Pool)



Source: Adapted from Bouddou et al. (2020)

some of the characteristics of bid-based spot markets, but with one significant divergence: the quantity and the price components of the bids are derived from formulas set by the market operator. For example, under this model, the price paid to thermal generators is set by the system operator at the marginal cost of the plant, based on fuel input prices and the technical characteristics of the plant (Figure 2.5).

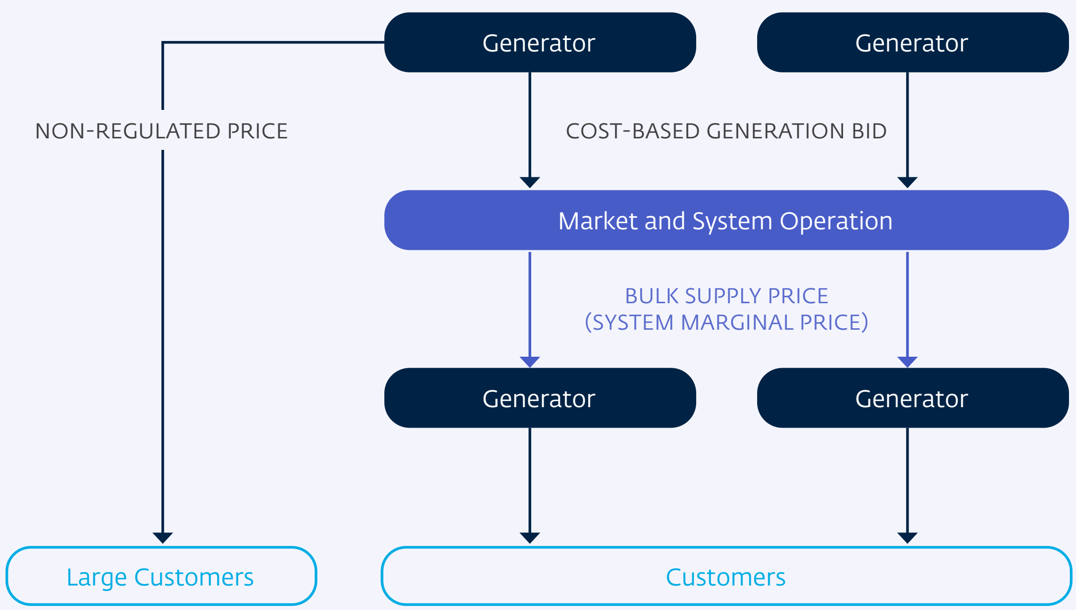
In addition, some groups of neighboring countries have created regional organized wholesale power markets to further enhance competition, energy security, and sustainability (Box 2.1).

Organized retail power markets

Sixty-six economies allow some competition in the retail segment of the electricity market, where the end users (residential, commercial, and industrial) can choose their power supplier and other services. If well implemented, this model enables pricing and service options that are tailored to customer needs, while facilitating the introduction of beneficial new technologies and processes. However, the vast majority of economies (164) operate structures that do not give customers different options for choosing a supplier or participating in the market.

FIGURE 2.5

Cost-Based Organized Wholesale Market Model



Source: Adapted from Power Engineering International (2003)

BOX 2.1

The Western Balkans Show How Regional Power Exchanges Can Boost Energy Security and Promote Renewables

For several years, the Western Balkan countries have sought to put in place competitive wholesale market structures by establishing a regionally integrated power market with a view to enhancing both energy security and sustainability. Most of them do not have a big enough power market alone to operate their own liquid power exchanges. However, by integrating liquid cross-border markets, they can cuts costs for energy consumers through more competition and foster more effective use of existing generation and transmission infrastructure.[25] Aggregating generation and demand over a larger trading region also promotes integration of more intermittent renewable energy sources. That is because expanding renewables in small isolated markets requires considerable investment in backup generation and storage, which increases the cost of the system.

Serbia established the first power exchange in the region in 2016—SEEPEX, or SEE Power Exchange—marking a significant step toward a regional power trading solution. Through a partnership with Norway's finance ministry, IFC has since 2016 provided the Albanian government technical and regulatory power market advice. This led to the establishment of the Albanian power exchange, ALPEX, becoming operational in 2023, the second such exchange in the region. ALPEX's design involves a transparent hourly price that can be projected forward and used to attract new and cheaper investments in the energy sector. By matching the hourly bids and offers to sell and buy energy in a centralized auction, ALPEX also helps Albania to optimize use of its hydropower reservoirs.

Montenegro and North Macedonia launched their individual power exchanges just after ALPEX launched, while Kosovo's power exchange became operational in 2024. The eventual joining up of these individual power exchanges is expected to forge a more liquid and transparent Western Balkans regional power market. This will benefit both consumers and producers by ensuring fair prices, a more secure and reliable electricity supply, and greater integration of renewable energy sources.

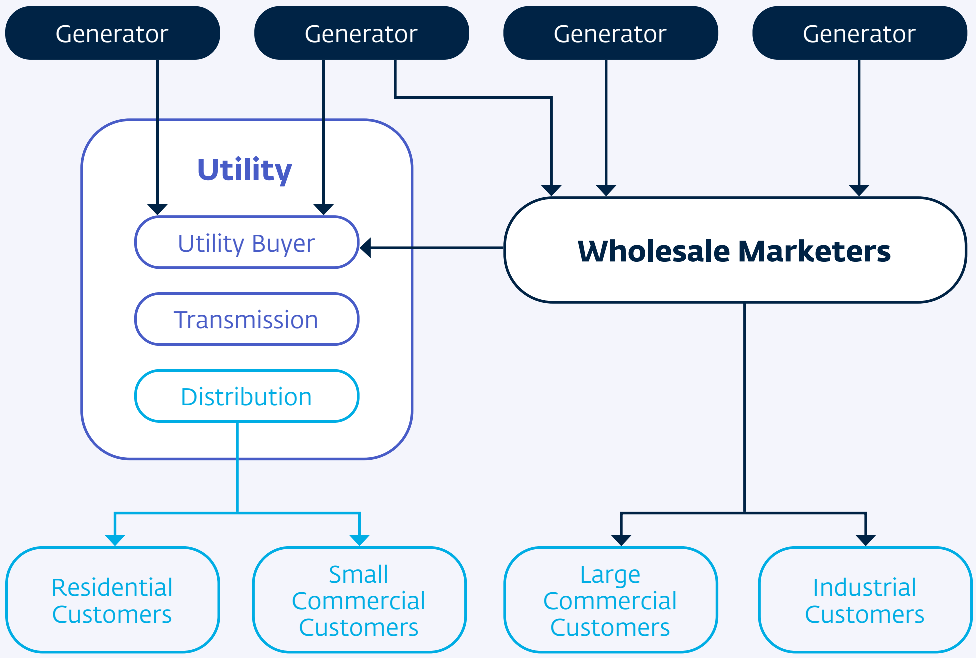
Competition in the retail segment can only exist if there is some form of wholesale competition market structure. This means that all countries that allow some level of retail competition also allow some competition in the wholesale segment of the market. Thirty-two economies permit partial retail competition (Figure 2.6.a) where large electricity consumers can freely choose their retail supplier but small consumers like households remain regulated. Thirty-four economies provide for full retail choice (Figure 2.6.b) where all consumers can choose their electricity supplier.

The partial retail model is used mainly in Latin America while the full retail competition model is more common in Europe, home to 82 percent of countries that use it. Advances in technology—especially digitalization of the sector through the adoption of smart meters—are creating new avenues in developing countries for introducing more retail competition (Box 2.2).

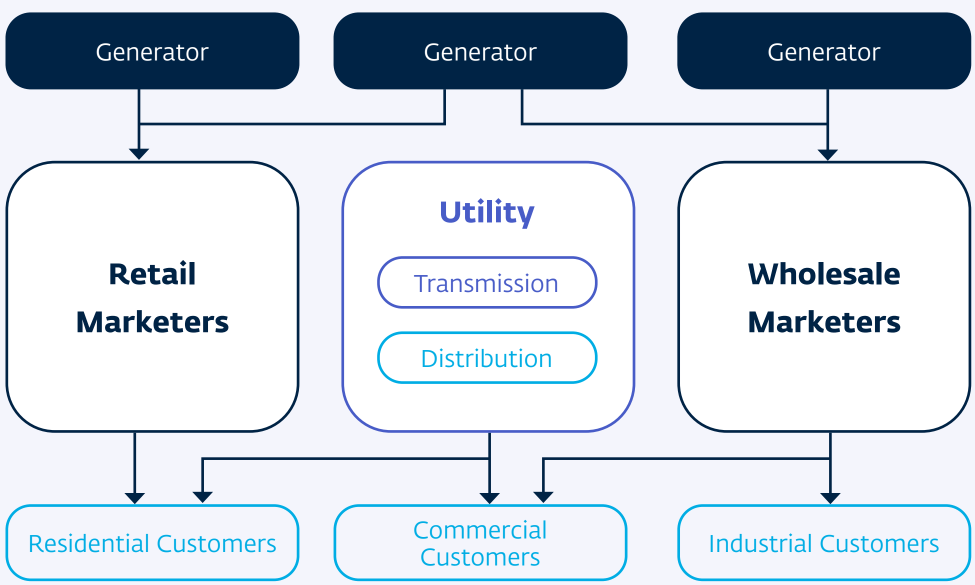
FIGURE 2.6

Retail Competition Structures

a. Partial retail competition



b. Full retail competition



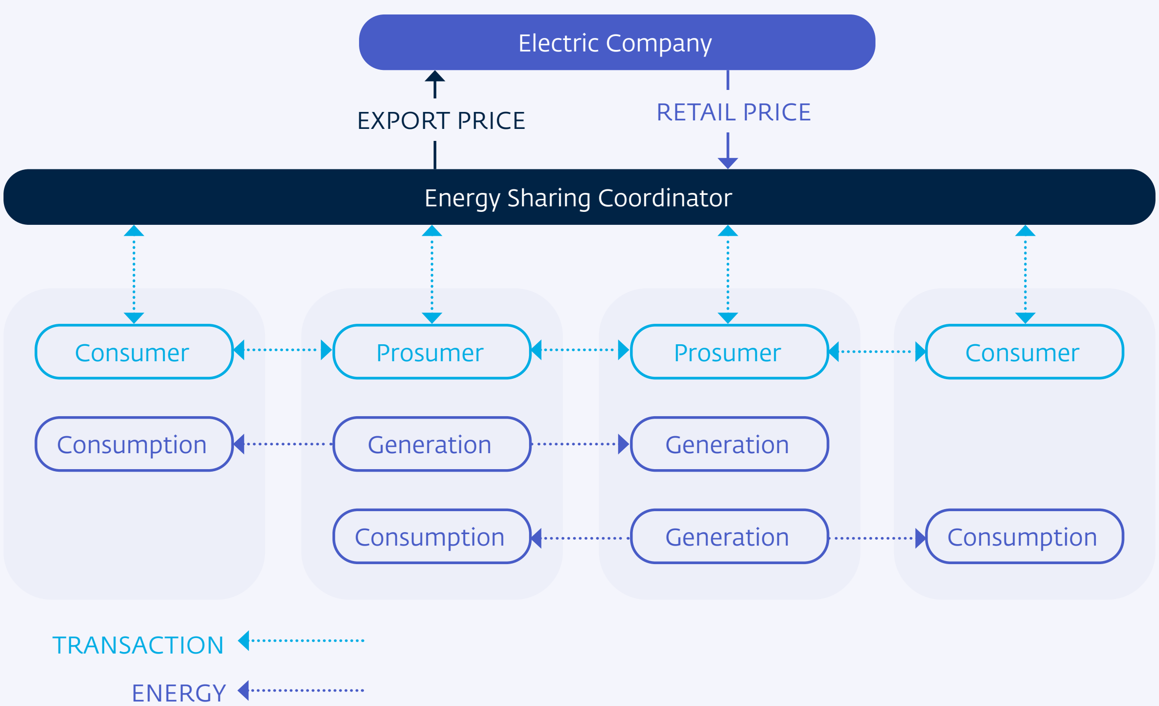
Source: Adapted from Enerdynamics (2023b) and Enerdynamics (2023a)

BOX 2.2

Localized Retail Markets—A New Frontier for Innovating on Renewables and Increasing Affordability

Advances in technology are enabling the formation of localized electricity retail markets through peer-to-peer electricity trading and virtual community power pools. In peer-to-peer (P2P) electricity trading, community members buy or sell power directly with each other without intermediation by conventional suppliers. In this system, the end-consumer can become a 'prosumer'—both producer and consumer—by exchanging their excess electricity with other consumers within their community. This trade is coordinated by a community manager, who provides the necessary controlling software or market platform and who can sell the collective surplus energy to third parties and manage the balancing group.

P2P trading can create savings for both consumers and the overall power system. For example, consumers with excess distributed generation capacity can monetize the energy, while consumers needing to purchase power can secure it from low-cost local (primarily renewable energy) generation.



Continued on Page 30

Thus far, localized retail markets have been primarily deployed in advanced countries, but they also hold promise for developing countries. In Colombia, most consumers including small businesses, commercial, industrial, and residential users cannot contract their energy directly with generators, nor buy it directly on the spot market due to their smaller size. However, retail aggregators, such as Vatia, are bypassing this restriction. Retail aggregators facilitate contracts between large generators and small retail customers. By aggregating both the supply and demand sides, aggregators allow generators to find a purchaser while enabling smaller end users to find generation sources adapted to their needs. Vatia sources its electricity from different generators, most of whom produce electricity from renewable energy, and matches them with small energy customers through back-to-back contracts, hedging itself via limited spot market exposure. In 2022, IFC approved a $10 million investment in Vatia intended to help it triple its generation capacity using solar and to increase its national market share.

In Bangladesh, the renewable energy start-up SOLshare is installing small-scale mini-grids to connect local consumers with prosumers who have solar panels installed in their homes. P2P trading platforms enable prosumers to trade in excess solar energy. A reliable power network is made available across the locality covered through a mini-grid. The company currently operates 34 mini-grids across Bangladesh.

Power Market Structures Continue to Evolve

Since 1989, many countries have changed their power market structures, experimenting with designs aimed at improving efficiency while meeting key policy goals (Figure 2.7).[ii]

While the VIU model was used in 215 economies in 1989, it has since fallen out of favor, with only 72 using it today, covering just 7.2 percent of the world's population (Table 2.1). In contrast, the number of countries using SBM and competitive wholesale market structures has increased from 14 to 89 during the same period. It has tended to be higher-income countries that have transitioned out of SBM. Back in 1989 Chile was the only country that operated a competitive wholesale market structure, while 69 countries were using it by 2024.

The experiences of countries in transitioning between market structures offer valuable lessons. By analyzing the Global Power Market Structures Database and other data sources, the report tackles two key questions:

> How have power market structures impacted key sector outcomes over the past 35 years?

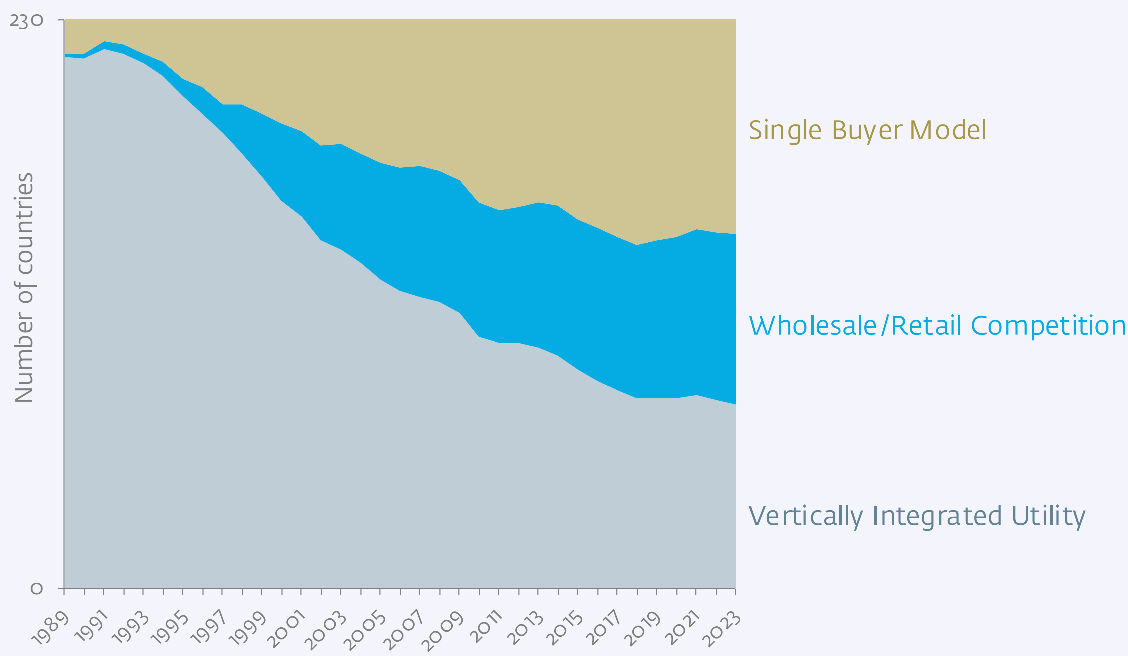
> How have power market structures impacted investment flows in the past 13 years?[iii]

ii For more details on each market structure please see a forthcoming working paper: Akcura and Mutambatsere (2024) Global Overview of Power Market Structures. Policy Research Working Paper. Washington, D.C.: World Bank Group. (forthcoming).

iii The 13-year timeframe is chosen because this analysis relies on IJ Global Database which has comprehensive transaction data for advanced and emerging markets mainly from 2011 onward.

FIGURE 2.7

Global Electricity Market Structure Transition 1989–2023



Source: Akcura, 2024

Market transformations increased access to electricity but impact on renewables is mixed.[iv]

To identify if differences in power sector outcomes can be discerned that are associated with the power market structure adopted, an analysis was conducted of the effects of transitioning from the previously dominant VIU model to either SBM or to wholesale and retail competition (WRC) models.[26]

This analysis reveals several significant relationships between power market structures and energy sector outcomes.

Overall, transitioning out of VIU, regardless of whether to SBM or WRC, resulted in potential short-term reductions in renewables' share of the overall energy mix and increases in carbon dioxide (CO_2) emissions. But the transition also tended to lead to significant improvements in electricity access, generation, and supply, as well as increased private sector participation

iv More details on the econometric analysis will be outlined in a forthcoming working paper: Akcura and Adewole "Impact of Power Market Structure on Key Energy Sector Outcomes."

through IPPs. Thus, while transitioning to SBM proved effective at expanding electricity access and attracting private investment through IPPs, it was associated with lower adoption of renewable energy, higher CO_2 emissions, and reduced total electricity supply. Transitioning to the WRC model, on the other hand, appears to be conducive to increases both in renewable

TABLE 2.1

Power Market Structures by Country, 1989 versus 2024

	Number of Countries		Population (share of the world population)		Regional Distribution*		Average per capita GDP (constant 2015 $)	
	1989	2024	1989	2024	1989	2024	1989	2022
Vertically Integrated Utility (VIU)	215	72	4.74 billion (92%)	0.57 billion (7.2%)	EAP: 40 ECA: 49 LAC: 45 MENA: 21 NA: 2 SA: 8 SSA: 50	EAP: 16 ECA: 13 LAC: 19 MENA: 3 NA: 1 SA: 1 SSA: 21	40,283	56,137
Single Buyer Model (SBM)	14	89	0.42 billion (8.2%)	2.33 billion (29.4%)	EAP: 1 ECA: 11 LAC: 1 MENA: 0 NA: 1 SA: 0 SSA: 0	EAP: 18 ECA: 4 LAC: 15 MENA: 16 NA: 0 SA: 6 SSA: 28	28,181	16,475
Organized Wholesale/ Retail Competition (WRC)	1	69	0.01 billion (0.3%)	4.98 billion (62.8%)	EAP: 0 ECA: 0 LAC: 1 MENA: 0 NA: 0 SA: 0 SSA: 0	EAP: 7 ECA: 42 LAC: 13 MENA: 2 NA: 2 SA: 1 SSA: 1	5,293	85,958

Source: Akcura (2024).

Note: GDP data is based on 2022 estimates from the World Bank's World Development Indicators. The 2021 data was utilized for economies whose 2022 GDP was not available, while the earliest available data was utilized for economies without GDP data for 1989. Legend for Regions: EAP = East Asia-Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; NA = North America; SA = South Asia; SSA = Sub-Saharan Africa energy use and overall electricity supply, thereby potentially contributing to lower CO_2 emissions. These findings are consistent some of the key insights in other studies,[27] which highlight the importance of private sector participation in improving electricity sector outcomes.

Greater competition boosts uptake of renewables.

The WRC model has performed best of the three models at accelerating the rate of renewable energy adoption. Countries operating under WRC saw a significant increase in share of renewables in their electricity mix compared to those operating under VIU. Specifically, each additional year a country spends in the WRC structure is associated with a 0.57 percentage point increase in the share of renewable energy. This finding underscores the potential of competitive electricity markets to drive the transition to cleaner energy sources.

The analysis also finds that countries that transitioned away from VIU may have experienced a temporary setback in renewable energy adoption if they replaced it with SBM. This does not indicate that the SBM structure is inherently biased against renewable energy generation. Rather it is more likely to be the case that renewable energy generation, especially solar and wind, was not cost effective until the last decade for most countries. As a result, most countries that transitioned from VIU to SBM mainly relied on thermal generators.

That trend is now shifting as solar and wind generation costs have significantly declined. Since 2015, eight out of the 16 countries that switched from VIU to SBM did so by bringing in a solar or wind power producer to the market. This is a big contrast with the previous decade where just 11 of the 46 countries that moved from VIU to SBM did so via renewable energy producers, with the rest turning to thermal IPPs. When countries transition to SBM it is important to carefully manage the reform process to ensure a smooth transition, while maintaining a focus on promoting renewable energy sources. Countries should avoid locking their systems to a high CO_2 emission pathway through rigid long-term PPA contracts with thermal generators.

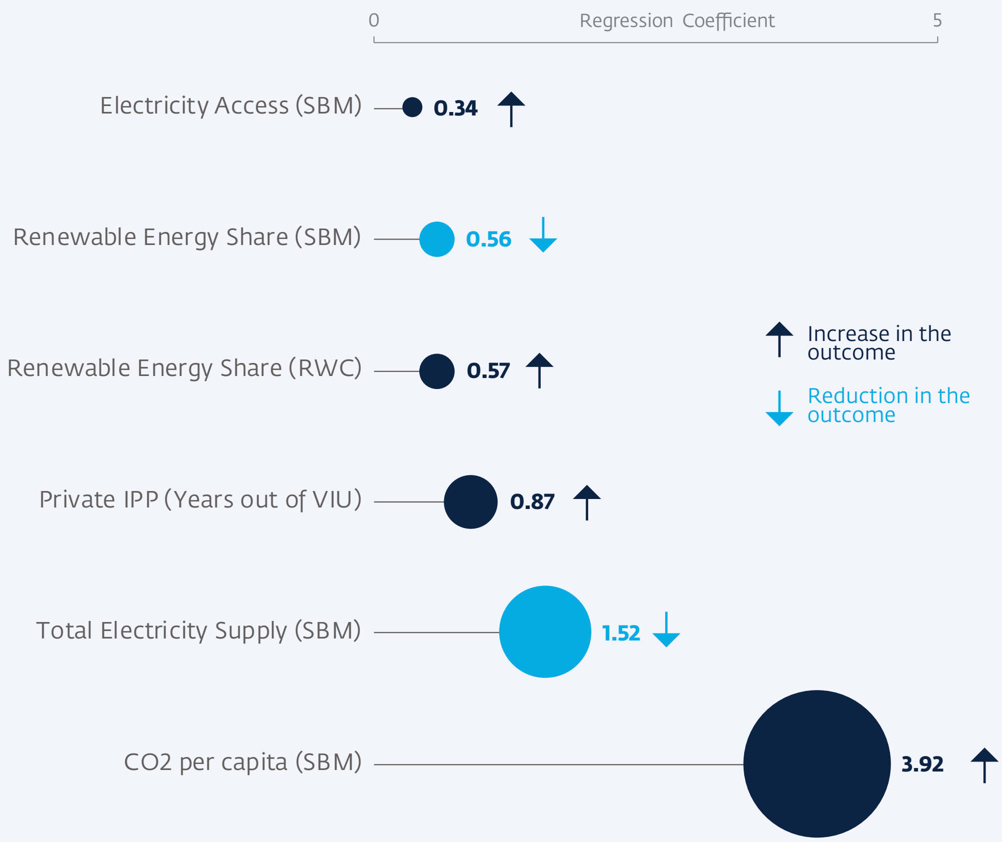
Single buyer model has a strong record of success for expanding access.

The analysis reveals that the SBM is associated with the best historical performance in expanding electricity access, particularly in rural areas. Countries that spent more years in SBM witnessed significant increases in overall electricity access and rural electrification rates relative to those under the VIU model. Each additional year with SBM was associated with a 0.34 percentage point increase in overall electricity access and a similar increase in rural electricity access.

SBM's success in expanding electricity infrastructure, especially to underserved populations, is due to multiple factors, foremost being its ability to attract private investment through IPPs, as well as unlocking public resources for transmission and distribution, and its focus on centralized planning. In contrast, the WRC model does not demonstrate a significant impact on electricity access. This may be due to the countries adopting the WRC model

FIGURE 2.8

Impact of Transitioning from Vertically Integrated Utility on Power Sector Outcomes



Source: IFC Analysis.
Note: Bubbles represent the impact of the transition from a vertically integrated utility on power sector outcomes. Outcomes in light blue indicate a reduction in the outcome, while navy blue indicate an increase. Statistically significant results at five percent level are shown.

often having already achieved high levels of electrification by the time they transition to it.[28]

Where SBM has been less successful, however, is in boosting supply of electricity. The analysis finds that SBM is associated with lower total electricity supply per capita compared to VIU. Countries operating under SBM had, on average, 1.52 percent lower total electricity installed capacity for every additional year they spent under the SBM model compared to those operating the VIU model. This suggests that SBM may not be as effective at expanding overall electricity generation capacity. However, it is important to note that its impact on electricity supply levels may vary depending on the specific country context and the implementation of complementary policies and investments.

More competitive markets are associated with an increase in supply.

In contrast, the WRC model exhibits a positive impact on total electricity supply. Countries operating under WRC saw a significant increase in electricity supply compared to those using the VIU model. Each additional year in WRC is associated with a 3.27 percent increase in total electricity installed capacity. This underscores the strong potential that competitive electricity markets have to attract investment, encourage efficiency, and stimulate the growth of generation capacity.

IFC's analysis finds that switching from vertically integrated utility to either a single buyer model or wholesale and retail competition significantly increases private sector participation in the power sector through independent power producers. Each additional year a country spends outside VIU is associated with a 0.87-year increase in number of years that have elapsed since the first IPP entered the market. Each additional year in SBM is associated with a 0.24-year increase in the number of years since the first private IPP entered, and a 0.34-year increase for WRC. The results suggest that both SBM and WRC are conducive to attracting more independent power producers, with WRC outperforming SBM. The analysis also implies that reforms that allow for more competition and private sector participation tend to encourage long-term involvement of IPPs in power markets.

The wholesale-retail competition model is associated with lower carbon emissions.

This analysis also sought to identify which models were most associated with lowering carbon footprints. The findings reveal that SBM-structured markets were historically associated with higher carbon emissions compared to VIU, with SBM countries seeing a significant increase in CO_2 emissions per capita. This is potentially due to their reliance on fossil fuel-based power generation to meet the growing electricity demand. Each additional year in an SBM structure is associated with a 3.92 metric ton increase in CO_2 emissions per capita. This finding highlights the need for countries that use SBM to pro-actively prioritize the use of cleaner energy sources and to implement policies that mitigate negative environmental impacts of power sector development.

On the other hand, the WRC model scored better on reducing the carbon footprint. Countries operating under it tend to have lower CO_2 emissions per capita compared to those operating VIU. Each additional year in WRC is associated with a reduction of 1.95 metric tons of CO_2 per capita, although the effect is not consistently significant across all model specifications. Many countries with WRC markets relied on renewable energy producers to launch their spot markets.

The analysis also assessed the impact of macroeconomic, political, and regulatory factors on electricity sector outcomes. It finds that economic indicators, particularly real GDP growth, have a significant positive impact on electricity generation, overall electricity access, and rural electrification. Regulatory indicators are positively associated with access to electricity, as evidenced by benchmarks like the Regulatory Indicators for Sustainable Energy, or RISE, which is a global set of indicators on countries' energy policies and regulations that focuses on access, efficiency, and renewable energy. Institutional factors, particularly political stability, are positively associated with total electricity supply. The analysis does not find significant relationships between a utility's creditworthiness and the key outcome variables. This could be because historically countries may have primarily relied on fiscal support and government guarantees to expand electricity access, backstop the utility obligations of IPPs, and scale up renewable generation.

More competition tends to generate increases in private financing flows.

The analysis also examined the relationship between the power market structures operated by countries and private financing flows across emerging economies between 2010 and 2023. The goal was to ascertain if certain models showed a greater propensity than others to attract more private investment in power infrastructures. The findings reveal that countries with more competitive power market structures tend to attract higher levels of private sector financing compared to countries that kept the VIU model (Figure 2.9).

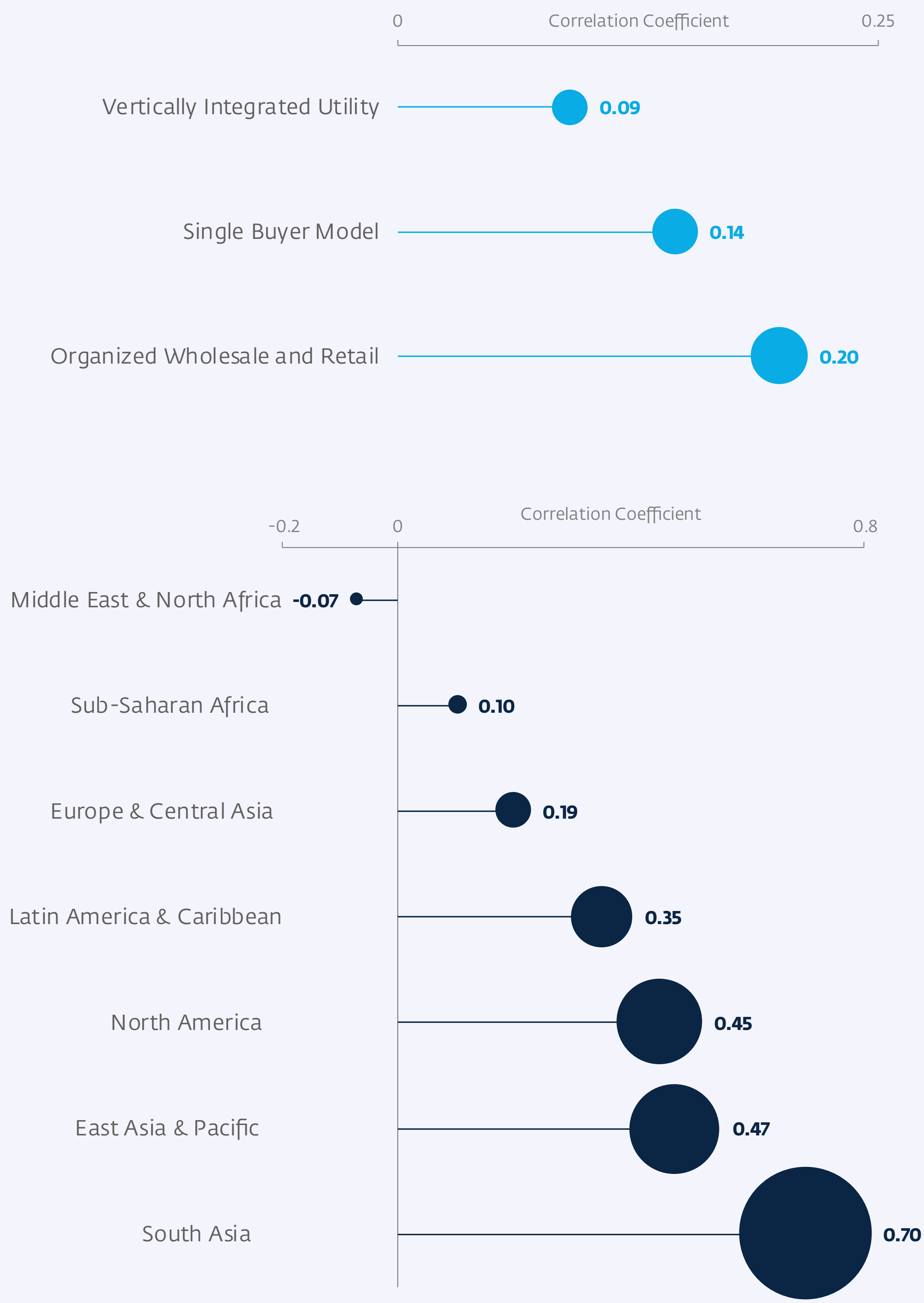
Specifically, countries that opted for competitive wholesale and retail market structures received higher private financing inflows for generation, transmission, and distribution. Conversely, the VIU structure demonstrates relatively weaker correlations with private investment. This implies that state-dominated, non-competitive market environments have more limited linkages with private sector investments in the power sector. This finding is not surprising as the VIU structure generally allows limited scope for private sector engagement compared to other market structures. Historically, private sector investments in countries with VIU structures occurred mainly through minority or majority shareholdings in the VIU or through build-transfer type investments in generation or network assets. However, that is changing, with growing scope for private sector engagement in VIU countries—for example through off-grid or mini-grid investments where the private sector is allowed to operate alongside the VIU.

The correlation analysis reveals some regional differences. In South Asia and East Asia-Pacific, the analysis suggests that as the power market structure evolves, there tends to be a significant increase in private sector financing. Eleven countries in these regions have transitioned to a more competitive power market structure since 2010. These transitions are correlated with the unlocking of substantial investment in the regions. Latin America and the Caribbean and North America also show a strong positive correlation between market liberalization and higher investment flows.

In Europe and Central Asia, the link is weaker, likely due to market liberalization having largely occurred in their economies in the 1990s, with most having already transitioned to an organized competitive wholesale structure

FIGURE 2.9

Relationship Between Market Structures and Private Sector Investment—Advanced and Emerging Economies



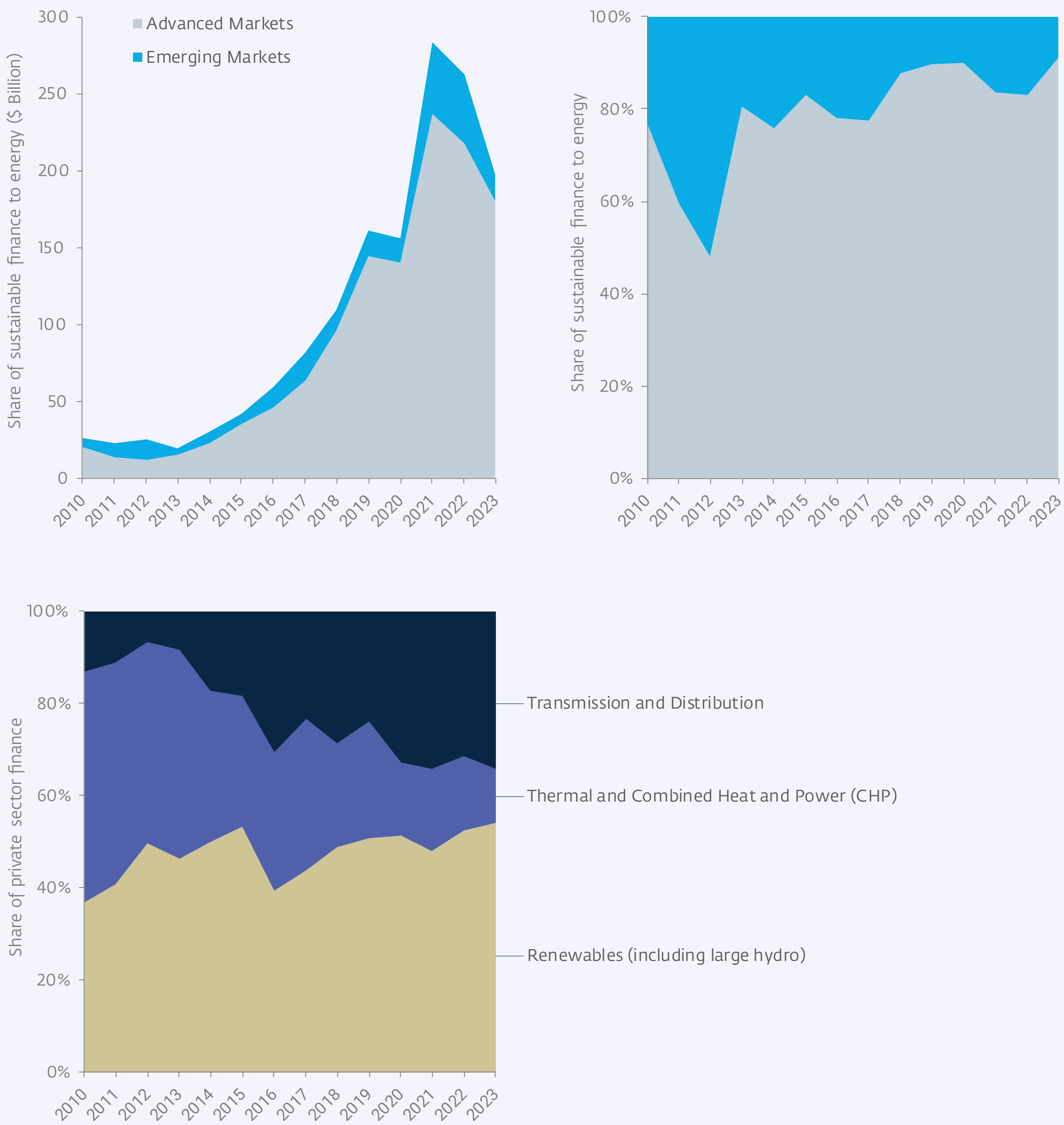
Source: IFC Analysis

Note: Size of the bubble represents the relative magnitude of the correlation

FIGURE 2.10

The Boom in Renewables Is Overwhelmingly Concentrated in Advanced Markets

Global power market financing trends 2010–2023



Source: IFC based on IJ Global (2023). Data includes project and corporate finance transactions with at least one private sector financing source.

by 2010. In the Middle East and North Africa, and in Sub-Saharan Africa, the correlation is very weak, indicating that market structure has been a negligible driver of private financing. State-controlled VIUs and SBMs still dominate in these regions and attempts at liberalization and introducing IPPs have yet to meaningfully boost investment. Historically, many countries that transitioned to SBM experienced delays in securing the first IPP and associated investments due to concerns about contract bankability and other sector issues.

The findings suggest that adopting more competitive market structures could stimulate private financing in countries where state monopolies dominate, but that the effectiveness varies across regions based on the composition of the existing frameworks. In addition, if the positive impacts on investment flows are to be sustained, market reforms must be complemented with stable governance and policy environments.

In Chapter 3, we will examine some of the key issues for countries to consider when adapting their power market structures. Some of these findings are informed by historical market realities, it should be noted, and these realities are being transformed by the current big trends impacting the sector—the so-called '3Ds' of decentralization, digitalization, and decarbonization. For example, there has been a marked decline in the cost of solar-generated electricity. This chapter will highlight key priorities and best practices for aligning power market designs to better leverage the private sector to achieve SDG7.

3

Leveraging the Private Sector

KEY INSIGHTS

The electricity industry is undergoing a transformation, driven by three overarching trends: decentralization, digitalization, and decarbonization (the 3Ds). Countries are repurposing their power market structures to meet the objectives of United Nations Sustainable Development Goal 7—ensuring access to affordable, reliable, sustainable, and modern energy for all. The 3Ds present a wealth of opportunities for countries to leverage the private sector to achieve these goals.

Mobilizing private capital through innovative financing instruments such as green bonds, sustainability-linked loans, and securitization can bridge the massive investment gap in clean energy infrastructure. Deploying smart grid technologies and strategically integrating efficient 'baseload generation' capable of running 24 hours a day can make systems more flexible and reliable while accommodating higher shares of variable renewable energy. Baseload generation efficiency is critical to integrating more intermittent renewable energy sources to ensure sufficient power generation capacity is available to cover demand when solar radiation levels dip, or wind is not blowing.

An area where the private sector can have a particularly positive impact is integrating renewable energy sources and unelectrified communities into power systems. Previously, the expansion of renewables like wind and solar was hindered by their intermittent nature i.e. they are not continuously available. However, the falling costs of energy storage technologies and the rise of solar-plus-storage hybrid systems are enabling greater penetration of intermittent renewables. The private sector has a vital role to play in scaling up distributed renewable energy solutions such as mini-grids and off-grid systems. Such technologies create an innovative complementary pathway to increasing access to electricity access in remote areas.

As countries repurpose power markets in different ways, the strategies and case studies presented in this chapter offer insights into how to effectively engage the private sector.

The electricity sector has entered a new phase of evolution. Three big trends—decentralization, digitalization, and decarbonization—are driving a repurposing of power market structures. Alternatives to the traditional centralized system are emerging thanks to advances in technology that allow for small-scale generation located directly at demand sites such as rooftop solar installations on houses or industrial sites. Decentralization is also blurring the distinction between producer and consumer. Customers are generating their own power, becoming 'prosumers' who both produce localized electricity and respond to market demand by adjusting their consumption patterns, either individually or through an aggregator.[v]

Meanwhile, digitalization of the power sector is breaking down the traditional boundaries between storability and grid dependency through, for example, cloud-based power-pooling solutions, which allow energy from multiple sources to be combined and managed together online, like a virtual power plant. This makes it easier to balance supply and demand, improving efficiency. As power infrastructures continue to digitalize, electricity systems are becoming 'smarter' with consumers and producers interacting more with the grid.

Decentralization and digitalization can in turn help catalyze the other big trend in the sector—decarbonization—as concerns about climate change continue to grow. Efforts are intensifying to shift power generation mixes and technologies away from fossil fuels and toward low- or zero-carbon resources. Solar and wind have emerged as the renewable energy sources with the greatest growth potential globally (Figure 3.1).

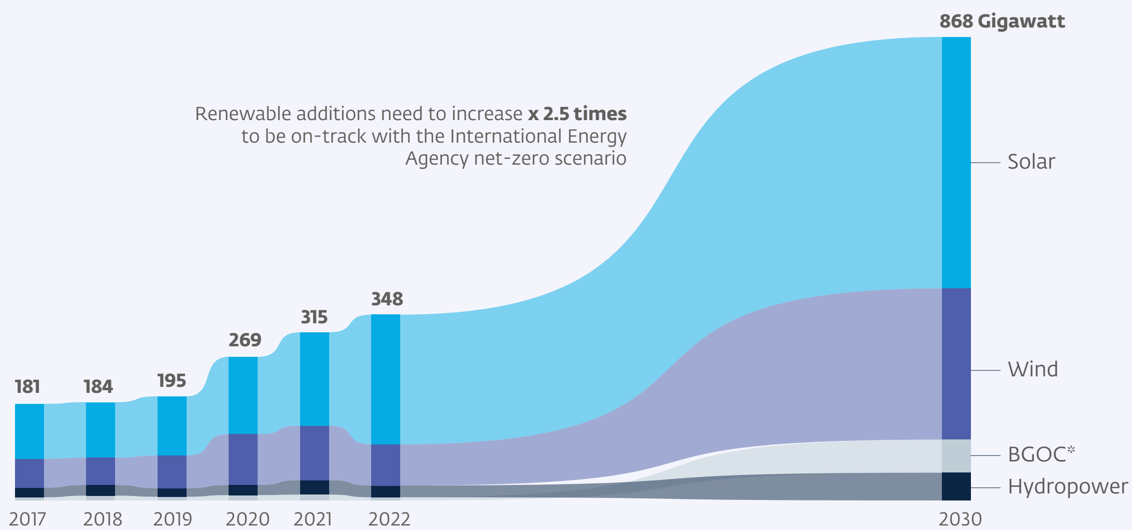
The addition of more intermittent energy sources like wind and solar into centralized electricity grids creates new challenges in managing power systems. Costs are being incurred to maintain the power system balance. Flexible non-intermittent electricity sources such as thermal or hydropower that can ramp up and down quickly, as well as extra energy storage capacity, need to be fed into the grid too to ensure a continuous, reliable supply given the ramp-up of intermittent sources, notably solar and wind. Ancillary services capable of promptly addressing supply-demand imbalances and avoiding power outages must be developed, along with robust frameworks for compensating flexible generators to ensure adequate supply. As more intermittent renewables enter the mix, flexible generators like gas power plants and batteries face greater unpredictability with revenues since they must remain on standby in case of a supply shortage e.g. solar production dips due to cloudy skies. To incentivize these producers to remain in the system, they need to be offered alternative financial compensation mechanisms. This marks a departure from the traditional model where power markets were designed to support electricity generated mainly from thermal sources, especially fossil fuels, which can be dispatched continuously.

v *Prosuming* often describes consumers—households, businesses, communities, organizations, and other agents—that rely on smart meters and generation units (such as solar photovoltaic panels) to generate electricity and/or combine them with home energy management systems, energy storage, electric vehicles, and electric vehicle-to-grid systems. Parag and Sovacool (2016)

FIGURE 3.1

To Get to Net Zero Emissions, Solar and Wind Need to Grow Quicker

Required renewable increases, by technology, to reach net zero emissions



*BGOC refers to Bio-power, Geothermal, Ocean power, and Concentrating Solar Power.

Source: Adapted from REN21 (2023).

Countries need to repurpose their existing power market structures to accommodate the ongoing transition from energy systems constrained by capacity (infrastructure-related issues) to systems constrained by the energy sources that feed the system. If they succeed in making this transition, it will both make power systems more resilient and help meet sustainability objectives. Many developing countries face a bigger burden with more complex challenges, seeking both to advance on sustainability goals, while at the same time needing to greatly expand access to their still-unelectrified populations. On top of this, developing economies are experiencing growing demand for electricity supply and governments and regulators face strong pressures to make power systems more reliable and affordable. For many developing countries the sustainability goals often come into conflict with other goals for the sector. Thus, while power systems especially in emerging markets remain underpinned by traditional structures, the overarching trends in the sector are challenging the status quo.

As highlighted in the previous chapter, there is no 'one size fits all' blueprint for how to structure power markets. Countries continue to experiment with models in response to the so-called 3Ds of decentralization, digitalization, and decarbonization. This presents new opportunities to leverage the private sector to increase energy access and make it more affordable. This chapter outlines strategies for countries to consider when repurposing their power markets, with a focus on those that leverage the private sector. Recommendations are summarized by market structure type at the end of each section.

Innovate — New Financing and Technology Solutions

The private sector will be instrumental in helping countries repurpose power market designs, especially in developing innovative solutions. Its contribution will be particularly useful in three key areas:

Financing instruments

> The private sector can help mobilize the massive investment needed for decarbonization by developing and deploying innovative financing tools. These include green bonds, sustainability-linked loans, and other instruments that align financial incentives with sustainability objectives. Diversifying the pool of financiers, such as through venture capital, capital markets, and securitization—which involves combining different financial assets and selling them to investors—can further expand the pool of available funding for clean energy projects.

Smart grid technologies

> Private sector innovation solutions in smart metering, advance communication, and control technologies will be critical to making power systems more efficient, flexible, and resilient. Technology can help utilities better manage demand, integrate intermittent renewables, and improve operational decision-making. It also lays the foundation for more advanced market designs that harness innovations like dynamic pricing—where electricity prices vary based on real-time demand and supply—and transactive energy models—where energy transactions are managed in real time using digital platforms. They can promote decarbonization by scaling up renewables generation while ensuring grid stability. And they are essential tools to further digitalize and decentralize the sector.

Baseload generation

> As countries flow more renewables into their power systems, the private sector can help optimize the role of baseload generation to make systems more stable and reliable. In any power system, a certain amount of so-called baseload generation needs to be supplied to the electrical grid at a given time to meet the minimum power demand. Typically, baseload generation is met by deploying flexible thermal or hydropower assets that can provide essential grid services, such as ramping up to full capacity in a short space of time, to balance the intermittent nature of renewable sources. Strategic

> placement and sizing of these assets, informed by rigorous planning and market analysis, can support the integration of renewables while avoiding stranded assets—infrastructure investments that may become obsolete or underused due to changes in technology or market conditions.

These areas are examined in more detail below.

Tapping nontraditional financing channels to ramp up renewables

Mobilizing private capital at scale is crucial to meeting the enormous climate financing needs of developing economies. Historically, they relied on public financing, typically state-owned enterprises and banks, to support power infrastructure investments. This has often exposed the sector to significant risks and financing constraints as public financiers face rising levels of non-performing loans and low capital adequacy ratios (for example, Bangladesh). Local commercial banks are an alternative financing source for power projects. However, these tend to have lending limits that restrict their exposure to the power sector or utility. In some countries such as Indonesia, local banks have reached these lending limits. In recent years, several financial instruments have been developed that are helping to bridge the growing gap between developing and developed countries in global infrastructure financing, especially for renewables.

One such solution is capital market financing. Capital markets, both international and local, have a large and underutilized financing pool that could fund power projects in most regions. By issuing debt securities such as corporate bonds or asset-backed securities, power companies can access more financing than is available from commercial banks and potentially with better financing terms. For example, in 2019, immediately prior to the COVID-19 pandemic, renewable energy companies globally were able to raise $6.6 billion through public markets. Capital market financing decisions are guided by expectations that typically refer to historical trends to project future performance. A study by Imperial College London and the International Energy Agency[29] comparing the financial performance of listed fossil fuel to renewable power companies found that the latter offered investors higher total returns. Renewable energy stocks also had lower volatility across the board compared to fossil fuels.

Innovative financial instruments and platforms can help attract greater private investment. Green, social, sustainable, and sustainability-linked bonds have emerged as an important mechanism to channel private climate financing to developing countries. Despite the potential, their issuance has been relatively constrained in developing countries given how much climate financing is needed, with only around $136 billion issued in 2022, of which China accounted for half.[30] However, the landscape is shifting positively, as detailed in the most recent IFC-Amundi report on Emerging Market Green Bonds.[31] This report highlights a significant surge in the issuance of green, sustainability, sustainability-linked, and social bonds in emerging markets, which increased by 45 percent in 2023, reaching an all-time high of $209 billion. Notably, issuers outside China boosted their transactions by approximately 65 percent, totaling $111 billion. This growth is driven by an increased demand from portfolio investors and a maturation of the asset class, signaling a robust future for sustainable securities in these regions. Development finance institutions such as IFC are actively expanding these financing sources (Box 3.1).

With more than $70 trillion in assets globally, institutional investors—particularly pension funds, sovereign wealth funds, and insurance companies—are a significant potential source of finance for power market assets. Institutional investors tend to have limited exposure to infrastructure assets in emerging markets. Traditionally more risk-averse than banks, they tend to invest in de-risked operating assets (that is, refinancing) rather than greenfield assets to avoid risks associated with construction projects. For example, in 2020 IFC supported a facility that mobilized financing from several institutional investors, including insurance companies, to refinance an existing debt package of Asahan 1, a 180-megawatt hydropower plant in Indonesia operating and generating revenue since 2011. The financial restructuring facility more appropriately reflected the project's de-risked nature, enabling institutional investors to take advantage of lower-cost debt and invest directly in an infrastructure asset for the first time in Indonesia.

Refinancing operating power infrastructure assets is vital as it creates opportunities for developers to recycle their capital while mobilizing investors with varying risk appetites. Innovation in financial structuring has introduced vehicles such as venture capital funds, bonds, and securitized assets in which institutional investors can participate. Such financing vehicles are increasingly popular in the renewables segment and could be further expanded through securitized assets pools that combine assets with different risk profiles.

BOX 3.1

Developing Countries Are Making More Use of Sustainable Financing

In June 2022, IFC extended an innovative $115 million 'super green' loan to Neoenergia Coelba, a Brazilian distribution utility, to bolster vulnerable grid infrastructure. This pioneering sustainable financing instrument combined green use-of-proceeds and sustainability-linked features, making it Latin America's first super green loan in the power distribution sector. As the sustainability coordinator, IFC is assisting Neoenergia in creating sustainability-linked financing targets on climate action and gender inclusion along with its first sustainability-linked financing framework.

Another recent example is IFC's green and sustainability-linked loan of €300 million ($329 million) to Iberdrola, the Spanish-based power utility. The loan's key performance indicators included the reduction of emissions by more than 60 percent relative to 2020 levels which, if achieved, would contribute to limiting global warming to 1.5 degrees Celsius in addition to more than doubling Iberdrola's renewable energy capacity by 2030.

Venture capital is driving clean tech innovation in emerging markets.

Venture capital is an important source of finance for commercializing early-stage innovative projects. It is unique because it facilitates funding for startups—new firms that are experimenting with unproven technologies or business concepts—which normally have scant access to traditional financing. Venture capital is being used to finance the more nascent segments of power projects like hybrid solar and wind technologies and off-grid power projects. According to the International Energy Agency, total equity investment (including growth equity) in energy technology startups in 2019, just before the pandemic began, was around $16.5 billion, of which $4 billion was early-stage venture capital.[32]

Overall, deployment of venture capital in the power sector has been more limited than in some other sectors such as software and medical technology. This is due to power technologies' commercialization being more capital intensive, often with long incubation periods that make investors wait longer before they see satisfactory returns. Renewable energy technologies have experienced success in mobilizing venture capital and private equity, with capital flows peaking in 2008 at $9.9 billion supporting global growth in renewable energy deployment. A sharp drop in such flows seen since that time signals a maturing of technologies such as solar and wind. By 2019 venture capital and private equity investment in renewable energy technologies was down to less than a third of its 2008 peak.[33] In recent years venture capital investors have switched focus to segments that are more software-focused such as smart grids where returns have historically been better. It has also shifted focus from developed to emerging markets, with India becoming the largest market for venture capital and private equity in 2019 reaching $1.4 billion, overtaking the United States and Europe.

Venture capital is far from the only financing solution for supporting innovative clean technology companies. Investors operating with a longer time horizon and higher capitalization levels can be better suited to scale up clean energy startups and realize returns. Development institutions are notably helping to bridge the financing gap in emerging markets (Box 3.2). For example, in 2012 IFC and the World Bank-managed Global Environment Facility launched the Cleantech Innovation Facility that targets small, highly innovative startups that promote green innovation and transfer of clean technologies to developing countries. More than 12 startups in Armenia, India, South Africa, and Türkiye have gained access to venture capital through the facility. IFC continues to support early-stage ventures in developing countries, including through investments in battery storage and smart-meter technologies.

Securitization can expand access to electricity to unserved communities.

Securitization is an innovative financing instrument that can help channel private capital toward expanding electricity access in unelectrified communities. By pooling together illiquid assets, such as loans or receivables, and structuring them into tradable securities, securitization allows for the mobilization of long-term funding from a wider range of investors.

This can be particularly valuable in the context of financing electricity connections for low-income households, where upfront costs are high and repayment periods are often extended.

A recent example of this approach in action is IFC's investment in 2023 of up to $48.8 million (30 billion West African CFA francs) in a social bond issued by a securitization vehicle to support the Electricity for All Program in Côte d'Ivoire. With an electricity access rate of 71 percent in 2021, Côte d'Ivoire faces significant discrepancies in access between urban and rural areas, with many customers who live in remote areas unable to afford the electricity connection fees.[34] The government's program, created in 2014, connects low-income households to the grid for an upfront cost of only $1.67 (1,000 CFA) with a balance of $249 (149,000 CFA) funded via flexible financing to the customer. By securitizing these receivables, the program can access long-term private sector local currency funding in the capital markets, allowing it to scale up and reach even more households. As of June 2023, the program had facilitated close to 800,000 new connections.

This landmark transaction, which includes a 15-year maturity tranche (the longest tenor for a securitization transaction in the region), demonstrates how such innovative financing structures can help unlock private capital to help reach universal access to electricity. By aligning financial returns with social impact, these instruments can attract a broader range of investors and channel much-needed funding to help close the electricity access gap in developing countries.

BOX 3.2

DARES—Boosting Private Investment in Renewables in Africa

The World Bank Group is working to increase access to electricity across Sub-Saharan Africa through its Distributed Access through Renewable Energy Scale-Up Platform (DARES) initiative. The program promotes private investment in distributed renewable energy systems with a focus on five areas: mini-grids, off-grid solar, systems for schools and clinics, solar irrigation and cold storage, and business models to improve reliability and displace diesel.

Tapping expertise from three different arms of the World Bank Group (IBRD, MIGA, and IFC), the program develops innovative financing and risk mitigation instruments that increase private sector investments at regional level. In Nigeria, for example, DARES offers performance-based grants to operators of mini-grids using a compensation model based on new customer connections (a monetary sum per end-user connected) for isolated mini-grids, and a percentage of capital expenditure for grid-connected mini-grid projects. DARES provides significant technical assistance to governments and the private sector, with differentiated approaches tailored to country contexts and markets.

Innovative financing approaches are also critical for scaling up investments in energy efficiency. Energy-efficient homes and buildings use less energy to heat, cool, and run appliances and electronics, and energy-efficient manufacturing facilities use less energy to produce goods. Improving energy efficiency both reduces energy costs for consumers and supports sustainability. Unfortunately, many countries lack robust and established financial markets to facilitate financing for energy efficiency enhancements. To advance on this front, countries can leverage private sector solutions such energy service companies (so-called ESCOs) that specialize in designing and implementing energy efficient options (Box 3.3). Digitalization within the power sector will also improve energy efficiency as smart tech-enabled automation and analytics reduce system losses and involve consumers more in operation. For instance, through demand response, consumers receive financial incentives to reduce their energy use during peak periods, actively contributing to grid stability. Advances in remote monitoring platforms will also likely make systems more energy efficient.

Innovative financing instruments are making electricity more affordable.

From a private sector perspective, recovering costs and ensuring earning margins are appropriate for the degree of assumed risk is essential for projects targeting low-income customers to be scaled up.[35] Innovative financing methods that harness technological innovations have been deployed to address payment challenges. For example, advances in metering technology have enabled businesses to better analyze consumer data and develop strategies accordingly, while also improving collection rates.[36] Improved payment systems and a better understanding of customer preferences have in turn allowed electricity providers to create asset-backed securities.[vi] This reduces the time it takes for investors to recover costs, thereby improving cash flow and enabling portfolios to grow at higher rates.[37]

Innovative approaches to off-grid energy financing include peer-to-peer lending and results-based financing, which consists of providing funds based on the achievement of specific performance milestones. Delivery of these milestones are usually outlined in a specified grant agreement.[vii] Results-based financing has been implemented in several Sub-Saharan Africa countries including Kenya, Rwanda, Tanzania, and Uganda. In peer-to-peer lending, the off-grid solar provider receives a loan from a group of individual or institutional lenders facilitated by a crowdfunding platform. This is beneficial for investors as the platforms processing the lending also perform credit checks.[38] Another new approach is results-based crowdfunding which combines peer-to-peer and results-based financing with online debt-based securities company issuing bonds at a fixed interest rate to investors

vi An asset-backed security is a financial instrument where income payments are derived from a pool of collateralized assets. In the case of off-grid solar, future receivables from customers' payments are sold to investors who, over time, recover their investments and earn interest.

vii In the case of results-based financing, a company is incentivized by payments made after the installation or delivery of their products or services. For example, in the case of off-grid solar providers, they receive the funds once they have installed an agreed number of customers (such as ex-post rather than ex-ante).

via an online platform.[39] Advances in online crowdsourcing and the digitalization of financial instruments have contributed to the rise of these alternative funding sources.[40]

Another such tool is outcomes-based finance, an advanced form of results-based financing where payments are contingent on achieving pre-agreed outcomes. This approach goes beyond the output-level indicators commonly used in development partner-funded results-based financing initiatives, such as the number of cookstoves or off-grid solar products sold or distributed. By focusing on outcomes rather than outputs, outcomes-based financing aims

BOX 3.3

Private Sector Solutions Are Advancing Energy Efficiency in Developing Countries

Energy Service Companies, or ESCOs, are important contributors to achieving UN Sustainable Development Goal 7 targets, in particular the goals around energy efficiency. An ESCO is an organization that provides a full range of services to design and implement energy efficiency options. Services include: identifying, designing, and developing energy efficiency projects; financing or acquiring financing for the energy-efficiency project; installing energy-efficiency technology/equipment; and measuring, monitoring, and verifying the project's energy savings. In developing countries, ESCOs have successfully operated for years and play a crucial role in the following aspects:

1. Reducing global energy consumption and greenhouse gas emissions. Because their profits are directly related to the energy savings, ESCOs are intrinsically incentivized to design effective systems, offer specialized support, and engage in ongoing monitoring and verification to ensure the highest possible energy efficiency.

2. Developing markets. Many developing economies are very energy intensive and energy inefficient. At the same time, they lack the capacity and/or incentives to identify, finance, and implement energy efficiency projects. ESCOs, by assuming most of the technical, financial, and performance-related risks under the performance-based contracts, can stimulate market demand for more energy efficient systems.

3. Providing access to innovative financing. Many industrial, commercial, or public sector clients refuse to invest in many energy-efficiency projects because these programs are small scale with high transaction costs. ESCOs can overcome this challenge by bundling resources, thereby helping these projects to proceed.

The World Bank Group has continually supported countries' efforts to become more energy efficient. For example, IFC advised on how to design a street lighting project in the state of Rajasthan in India, specifically on how to design the transaction and prepare the necessary documents to support ESCOs' operation. By 2015, the project had already reduced greenhouse gas emissions by more than 4,000 tons and Rajasthan had reduced its annual electricity costs for street lighting by 23 percent.

to drive a more meaningful and sustainable impact. IFC has supported several innovative outcomes-based financing pilot projects and is exploring ways to replicate and scale them. For example, IFC was a key partner in developing the world's first impact bond for clean cooking. IFC provided technical assistance to support the measurement and 'sale' of health and gender outcomes separate from carbon credits to generate cashflows for modern energy cooking solutions that target low-income consumers and women.[41]

IFC is itself a financing innovator too, for example through its support for distributed renewable energy certificates. Designed to monetize the positive climate impacts achieved through communities using distributed renewable energy, these certificates provide an additional revenue stream for renewable energy projects. They also create a tangible link between the investor and the positive social and environmental impacts that stem from extending access to clean energy. IFC invested a $3.5 million senior loan to Bix Capital, which provides debt financing to decarbonizing projects secured against future cashflows from carbon credit off-take agreements. This form of financing is starting to gain traction among major corporations. In early 2023, the U.S. software company Salesforce agreed to purchase 280,000 megawatt hours of the certificates from aggregator Powertrust. The agreement will support projects in multiple countries and regions, including Brazil, India, Sub-Saharan Africa, and Southeast Asia, illustrating the global reach and scalability of such mechanisms.

Innovative payment models can reduce financial risk for providers.

In parallel, innovative electrification business models are emerging, reflecting the diverse markets in which private energy providers operate.[42] These models fall into the following broad categories: pay-as-you-go (PAYG), cash-based sales, lease-to-own, and service-based. Under PAYG, consumers pay for the energy they need and top up their accounts with credits. PAYG has been perhaps the most significant model for deploying off-grid electrification since first used in Eastern Africa in 2010.[43] It has been accompanied by the rapid expansion of digital infrastructure and has benefited from the rising number of previously underserved communities in Africa that have gained access to mobile digital services, particularly mobile money.[44] Providers serving consumers through PAYG benefit from consumers' familiarity with PAYG offerings for various mobile services.[45] For example, Azuri PayGo Energy has installed tens of thousands of PAYG solar home systems in Ethiopia, Ghana, Kenya, Malawi, Rwanda, Sierra Leone, South Africa, Tanzania, Togo, Uganda, and Zimbabwe.[46] The user pays a small one-time installation fee, then purchases a scratch card or uses an integrated mobile money service to top up. After 18 months of top-up payments the user fully owns the system and can use renewable energy at no further cost. A key feature of countries that support the PAYG model is a strong policy environment for off-grid electrification.

Several African countries, including South Africa and Zimbabwe, have transitioned to PAYG as a way to manage commercial losses. Since

1990 South Africa has installed prepayment meters for more than 4.3 million domestic customers,[47] while Zimbabwe has 750,000 domestic customers on PAYG and aims to move its remaining 103,000 customers into it.[48]

In lease-to-own models, customers own the system once they have reimbursed the full price, which usually takes two or three years. In both models, after-sales services are offered for as long as payments are made. If customers delay payments, their systems get switched off. In the service-based model, the system remains the provider's property for the lifetime of the product, and customers pay a regular fee to continue using the energy services.

Deploying Smart Grid Technologies Can Promote Cleaner Power

Smart grids and smart meters play an increasingly critical role in electricity systems as more intermittent renewable energy comes into the system. By sending data directly to a central computing facility, advanced smart meters enable accurate remote reading. System operators use smart meter data to manage the electricity more optimally, improving decision-making on energy procurement, operations control, and risk management.

Smart meters permit two-way interaction between the consumer and utility. Modern smart meter solutions provide extensive power load profiling, outage reporting, the ability to connect and disconnect remotely, and voltage monitoring and net metering capabilities. Smart meters allow consumers to adjust their demand in response to price signals, a feature that also benefits system operators by helping them to manage peak loads and identify in advance when a grid is under strain and susceptible to fail. This will become increasingly critical because the increase of solar and wind capacity in the grid also increases the risk of imbalances between energy production and demand—for example, when the wind is not blowing, when it is cloudy, or at nighttime.

Smart grids integrate advanced communication and control technologies, including smart meters, into the grid infrastructure to better manage electricity flows. A smart grid allows an electricity system to run more efficiently, reducing the need for spinning or backup generators to handle fluctuations in demand. In addition, smart grids help integrate localized distributed power generation by measuring power in both directions, allowing smaller generators to sell unused power back to the grid. Smart grid technologies also promote system innovations such as virtual power plants—cloud-based data control centers that provide reliable power supply by integrating several types of distributed power sources by aggregating data on production. When fully utilized, such platforms can improve operational efficiency and enhance capacity to connect variable renewable energy to the grid.

Deploying smart technologies brings challenges, the experience of early adopters has shown. Many technological complexities and integration issues that can arise when incorporating them into systems need to be mastered. For smart grid technologies to be successfully launched, there needs to be a business case and a plan for systematic

BOX 3.4

Using Smart Meters for Dynamic Retail Pricing: Türkiye

As variable renewable energy comprises a growing share of power generation, demand-side flexibility will play an increasingly vital role in balancing electricity systems. Retail tariffs based on time-of-use mirror underlying price fluctuations at the wholesale level and reflect real-time power supply conditions. The price signals they give consumers in turn incentivize them to conserve energy during high-cost periods, helping them to manage their energy use and storage more effectively. Adding a locational component—meaning prices also depend on the geographic location of the customer—can be beneficial by encouraging distributed energy resources to be placed in locations where they most effectively support the grid and alleviate local congestion.

In Türkiye, IFC has financed grid upgrades made by Osmangazi Elektrik Dagitim A.S. (OEDAS), a leading power company, to expand electricity distribution and accelerate smart meter adoption. As more renewables are integrated into power grids, time-based pricing enabled by smart meters will be key to aligning how and when customers consume electricity with when the supply is available. Linking pricing to the real-time conditions of power systems incentivizes customers to adjust demand and tap into new value streams. The flexibility and responsiveness unlocked by smart meters can help integrate clean, variable power sources in a cost-effective way.

deployment, and an implementation framework that considers market maturity, data privacy and cybersecurity, and adaptive regulation.

Smart metering costs have declined over the past decade due to increased competition among vendors, improvements in metering communications and data management systems, and integration with grid management platforms. The proliferation of lower cost meters has enabled more widespread smart meter adoption, expanding beyond large industrial and commercial customers to encompass mass deployment for residential consumers too.

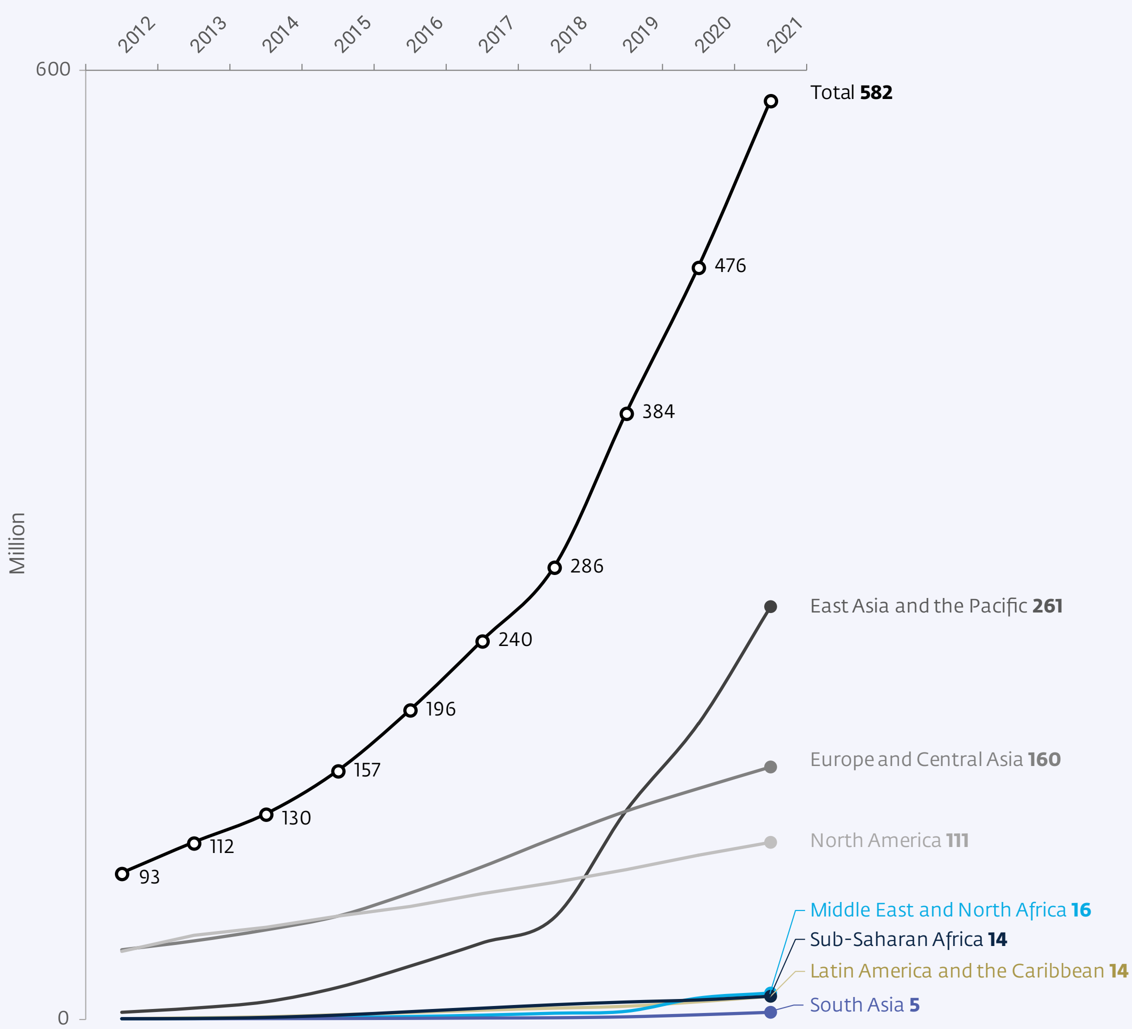
Smart meter penetration rates vary worldwide but are accelerating in many markets, especially for utilities looking to modernize aging analog meter stocks (Figure 3.2). The residential smart meter penetration rate is expected to double from 30 percent in 2022 to 60 percent by 2030.[49] Technological improvements continue to make smart meters more cost-competitive. Declining metering and IT costs, combined with new grid-edge capabilities,[viii] are increasing incentives for utilities to invest in smart metering infrastructure. Ramping up deployment of smart meters should be encouraged as it will lead to more dynamic, responsive, and transactive electricity grids (Box 3.4).

viii 'Grid-edge' is an umbrella term that covers all the technology, hardware, software, and business innovations in the proximity of the end consumer near the 'edge' of the power grid. Examples include electricity generation, transmission or storage resources located onsite at residential or commercial premises such as home solar panels, small wind turbines, and electric vehicle charging infrastructure. Smart meters, smart thermostats, smart appliances, and software that automates price-responsive demand response and real-time grid optimization are also considered as grid-edge.

FIGURE 3.2

Developing Regions Lag in Smart Meter Uptake

Number of smart meter installations globally



Source: Northeast Group (2023)

Smart Deployment of Baseload Generation

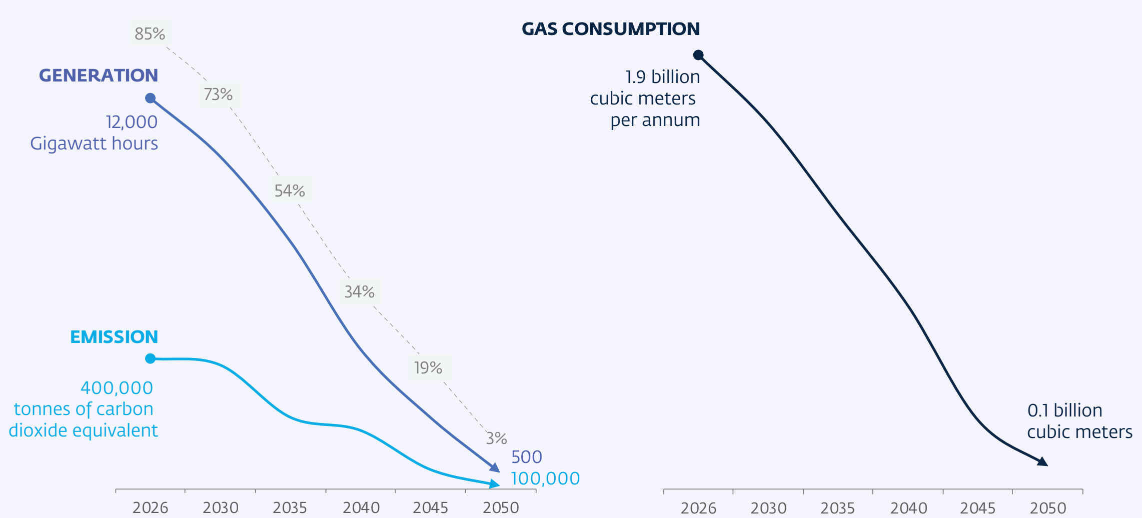
As countries scale up variable renewable energy sources like wind and solar, baseload generation—delivering the minimum level of power needed in the system to meet demand—remains vital to ensuring an affordable, reliable electricity supply. The intermittent nature of renewables poses grid integration challenges that underscore the continued near-term need for flexible baseload assets to balance fluctuations and meet peak demand. Strategic deployment of baseload hydropower and high-efficiency gas power plants in 'peaking' roles allows greater renewable energy penetration while maintaining system stability.

For example, recognizing the need for efficient baseload capacity, Uzbekistan worked with IFC as lead advisor in structuring a novel public-private partnership tender for a combined cycle gas turbine (CCGT) project in Uzbekistan's Syrdarya region. With 1.5 gigawatt capacity and a 62 percent efficiency rating, the Syrdarya plant will be able to meet 17 percent of Uzbekistan's electricity demand when operational. Its high efficiency, flexible CCGT

FIGURE 3.3

Uzbekistan's Syrdarya Plant Shows How Combining Sources Can Enhance Reliability and Lower Carbon Footprint

Syrdarya-2 generation, carbon dioxide-equivalent emissions and natural gas consumption forecast under 2050 decarbonization scenario



Source: IFC

technology will optimize the country's energy systems by balancing and scaling up variable renewable energy capacity (Figure 3.3).

Deployment of efficient CCGT plants needs to be selective and aligned with national renewable energy targets and decarbonization timelines, as well as with international commitments such as the nationally determined contributions enshrined in the 2016 Paris Climate Agreement. Similarly, the use of CCGT plants should also be informed by holistic planning to ensure they are right-sized—carefully tailored to match expected demand—thereby avoiding over-investment and the risk of creating stranded assets (these are assets that become prematurely obsolete). How they are deployed should be informed by studies on grid integration that assess the hourly availability and flexibility of renewable energy resources. Such CCGT plants should be dispatched on a merit-order basis, meaning the plant will only be dispatched when required and ahead of less-efficient gas-fired generation.

The following are important considerations when deciding whether to use gas for peaking reserves:

> Does the power system require firm power, meaning power available at all times, either for continuous baseload generation or to complement renewables?

> Is gas a realistic, affordable, and lower carbon alternative to coal, diesel, or fuel oil?

> Are there alternatives to gas that would not entail investing in coal-fired capacity?

> Does the power system require peak power and/or ancillary services that help integrate intermittent renewables while maintaining reliability?

Recommendations

INNOVATE

Cross-Cutting

- Leverage innovative financing tools like green bonds and sustainability-linked loans that align financial incentives with sustainability goals when scaling up private sector participation.
- Diversify the pool of financiers through venture capital, institutional investors, capital markets, and securitization, to expand the funding sources available for clean energy projects.
- Deploy tailored financing methods to mobilize financing from specific sources such as refinancing to mobilize institutional investors, and outcomes-based finance to make power more affordable.

- As intermittent renewable energy sources grow, scale up smart grid technologies that make electricity systems run more efficiently and reduce the need for spinning or backup generators to handle fluctuations in demand.
- Carefully consider the shifting role of traditional baseload power generators such as coal and gas power plants when designing future power systems to ensure alignment with decarbonization goals. Renewables' intermittent nature presents a challenge to their integration in the grid. Flexible baseload assets are therefore needed to balance fluctuations in supply and meet peak demand.
- Review new investments in non-renewables, especially thermal-fired power plants, as baseload power generators. While they can be part of a country's holistic least-cost power model, helping to ensure projects are economically viable as more renewables enter the mix, caution should be exercised to prevent over-investment in them which could lead to stranded assets.

Vertically Integrated Utilities (VIUs)

- Issue debt securities such as corporate bonds or asset-backed securities, through which VIUs can access more financing than they can from commercial banks and potentially with better financing terms.
- Tap institutional investors such as pension funds, sovereign wealth funds, and insurance companies as these can be good sources for refinancing brownfield renewable energy assets.
- Install bidirectional smart meters to promote distributed renewable energy generation, such as solar panels on residential rooftops. Residents can sell unused locally generated power back to the grid. This also promotes a transition to a more competitive market structure if desired.
- Experiment with innovative approaches to off-grid energy financing such as peer-to-peer lending and results-based financing that can benefit both VIUs and private sector off-grid operators.

Single Buyer Model (SBM)

- In SBM markets, system operators can use the wealth of data collected by smart meters to improve management of the electricity system, aiding decisions on energy procurement, operations control, and risk management.
- SBM structures that integrate renewable energy producers need to carefully consider the role of flexible generation assets like energy efficient combined cycle gas turbines that can rapidly load power to grids as needed and offset sudden dips in wind and solar output. This can be particularly useful in countries that still rely heavily on coal.

Wholesale and Retail Competition (WRC)

- Scale up financing of networks to enable further renewables integration and incentivize greater participation of consumers in the market through mechanisms such as demand response, where consumers adjust their electricity usage in response to supply conditions.
- Deploy more smart grid technologies as these help to expand localized retail power markets by enabling prosumers (consumers who also produce energy) to participate in the market.
- Ensure sufficient flexible baseload generators such as hydropower and combined cycle gas turbine plants that provide backup energy supply to balance out the intermittent supply of renewables and maintain grid stability. As more renewables come onto grids, baseload power generation will be exposed to far greater volatility in seasonal, daily, and intraday load, underscoring the need to ensure reliability and predictability in supply. To support this reliability, it may be necessary to develop capacity markets that compensate providers of dispatchable peak power—generators that can be called upon quickly during high demand periods—to ensure they are economically viable and available when needed.

Integrate — Scale Renewables, Reach Unelectrified Communities

As countries navigate the clean energy transition, the private sector can play a pivotal role in developing innovative solutions that support the at-scale integration of renewable energy to the grid and extend electricity access to communities without power. The private sector is at the forefront in developing energy storage technologies and hybrid renewable energy systems, which are crucial for providing stable, reliable, cost-effective clean energy that makes a significant contribution to decarbonizing the economy.

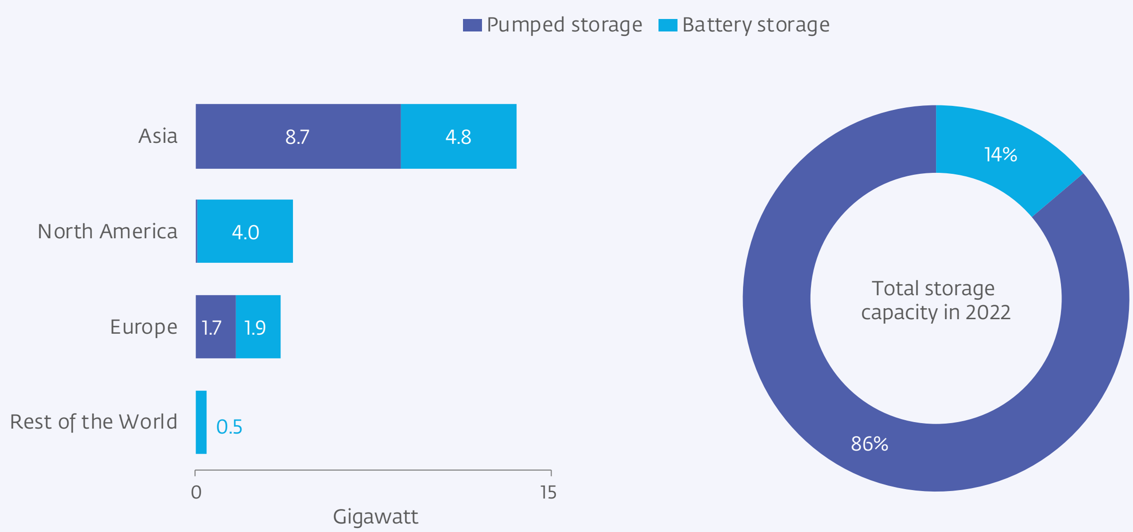
Energy storage technologies are increasingly key to sustainability goals.

As the clean energy transition accelerates, storage technologies like pumped hydropower and battery energy storage systems (BESS) are poised to play an increasingly vital role in power markets and systems (Figure 3.4). By charging (storing) when renewable generation exceeds demand and discharging when required, storage can help increase the amount of variable wind and solar that can be integrated into systems. Storage also enables two-way power flows, supporting mini-grid and off-grid access.

FIGURE 3.4

Asia Leads for Energy Storage Technology in Emerging Markets

Capacity additions of pumped storage and utility-scale battery storage, 2022



Source: REN21 (2023)

Note: Pumped storage is a type of hydropower where water is pumped to a higher elevation during periods of low demand and released to generate electricity when demand is higher. Battery storage, on the other hand, uses chemical batteries to store electricity for later use. Both technologies are essential for managing the variability of renewable energy sources like wind and solar.

Unlocking storage's diverse capabilities—to store excess clean electricity, to provide grid services, and to dispatch energy on demand—is key to driving the energy transition.

The size and type of BESS depends on the purpose and context—for example, whether it is for on-grid or off-grid use, or whether it will be integrated with renewable energy power plants, or is for standalone 'utility-scale' units. Utility-scale storage systems help advance large-scale decarbonization goals as they can be connected to distribution and transmission networks or power generation assets. Examples of the services they provide include frequency regulation (helping to maintain stable electricity supply by balancing the frequency of the grid on a minute-by-minute basis), time shifting (building in the ability to buy and store power when it is least expensive and to release it during peak demand when prices are high), and alleviating local transmission constraints.[50]

Falling costs in the battery manufacturing sector are making BESS viable for a range of services. For example, lithium-ion battery pack costs fell by 89 percent between 2010 and 2020 and are projected to continue falling for the next decade (Figure 3.5).[ix] At the same time, energy storage installations are forecast to grow by a factor of 27 between 2020 and 2035 and to attract close to $400 billion in investment.

As the economics become more viable, BESS are getting bigger. The first 10 megawatt-hour project was built in the early 2010s while the first 100 megawatt-hour project was completed in 2016. The largest project in operation currently is the 3 gigawatt-hour Moss Landing installation in California, United States, while the largest planned project is the 4 gigawatt-hour SolarQ Gympie installation in Queensland, Australia.

Emerging markets excluding China lag in BESS, with the largest projects in the tens of megawatts rather than at gigawatt scale (1 gigawatt = 1,000 megawatts). They include the 24.5 megawatt Hunts Bay project in Jamaica and a 10.5 megawatt project in Mexico of Aura Solar III, an IFC client. A five-hour duration 20 megawatt battery became operational in South Africa in 2023, making it the largest BESS in Africa. While in developed markets it has typically been large companies using their corporate balance sheets to finance battery storage projects, this is rare in emerging markets, where access to finance is still in its infancy. Project finance—the basis for financing power projects for the past 40 years—needs to be adapted to cater to various factors in emerging markets. Nevertheless, progress is evident—IFC estimates that annual new installations in BESS in developing countries will grow from 1.1 gigawatts in 2020 to 27.3 gigawatts in 2030.

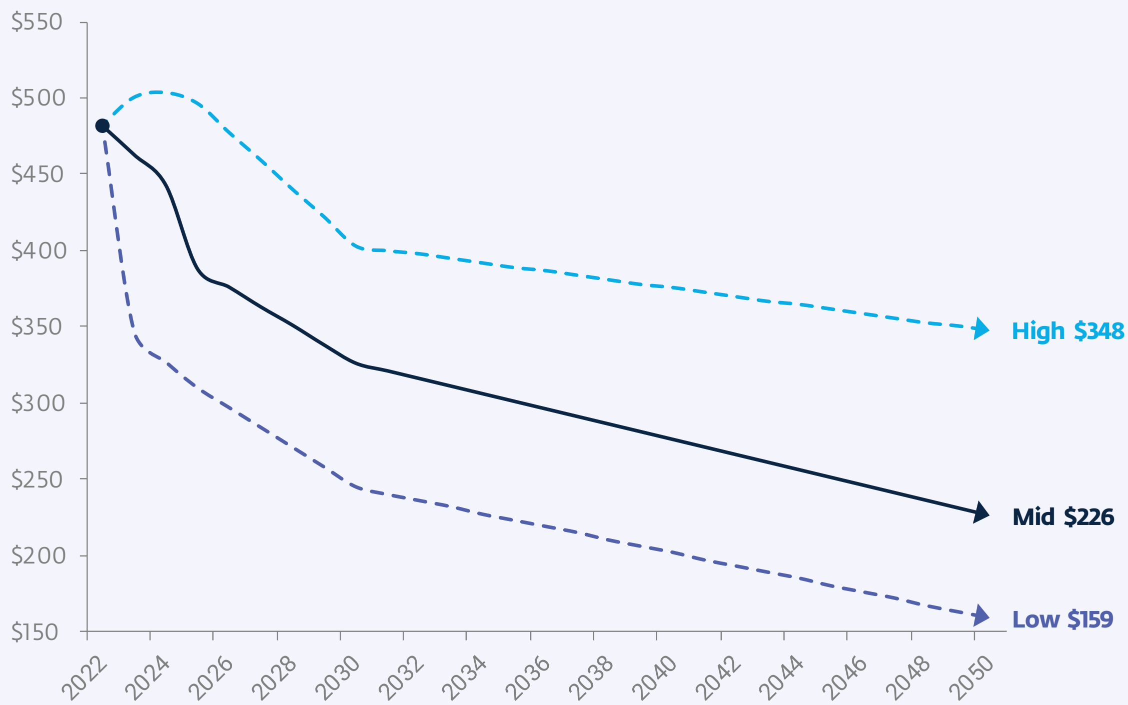
Unfortunately, the regulatory framework has not kept up with the advances and innovations in the technology. A more supportive regulatory environment would help energy storage developers align their plans with national energy goals and targets—for example, renewable energy and storage mandates. It would also enable them to be appropriately compensated for their services, to benefit from clear and

ix The turnkey cost of utility-scale BESSs are set to almost halve between now and 2030, due to continued reductions in battery costs.

FIGURE 3.5

Advances in Technology Are Making Storage Increasingly Affordable

Battery cost projections for 4-hour lithium-ion systems



Source: Cole & Karmakar (2023)

transparent procurement processes, and to legally integrate with other energy assets. In the United States, regulators in the states of California and Hawaii have successfully built regulatory environments that enable storage, as have Australia (particularly grid-scale) and the United Kingdom. Developing countries can learn from these experiences.

To incentivize deployment of battery storage and enable greater penetration of renewable energy, countries can implement various strategies (Table 3.1). These should focus on creating financial incentives, putting in place a supportive regulatory framework, and considering complementary policy options that add more storage to systems.

TABLE 3.1

Toolbox for Promoting Battery Energy Storage Systems

	Action	Description
Targets	Battery energy storage system (BESS)	Setting a BESS capacity target makes it easier for private investors to calculate how much to invest and is recommended as a first step.
	Renewable energy (share of overall electricity supply)	Setting a national renewable energy target paves the way for various policies that expand both renewables and BESS.
	Transportation (number of battery-powered vehicles)	Setting an electric vehicle or e-mobility target provides a clear picture of the anticipated increase in demand for power. This in turn helps government ministries and utilities to better respond to the increase in demand.
Policies *Direct*	BESS mandate (percent)	Mandatory BESS installation for utilities or public/government buildings is an effective way to promote more renewable energy generation.
	Investment tax credits	Private or public funds can be incentivized to invest in BESS.
	Tax reduction or exemption	Tax reductions and exemptions for BESS projects (or BESS profits) incentivize private investors to participate in them.
Policies *Indirect*	Auctions or reverse auctions	The presence of an auction or reverse auction platform attracts private players including investors and operators to compete on cost-effectiveness, which incentivizes BESS installation to increase performance. Operating a single-buyer model or higher-level market is a pre-requisite for this measure.
	Feed-in tariff	A feed-in tariff—a policy mechanism that guarantees a fixed price for energy fed into the grid from renewable sources—incentivizes consumers to invest in BESS. Feeding the grid with energy stored in BESS provides a source of income to either the utility or the system developer that owns the BESS.
	Interconnection standards	Standards are necessary to enforce the safe incorporation of small/medium/large BESS.
	Energy access/electrification rate	In countries with low electrification rates, embedding BESS with off-grid energy access and/or electrification rate policies facilitates the deployment of innovative business models like community solar, solar, and storage services.
	Renewable portfolio standards	The adoption of renewable portfolio standards, which require a certain percentage of electricity sold to come from renewable sources, can incentivize utilities to adopt BESS.
	Time-of-use and net metering	Time-of-use and net metering programs enable utilities and system operators to profit from arbitrage, or selling energy stored in BESS that is charged during low-cost hours at high-paying hours.

Source: Adapted from World Bank (2021)

Direct policy measures include mandates for BESS deployment, tax credits given for investments, and tax reductions or exemptions for BESS projects, all of which incentivize private sector involvement as evidenced, for example, with the United States' experience.

Indirect measures can include energy policies that incentivize utilities and generators to supply electricity more effectively or to scale up renewable energy capacity. Examples include auctions or reverse auctions, where developers bid to provide energy at the lowest price, creating competition and driving down costs, which encourages competition and cost-effective deployment of renewable energy projects. Other examples include measures that expand access to electricity by creating opportunities for BESS deployment in underserved areas. On decarbonization, targets can be set for utilities to procure a certain percentage of their energy from renewable sources, which in turn drives up demand for BESS. Time-of-use and net metering policies incentivize utilities and consumers to optimize their energy usage and to integrate renewable energy, creating further opportunities for BESS participation.

Governments and utilities should also consider revenue models and life-cycle considerations when deploying BESS as these will determine how a project generates revenue and establishes agreements with relevant stakeholders. It is essential to assess the long-term costs associated with operating and maintaining BESS, to plan for eventual decommissioning and recycling, and to clearly allocate risks and responsibilities between the public and private entities involved.

Hybridization is promoting reliability and sustainability.

In recent years, there has been an uptick in the deployment of hybrid renewable energy systems, which consist of variable renewable energy sources like solar or wind paired with battery energy storage systems to provide dispatchable renewable power. Business models and financing options for these systems are still evolving (Table 3.2). If effectively deployed, hybridization, which refers to the integration of multiple energy sources such as solar, wind, and battery storage systems to create a more stable and reliable power supply, can serve as a cost-effective transition toward secure, sustainable electricity access for all. Blended solar and storage power purchase agreements can ensure a continuous supply from intermittent renewable sources, enabling round-the-clock availability.

Reforms in grid planning and market design are critical to fully leverage hybrid systems. These design choices to accommodate hybridization should consider for the tradeoffs between ensuring reliable power availability (dispatchability) and managing the associated risks such as increased costs or system complexity. To procure hybrid systems, countries can utilize competitive auctions tailored to the business model, with selection criteria based on least-cost capacity or energy bids over the contract duration.

Contracts should be structured in a way that incentivizes both producers and

TABLE 3.2

Types of Contracts Used in Solar-Plus-Storage Project Contracts

	Solar-Plus-Storage	Single Capacity	Blended Energy
Entities Involved	A state utility, likely the grid operator	A state utility, likely the grid operator	A state utility or a central procurement agency reassigning contracts to utilities
Renewable Energy and Storage Remuneration	Single contract with two types of payment: • Payment for photovoltaic cells is for energy produced (dollars per megawatt hour) • Payment for storage is for capacity made available (dollars per megawatt month)	Single contract, single fixed payment based on available capacity (dollars per megawatt month)	Single contract, single fixed payment based on energy produced (dollars per megawatt hour) with no explicit capacity payment.*
Variations	Not applicable	Not applicable	• Simple blended • Time-differentiated rates (peak and off-peak) • 24/7 firm power supply
Emphasis	Dispatchability	Dispatchability	Firmness
Dispatch Decisionmaker	Buyer	Buyer	Seller or system operator
Operation and Maintenance	Separate entity	Separate entity	Separate entity or the seller
Suitability of Storage Services	High	High	Low, as the seller has control of the storage assets
Risk Allocation: Resource Variability	On seller	On buyer	On seller
Risk Allocation: Curtailment	On buyer	On buyer	More on buyer
Risk Allocation: Market Variability	On buyer	On buyer	On buyer
Commercial and Technical Similarities to Thermal-Generation Power Purchasing Agreements	Very high	High	Low for commercial characteristics; some similarities based on technical specifications of the solar-plus-storage project
Procurement/ Award Criteria	Two products, simultaneous auction; award possibly based on levelized cost of electricity	One product, award based on lowest dollar per megawatt hour	• Blended simple and 24/7: One product award based on lowest dollar per megawatt hour • Time-differentiated: two products, simultaneous auction, average peak/ off-peak price

Source: Adapted from ESMAP (2023)

* This pricing assumes all resource variability, fuel cost volatility and market risks have been transferred from seller to buyer. Power purchase agreements in other jurisdictions may have more nuanced pricing structures whereby some risks remain with the buyer, and a fixed-plus-variable payment structure is advisable.

buyers. Thoughtful project planning and structured frameworks are imperative given the complexity of hybrid models compared with single variable renewable energy. The World Bank Group is using the hybrid approach to expand electricity access and renewable energy integration (Box 3.5).

Private Sector Solutions to Integrate Unelectrified Communities and Meet Sustainability Goals

Improving electricity access, reliability, and affordability alongside sustainability is a major challenge for developing countries. While rapid progress was made on expanding electricity access from 2010 to 2018, with over 130 million people gaining access annually, this pace has since slowed to only 109 million people per year gaining access from 2018 to 2020.[51]

The COVID-19 pandemic was a further setback. In 2022, the global access rate declined for the first time in decades. In Sub-Saharan Africa, the number of people without access to electricity increased by an estimated 6 million.[52] Unelectrified households, businesses, and smallholder farmers rely on increasingly expensive and polluting fossil fuel alternatives such as kerosene and diesel. While many

BOX 3.5

How Hybridization Can Help Small Island States Decarbonize: Maldives

As the small island nation of Maldives advances on its clean energy transition, the World Bank-financed ASPIRE and ARISE projects have been helping it continue down that path. These projects have enabled the installation of over 53.5 megawatts of solar capacity and 50 megawatt-hours of battery storage. This has reduced the Indian Ocean country's annual import bill by around $30 million, with projected lifetime savings of $756 million over 25 years. It has also decreased Maldives' reliance on subsidized, imported diesel and has lowered electricity prices.

The robust risk mitigation package developed by the World Bank gave private investors the confidence to bid competitively on solar power purchase agreements. Bids became increasingly competitive over time as project pipelines expanded. The projects ensured adequate integration of new solar capacity into the power grid. They also provided payment security mechanisms and dollar-denominated power purchase agreements to attract investment. Leveraging co-financing from partners like the Asian Infrastructure Investment Bank was crucial to fund complementary grid upgrades. Given the success so far, Maldives has requested additional financing to meet its ambitious renewable energy goals. The World Bank aims to replicate this model in other small island developing states. By mobilizing private investment in clean energy infrastructure, these projects have enabled access to affordable, sustainable power in the Maldives. Such partnerships can serve as a blueprint to accelerate the global energy transition.

governments pursue ambitious electrification programs, their budgets are constrained, the costs of financing have risen, and households' capacity to pay is diminishing, all of which is hampering electrification efforts.

At current rates, electricity access will only be expanded to an additional 260 million people by 2030, leaving 670 million without access, predominantly in Sub-Saharan Africa. Coordinated policies and financing will be critical to get electrification efforts back on track and achieve full access by 2030. Reliability of supply also remains a challenge. Even where grid connections exist, power outages are common in many developing countries. This negatively impacts quality of life and constrains productive uses of electricity. Connectivity and reliability of supply are not the only challenges. Ensuring that households can afford to use electricity once connected remains a significant challenge for developing countries.

This section presents several examples of private sector initiatives to expand electricity access to unelectrified communities sustainably and affordably. This can be achieved in various ways, including by deploying centralized solutions and distributed renewable energy solutions such as solar home systems, mini-grids, and microgrids.

South American success stories offer lessons on rural electrification.

The progress made to date in electrifying underserved populations in developing countries has been achieved mostly through centralized grid-scale investments. For example, this is how Chile has attained universal electrification of both rural and urban populations. Back in 1990, about 41 percent of the rural population of Chile had no access to electricity compared with about 1 percent of the urban population.[53] By 2012, the country had achieved full rural electrification. An electrification program launched in 1994 aimed to increase the rural electrification rate from 50 to 75 percent by 2000. The program was aligned with other electricity sector reforms that increased competition between both technologies and suppliers, promoted more private investment, and decentralized decision-making. It mobilized funding from all stakeholders—consumers, private companies, and existing cooperatives. The program was a major success, with the rural electrification rate rising from 53 percent in 1992 to 76 percent by 1999, exceeding the original 75 percent target a year early.[54] Ingredients in its success include:

> The presence of a competitive environment. Competition was introduced at several levels: among the communities involved for financing the projects, among distribution companies for implementing their projects, and among regional authorities for the funds provided by the central government.

> The willingness of many established distribution utilities to participate.

> Implementation by a competent and motivated government agency. Chile's energy commission was given sufficient authority to develop and guide a national electrification policy initiative.

Peru and Bolivia adopted the Chilean model for handing over the interconnected and commercially viable system to the private sector, allocating government resources and subsidies to rural areas. Peru's urban areas achieved a 99 percent electrification rate, while rural areas reached 95 percent—a major increase from the 60 percent pre-reform electrification rate. Meanwhile, Bolivia increased its rural electrification rate from 40 to 80 percent.

Based on international experience, a set of principles for expanding grid-based rural electrification programs was developed by a group of development experts.[55] These principles include the sustained commitment of governments, evidenced by the emergence of institutions with operational autonomy; regularly updated rural electrification plans; and electricity priced at cost recovery once electricity network lines are handed over to the distribution utility or other service provider. Involving communities is key as it builds grassroots support and lowers barriers to adoption for new customers seeking electricity. Finally, to minimize investment costs, customizing the technical design standards to meet the low demand seen in remote rural areas is recommended.

Scaling solar and off-grid solutions can help meet twin goals.

Renewable energy-based distributed generation and standalone off-grid solutions provide a complementary tool to advance on sustainability goals while improving access, reliability, and affordability. This is especially useful in countries where governments lack the resources to deliver universal energy access through subsidized grid extension. The private sector can play a vital role in scaling up these technologies, complementing public investment and taking advantage of the opportunities presented by decarbonization and decentralization. Its role is particularly apparent for achieving household electricity access through standalone off-grid solutions that use renewables like solar. These solutions can deliver basic electricity access more rapidly and at scale than on-grid solutions.

Regions where electrification rates remain low such as Sub-Saharan Africa have seen targeted electrification strategies that aim for the wide deployment of decentralized off-grid solutions, as evidenced in Kenya, Rwanda, and Uganda.[56] Even in countries where the government's focus is more on grid-based solutions, off-grid solutions can accelerate the electrification process.[57] Off-grid technologies can reach more remote households years or even decades earlier than grid extension programs, thus accelerating economic development in remote areas. They can also provide reliable electricity in areas where grid-based electricity is constrained. A market-based approach to promoting off-grid solar can achieve electricity access at scale, speed, and lower cost, making it an attractive option for resource-constrained countries.

In addition, existing standalone fossil fuel-based generators can be replaced with renewable energy sources (Box 3.6). In parts of South Asia and Sub-Saharan Africa, a significant proportion of households, industrial facilities, and mines utilize diesel-based backup generators to cope with unreliable grid electricity. In Western Africa, these generators are estimated to account for over 40 percent of the electricity consumed annually.[58] As well as their negative environmental effects, these generators are increasingly unaffordable due to ongoing high volatility of diesel fuel prices.

Demand is soaring for installing solar home energy systems.

Across the world, standalone off-grid renewable energy solutions led by startups are rapidly growing in response to market demand. Financing in the form of debt, equity, and grants to the off-grid solar sector increased from $19 million in 2013 to $457 million in 2021.[59] Global sales of solar home systems and pico-solar (very small) systems reached a record 9.5 million units in 2022,[60] and 401 million people are estimated to have benefited from improved access to energy through off-grid solar energy kits.[61] In Africa, solar home system companies such as Bboxx, M-Kopa Solar, and Mobisol have successfully increased energy access through standalone solar systems, demonstrating the private sector's effectiveness in helping countries meet universal electrification targets.

These experiences suggest that standalone systems should emanate from a government-supported off-grid strategy that incorporates

BOX 3.6

Distributed Solar Hybrid Power Is Helping Nigeria to Decarbonize

With an unreliable grid supply and frequent blackouts, businesses in Nigeria face severe electricity access challenges. Diesel generators are often the only backup option, despite being costly and polluting. Distributed renewable energy solutions can provide cleaner, more reliable, and affordable power. However, the commercial viability of solar hybrid systems needs to be demonstrated to attract investment in this nascent market.

IFC in 2021 financed the expansion of energy company Daybreak Power Solutions' distributed generation capacity. The project provides power system management services and alternative energy sources to commercial and industrial customers in Nigeria. It offers two main products: power-as-a-service which involves building power solutions, taking over complete management of power project sites, installing solar photovoltaic modules, and installing battery energy storage systems or replacing diesel generators where necessary; and solar-as-a-service which entails installing solar photovoltaic modules to reduce dependence on other sources of power available onsite.

The transaction was IFC's first distributed energy investment in Sub-Saharan Africa. Daybreak is the second largest provider of commercial solar hybrid power in Nigeria. The $20 million equivalent financing enables Daybreak to increase its solar photovoltaic capacity fourfold to 38 megawatts. By funding the growth of this pioneering company, IFC helped catalyze Nigeria's distributed renewable energy sector. Although diesel is still required as backup, Daybreak's solar hybrid systems minimize its use to ensure availability for commercial and industrial customers.

The project is making energy more sustainable and affordable for commercial and industrial customers that depend on unstable grid supply. And by making their electricity supply more reliable too, it supports productivity and economic growth, enabling clean growth and catalyzing climate-smart private sector investments in Nigeria's off-grid power sector.

local characteristics, innovative financing structures, and incentives for solar home system providers such as tax and import duty waivers. Kenya, Rwanda, Tanzania, and Uganda used such fiscal exemptions to drive growth. These four countries alone account for more than 25 percent of off-grid solar markets worldwide. In 2022 Kenya further granted a 50 percent tax exemption for companies providing off-grid solutions that sell electricity from renewable sources.[62]

Tax exemptions for operators tend to attract more companies than end-user price subsidies. Having more operators in the market in turn creates competitive price pressures and that ultimately benefit consumers and is less likely to cause market distortion.[63,64] Successful deployment of off-grid renewable energy markets is also linked to innovative financing instruments that include access to mobile payment systems for customers. Innovative business models in Bangladesh, Kenya, and Peru have dramatically increased their populations' access to solar energy (Box 3.7). Training local technicians and workers to provide support services like repairs also plays a role.

Net metering is a useful innovation, but designs need fine-tuning.

In some countries, large capacity additions of renewable energy have been supported by

BOX 3.7

Innovative Business Models Are Helping Scale Solar in Kenya, Bangladesh, and Peru

Building on the success of mobile money transfers through African service provider M-PESA, some firms such as Azuri, M-KOPA, and Sun King have adopted a pay-as-you-go model for solar energy panels in Kenya. These firms finance solar installations for customers, using both debt, equity, and grants. M-KOPA has connected more than 1 million customers in Sub-Saharan Africa to solar energy.

In other countries, financing for solar panels has taken advantage of existing structures or institutions. In Peru, for example, Powermundo supports a range of clean technologies including cookstoves and water filtration systems in addition to solar panels, offering different credit arrangements across the supply chain for wholesalers, retailers, and end users.

In Bangladesh, the government set up the Infrastructure Development Company Ltd. in 1997 as a non-bank financial institution which in addition to solar home systems, offers domestic biogas, solar irrigation, renewable systems (including solar mini-grid), energy efficiency and other infrastructure. The Company does not provide loans directly to end users but rather works with participating organizations that act as intermediaries. More than 50 power operators are responsible for identifying customers, installing the system, and providing maintenance. Between 2003 when it entered the solar home system market and 2019, it helped finance access to solar electricity for 18 million people—12 percent of the population—delivering more than 4 million home systems.

FIGURE 3.6

Outlook for Mini Grids: Regional Breakdown

Projections for mini-grid expansion, 2021–2030

Source: Energy Sector Management Assistance Program 2022.

behind-the-meter rooftop systems. In such off-grid solutions involving intermittent energy sources, prosumers with grid access depend on the grid when their captive generator does not produce power. These prosumers can sell surplus power to the grid when the captive generator is active and are compensated through net metering (calculated by subtracting total energy produced from consumed). Battery storage may be used in the absence of grid backup, or to complement it. The market design challenge of this option is twofold: recovering the fixed costs of the network infrastructure serving prosumers and managing the higher balancing costs of additional intermittent power.

Ideally, congestion rents[x] would cover the cost of network infrastructure serving these prosumers. But under current tariff structures, final customers are charged a per-kilowatt-hour tariff that covers the cost of energy and transport services by the grid system. As a result, net metering systems do not recover all overhead costs of the grid. Additional practical challenges have emerged with the net metering modalities adopted by mature renewable energy markets such as the European Union. For example, net metering fails to reflect the real-time power market price signal reflecting the real-time supply-demand balance.

Also, net metering increases the risk of a mismatch between demand and supply, which could create system operation problems—for example, when power gets injected into

BOX 3.8

Mini-Grids Are Expanding Access to Clean Power in Democratic Republic of Congo

The Democratic Republic of Congo (DRC) has one of the lowest electrification rates in the world, with only about 19 percent of the population having access as of 2019. To address this alarming deficit and meet the government's goal of connecting 30 percent of the population by 2024, IFC partnered with the government on the Scaling Mini-Grid program that aims to bring clean, solar energy to over 1.5 million households, businesses, schools, and health clinics through public-private partnership mini-grids.

In 2022, the program secured $400 million in funding from private investors to deploy 180 megawatts of solar photovoltaic capacity to the cities of Mbuji-Mayi and Kananga. The government partners and IFC worked together to assess electricity demand, identify potential solar plant locations, and engage with local authorities to garner community support. The program features innovations like a first-of-its-kind minimum revenue guarantee to help reduce risk and attract further private investments. The other supporters of the program are the Global Infrastructure Facility, the Green Climate Fund, the Rockefeller Foundation, the Sustainable Renewables Risk Mitigation Initiative, and the governments of Italy and Canada.

x Congestion rents are financial incentives for power generators and other market participants to adjust their output or transmission patterns to reduce congestion and increase grid reliability. These payments are the difference between the market price of electricity in the congested area and the cost of generating and transmitting the electricity. The payment is made to the generators or other market participants who help to alleviate congestion.

the system even when demand is low. These challenges led the EU to amend its renewables framework, which will affect how net metering is designed in the future by, for example, requiring variable renewable energy producers to provide balancing capacity. The EU experience offers lessons on how to design distributed generation markets in developing countries for customers who have unreliable grid access.

Renewable-based distributed generation and standalone off-grid solutions face constraints from lack of scale, incomplete regulation, and credit-risk exposure. Companies offering off-grid solutions face financial risks stemming from customers' lack of creditworthiness because they have direct exposure to corporate or household risk. This marks a significant departure for power sector investors who previously would not typically assume such risk.

Off-grid private investments can be scaled up by diversifying the risk they pose to supply using a range of products to both households and creditworthy firms. IFC's InfraVentures fund, for example, uses seed equity to fund scalable distributed generation and off-grid pilot projects that incorporate disruptive

TABLE 3.3

Mini-Grid Industry Growing Steadily As Performance Improves

Key performance indicators

	2018	2021	2025*
Cost (calculated as the levelized cost of energy in dollars-per-kilowatt hour of a best-in-class solar hybrid mini-grid)	$0.55/kWh	$0.38/kWh	$0.30/kWh
Pace of deployment (number of mini-grids built per year aimed at addressing deficits in access to electricity)	20-75	150	450
Service quality (expressed in 'uptime,' the industry-wide standard based on the percentage of time a system is up-and-running)	90-97%	99%	99%
Finance (total cumulative investment)	$13 billion	$16 billion	$25 billion
Enabling environment (average score for mini-grids framework in top 20 electricity access-deficit countries, based on World Bank RISE index)	59/100	64/100	75/100

Source: Energy Sector Management Assistance Program 2022.

*2025 is a projection based on a business-as-usual scenario.

technologies. This includes concessional financing to help shoulder risk and ensure adequate capital for early stage investments.

Another initiative is Lighting Africa, an IFC–World Bank program active in 26 African countries which provides technical assistance and financing to extend off-grid solar products through private operators. Such approaches promote generation and distribution in an integrated and replicable format, reducing the risk of a supply-demand mismatch.

For hardest-to-reach communities—including those living in remote areas, in marginalized urban communities, and displaced populations—advancing on electrification goals is especially challenging and requires tailored solutions.

Alternatives to grid-based access extension through mini-grids and micro-grids are thus becoming prominent in Africa and South Asia where many such communities live (Figure 3.6).

Renewable energy mini-grids can improve access, affordability and sustainability. Their costs have been declining since 2018 while their quality of service has improved (Table 3.3). These characteristics make mini-grids an attractive proposition for countries suffering from poor quality electricity supply and low access rates (Box 3.8). They also make this segment potentially attractive for private sector investors.

Recommendations

INTEGRATE

Countries can leverage the private sector to scale-up integration of renewables and extend access to unelectrified populations. Recommendations, both cross-cutting and by market structure, are presented below.

Cross-cutting

- Leverage the private sector to scale up energy storage technologies and hybrid renewable energy systems to provide stable, reliable, and cost-effective clean energy.
- Utilize private sector solutions for integrating unelectrified communities both through centralized grids as well as renewable energy-based distributed generation and off-grid solutions.
- For electrification of hardest-to-reach populations, the private sector has a major role to play in scaling up renewable energy-based mini-grids and micro-grids. The private sector can supplement public investments and in tandem help drive up access rates while meeting sustainability goals.
- In many countries mini-grids are more cost effective than grid extensions but remain unaffordable for the poorest. Development finance institutions can provide countries with upfront investment capital to make such access more affordable. Innovations in financing such as flexible payment options can help too. National rural energy agencies should consider including mini-grids in existing subsidy programs. Tanzania has done this, for example, through a per-connection subsidy for mini-grids.

Vertically Integrated Utility (VIU)

- Countries with VIUs need to create a supportive regulatory environment that ensures energy storage developers can align their plans with national energy goals and targets including with renewable energy and storage mandates (Table 3.1).
- VIUs with deficits in access to electricity and lack of reliable supply should scale up renewable energy-based distributed generation and off-grid solutions.
- To address deficiencies, VIU countries can consider allowing the private sector to enter the off-grid space to provide services to hard-to-reach rural communities. Where the private sector is permitted to provide power in rural areas, authorities should have in place an appropriate tariff framework for rural service providers, key performance indicators along with an incentive framework for achieving them, and an appropriate investment framework.

Single Buyer Model (SBM)

- Storage technologies provide valuable ancillary services such as spinning reserve and voltage support. SBM countries need to ensure that energy storage developers are appropriately compensated, procurement processes are clear and transparent, and storage is legally integrated with other energy assets.
- To procure hybrid systems, countries with SBM can utilize competitive auctions tailored to the business model, with selection criteria based on least-cost capacity, or energy bids over the contract's duration. Contract structures must balance incentives between producers and buyers.
- Standalone renewable energy-based systems should emanate from a government-supported off-grid strategy that incorporates local characteristics, innovative financing structures, and incentives for solar home system providers such as various tax exemptions and import duty waivers.

Wholesale and Retail Competition (WRC)

- The creation of an ancillary services market alongside the competitive wholesale market can be instrumental in scaling up batteries in WRC countries. Batteries' participation in this market segment to provide frequency regulation and spinning reserve creates another revenue stream.
- Time-of-use and net metering policies can incentivize utilities and consumers to optimize their energy usage and to integrate renewable energy, creating opportunities for battery energy storage systems participation.
- Utility-scale hybrid storage projects are growing in countries with organized wholesale/retail markets. However, it can be difficult for market and system operators to find efficient and reliable ways to integrate and operate these technologies. Hybrid generators need to be effectively represented in the market-clearing software used to clear bids in day-ahead and real-time markets, and dispatch models that use advanced mathematical techniques to model the dispatch of power plants.
- Behind-the-meter policies can incentivize scaling up of renewable energy-based distributed generation under organized retail market structures. Distributed generators can be integrated into the wholesale and retail markets by allowing localized retail markets to be set up through peer-to-peer trading.

4

Enabling the Private Sector

KEY INSIGHTS

Countries are stepping up efforts to repurpose their power markets as they pursue more affordable and sustainable energy for all their population. Increasingly they are harnessing the private sector to achieve these goals. As the power sector continues to be transformed by three overarching trends—decentralization, digitalization, and decarbonization (the 3Ds)—countries need to adapt by repurposing their power market structures. While this is challenging, it also unleashes a wealth of opportunities. Chapter 3 showed how the private sector can be a critical and effective partner for countries in achieving UN Sustainable Development Goal 7—access to affordable, sustainable, reliable, and modern energy for all. Chapter 4 outlines what the main barriers are to private sector engagement in developing countries.

These barriers, most pronounced in less well-established markets, can be grouped into four broad categories: cost, complexity, corruption, and lack of cost recovery (4Cs). Action needs to be taken to overcome each one and ensure that risk is allocated appropriately across stakeholders. To entice the private sector to engage more, key areas where progress is needed include design and transparency of electricity procurement processes, governments' willingness to create the right incentives for participation of private operators, and buyers' track record and creditworthiness. The degrees of success in advancing on these fronts will determine what kind of private sector investor enters the market and at what scale.

Chapter 3 discussed how countries' responses should be guided by two underlying principles: innovate and integrate. Chapter 4 further details the specific actions governments can take to put and keep them on the path to more accessible, affordable, and sustainable energy. The actions are categorized under four broad themes (4Is):

- **Institutionalize** investor-friendly practices.
- **Incentivize** private sector participation through how power markets are designed.
- **Invest** alongside the private sector in key infrastructure.
- **Identify** opportunities for development partners to support this process.

To ensure access to sustainable, affordable, and reliable energy for all by 2030, financing for electrification from both public and non-public sources needs to be scaled up along with investments in renewables and in improving power grids. Existing infrastructure deficits and rising aspirations have created large investment gaps that cannot be met by the public sector alone (Figure 4.1)—it will require an unprecedented mobilization of private capital toward developing countries.

As Chapter 3 highlighted, there are growing opportunities for the private sector to support developing countries in repurposing power market designs. At the same time, the public sector's roles of policymaker, regulator, and sector planner are crucial to enable private sector participation. This chapter identifies the enablers and challenges to private sector engagement. The following are the four cross-cutting action areas where policymakers can create a more enabling environment: institutionalize investor-friendly practices; incentivize the private sector through the design of power markets; invest alongside the private sector in key infrastructure; and identify opportunities for development partners to support this process.

Institutionalize Investor-Friendly Practices

Market mechanisms provide the basis for greater mobilization of private investments in power systems but are not sufficient to attract investors—explicit reform is needed in tandem. Four constraints—cost, complexity, corruption, and lack of cost recovery—limit private sector engagement, especially in less-established markets.

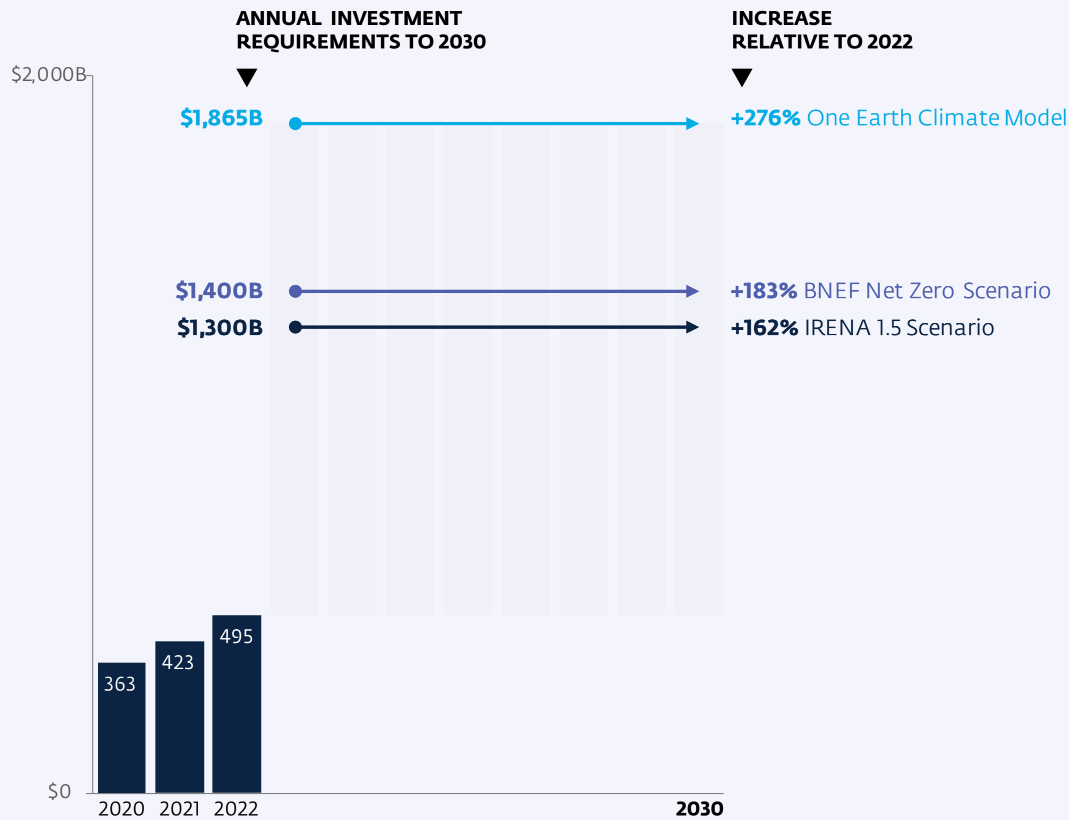
A project's cost is determined by capital expenditure, operations and maintenance costs, and upfront costs incurred in preparing it. Private investors also need to be compensated for the risks they take. When governments make a cost-benefit analysis of private sector engagement, they often conclude that there is not a compelling enough case for private sector involvement, with public options seeming more attractive. The 'complexity' constraint refers to the challenges associated with structuring of power projects in less-established markets where the requisite technical expertise and financial markets are scarce. The prevalence of corruption in a market inhibits private sector engagement by creating bottlenecks, notably forcing private sector players to expend resources in navigating bureaucratic environments. Lack of scope for cost recovery dampens investor interest, especially in distribution of electricity, where they directly interface with customers.

To address these constraints (the'4Cs'), the following cross-cutting measures should be taken:

- Implement transparent regulation and procurement practices.
- Strengthen technical capacity and independence of the sector regulator.
- Prioritize reforms that enhance financial sustainability and creditworthiness of power utilities.

FIGURE 4.1

Projected Clean Energy Investment Needs by 2030 and Constraints on Public Investment



ENHANCE ROLE FOR PRIVATE SECTOR

FISCAL

Limited fiscal space and elevated borrowings constrain scope of public sector investment in major infrastructure projects

POLITICAL

Scarce public funds compete against other governmental priorities like health and education

Public subsidies and tariffs to consumers distort energy markets

INNOVATIVE

The power sector is in a period of transformative technological change

State owned utilities are less able to adapt

Source: Adapted from REN21 Global Status Report 2023

Note: The graph depicts three different scenarios for annual investment requirements to 2030 in the clean energy sector. These scenarios represent varying levels of ambition and the associated financial needs. The One Earth Climate Model represents the highest level of ambition, requiring an estimated $1,865 billion annually by 2030 to meet global climate targets. This scenario assumes rapid and extensive decarbonization efforts to limit global warming to 1.5 degrees Celsius. The Bloomberg New Energy Finance (BNEF) Net Zero Scenario estimates that $1,400 billion annually is needed by 2030 to achieve net-zero carbon emissions by 2050. This scenario considers moderate policy and technological advancements. The International Renewable Energy Agency (IRENA) 1.5 Scenario estimates that $1,300 billion annually is required by 2030 to meet the 1.5 degrees Celsius climate target. This scenario involves significant shifts toward renewable energy and energy efficiency, albeit with a slightly lower investment requirement than the One Earth Climate Model.

Transparent regulation and procurement processes are essential for attracting private investors. Public procurement processes in the electricity sector are prone to established vested interests such as incumbent utilities and fuel suppliers seeking ways to ensure they benefit from new contracts or prevent outside parties from participating in the sector. When a sector develops a reputation for corruption and cronyism, it can be a major disincentive for private operators to enter the market. In such cases independent power producers (IPPs) are usually relegated to operating on the sector's margins, in smaller-scale renewable energy generation or off-grid solutions. In some countries, only politically connected private sector companies operate—enjoying benefits such as tax breaks, subsidized loans from state-owned banks, and preferential access to assets being privatized. These companies have vested interests in the existing government and try to stop new players entering. As a result, the sector suffers from restricted competition, resource inefficiencies, and limited growth opportunities.

With a power project, the procurement process starts with choosing a company or consortium responsible for a high-value, immovable asset over a long period. It covers development and design and moves through finance, construction, commissioning, operations and maintenance, and, finally, the end of economic life phase of repowering or decommissioning. The design of the procurement process is critical given the long-term contractual nature of the agreement and the difficulty of quantifying risks (current and future) throughout a power project's lifetime. Costly, complex, or corruption-plagued procurement processes cause long project delays that can lead even the most determined developers to walk away.

When electricity generation contracts are negotiated out of the public eye, the result can be a poor deal for the sector and consumers. Qualified private sector investors, especially first-time foreign investors, can be deterred by complex and uncertain award processes, with corruption often playing a role. Lead times to prepare are often long (in some markets, two years or more) and expensive (such as high due diligence costs) as the developer needs to invest resources putting together a bid and managing construction, environmental and social, and other project development risks. The prevalence of unsolicited bidding can keep experienced qualified investors out of the market as they need to know that their bids will be evaluated fairly before investing time and money in project development.

On the other hand, having a transparent procurement process facilitates private sector engagement by limiting transaction costs, reducing the complexity of the bidding process, ensuring fairness in selection of bidders, and eliminating or at least reducing opportunities for corruption. A fair process reassures investors that the public contracting authority will assess the projects and make awards based on honest contracting practices.

Some countries have embraced technological innovations to improve their procurement practices. For example, electronic procurement (e-procurement) can make the process more transparent, shorten procurement cycles, and provide real-time data that aids better decision-making. E-procurement also provides a clearer audit trail as each step in the process is well documented, making it easy to see which suppliers have bid for a contract and what they have bid. The government of Kenya reformed its procurement regulations in 2013, requiring all public entities to adopt and implement e-procurement. The system included, for instance, built-in price referencing, meaning that bids that were above an indicated benchmark could not be accepted. Kenya Power is one state corporation that adopted e-procurement systems.

Enhance role of regulators as honest brokers.

Companies and consumers create power markets, but institutions and policies set the rules that shape them and can make them more likely to succeed. Strategic policy interventions can spur the dynamic development of power structures, making them more productive, environmentally friendly, and inclusive. Energy regulatory agencies have a valuable role to play (and increasingly they are playing it) both in realizing overall sector objectives and enabling effective private sector participation. They need to perform a balancing act to protect consumers from abuse by firms with substantial market power while supporting investment by protecting investors from arbitrary government action.

Specifically, energy regulators should: constrain the exercise of monopoly power by incumbent suppliers; provide incentives that drive operational efficiency and improve quality of service; optimize how the sector is structured; help expand the system in the least costly way (for example, by tapping private capital invested in IPPs); and stimulate energy conservation and research and development (Figure 4.2).[65] As private sector participation grows, the regulator's role is increasingly that of honest broker, creating solutions and building consensus between private investors and national stakeholders including the government and consumers.

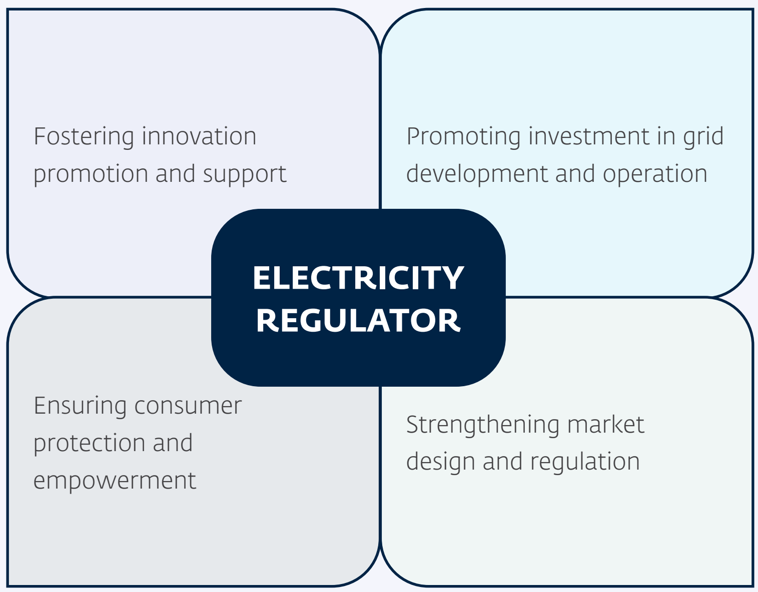
To carry out these functions, a well-functioning regulatory agency needs to be equipped with adequate resources, an appropriate legal mandate to protect its autonomy, and clear agency values and operating procedures. Currently, 153 economies have an energy sector regulator, 97 of which have been established in the past 25 years (Table 4.1). Their level of resources, independence, and capacity varies greatly. Sub-Saharan Africa has the most recently established energy regulators and 13 countries in the region do not yet have a sector regulator of any capacity. According to the World Bank's Global Electricity Regulatory Index,[66] the lack of independence of the energy regulator, especially with regard to independence from stakeholders and tariff setting, is a challenge in almost all countries. To address this, policymakers should prioritize improving the capacity of sector regulators. Private investors need credible, competent, accountable, and reliable energy regulators to effectively function in the sector.

Credible, creditworthy power utilities can draw private capital.

To succeed, projects need a reliable, steady cash flow that ensures cost-recovery. In power generation, the off-taker (buyer)'s credibility, reliability, and creditworthiness

FIGURE 4.2

Role of Regulators in Achieving UN Sustainable Development Goal 7



Source: Adapted from Raza (2023)

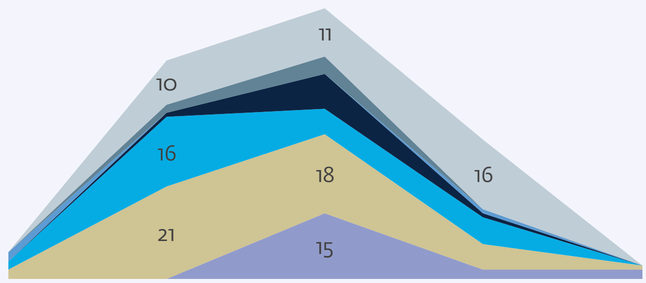
are key considerations for investors. They need to minimize the risk of retroactive tariff adjustments and payment delays that will challenge the financial sustainability of their project. Their perceived risk that one of these outcomes may materialize will be priced into the PPA and is factored into loan assessment and conditions attached to the loan agreement by banks, which affects the amount of debt financing available for the project. In certain cases, the off-taker's riskiness could be perceived as far beyond investors' acceptability limits. They may therefore be unwilling to proceed even with the incentive of higher returns. This could lead to underinvestment in the sector. That is why private generation investors and commercial banks prefer sectors where a well-functioning power utility exists.

In countries with VIU and SBM structures, the off-taker is typically a public power utility. However, in many developing countries power utilities are barely financially sustainable. According to a World Bank database[67] that tracks the financial and operational performance of over 180 utilities in 90+ countries, less than 40 percent of utilities generated enough revenue to meet their annual operating and debt service costs. Financially weak off-takers deter private players from investing.

TABLE 4.1

Most of the Newer Energy Regulators Are in Africa

Number of countries/territories that established an energy regulator in past four decades



	Pre-1991	1991-2000	2001-2010	2011-2020	2021-2024
Sub-Saharan Africa		10	11	16	
South Asia		2	4		
North America	2			1	
Middle East and North Africa		1	8	1	
Latin America and the Caribbean	2	16	6	6	
Europe and Central Asia	2	21	18	6	1
East Asia and the Pacific			15	2	2
Total	**6**	**50**	**62**	**32**	**3**

Source: Akcura (2024)

Policymakers need to put utilities on a sounder financial footing. A review of the database reveals that private power utilities in high- and middle-income countries have had slightly higher levels of cost recovery in recent years.

To put themselves on firmer financial footing, utilities that are off-takers should become less reliant on government support to meet their contractual obligations. In cases where off-takers are not creditworthy, investors will look at the government's track record in supporting and improving the financial health of these entities. In Bangladesh, for example, the off-taker is not yet creditworthy, but the government has a solid record of covering imbalances in the off-taker's balance sheets. In Indonesia, investors are assured by a legislative mechanism that requires the government to pay for any budgetary shortfalls of its off-taker, Perusahaan Listrik Negara. In contrast, in Honduras, the off-taker National Electric Power Company has a history of payment arrears to generators (usually four to eight months late), including reneging on support payments to the first solar IPPs that entered the market in 2014–2015. Elsewhere, governments' decisions to reduce generous administrative feed-in-tariffs such as occurred in Ukraine and Viet Nam also had a negative impact, denting investor confidence to enter a nascent, already risky market.

In markets with limited private sector engagement, an additional challenge is where an off-taker lacks a track record to assure investors and financiers that it will honor the PPA's terms. To attract financing, the government may need to offer sovereign guarantees to reduce risk. Governments can leverage their higher credit ratings and larger balance sheets to support a large portfolio of projects. As the off-taker builds a track record of creditworthiness with investors, such guarantees become no longer necessary. Examples of this kind of transition include Colombia, Mexico, Philippines, and Türkiye (discussed later in the chapter).

Countries can pursue private sector solutions in commercializing utility operations (Box 4.1). For example, state-owned utilities can offer shares to strategic partners before an initial public offering (IPO) or fully privatizing, a solution that can work well for distribution companies. The strategic partner often executes the turnaround plan—for example, Karachi Electric in Pakistan, which IFC supported with an investment. The strategic partner brings technical value, global knowledge, and capacity, helping prepare the utility for the IPO or privatization. Sometimes the (partial) IPO itself triggers efficiency improvements, although utilities need to have reached a certain level of efficiency before successfully launching an IPO.

When governments plan and coordinate, private investors come.

Another essential ingredient is effective government coordination and planning. Specifically, governments have an indispensable role to play to ensure alignment among various sectors, local and regional governments, the private sector, and other stakeholders. The World Bank Group's experience with rolling out so-called least-cost geospatial electrification—which integrates grid, mini-grid, and off-grid solutions with each accompanied by investment financing prospectuses—provides valuable insights into how this can be done.

Originally developed around 2008–2009 in Rwanda and Kenya, these plans have since been replicated in many countries. They are based on the principle of creating markets through collaboration with multiple partners. They coordinate off-grid, mini-grid, and on-grid solutions with demographic and geographic information system mapping techniques. This approach combines technical, economic, demographic, and demand-supply data to create comprehensive, data-driven electrification strategies.

Such a geospatial planning approach enables governments to optimize allocation of resources and prioritize investments across different electrification options. It does this by making it easier for them to identify the most cost-effective and efficient ways to expand electricity access, taking into account factors such as population density, terrain, existing infrastructure, and renewable energy potential.

Moreover, these plans serve as powerful tools for attracting private sector investment. The accompanying investment financing prospectuses provide a clear roadmap for potential investors, highlighting opportunities across different segments of the electricity sector value chain. This transparency and strategic vision can significantly enhance investor confidence, thereby driving private sector engagement.

By embracing a coordinated planning approach, governments can foster a more inclusive and collaborative environment for achieving universal access to electricity. This process not only optimizes resource allocation but also helps to align electrification efforts with broader development goals, creating a solid foundation for sustainable and equitable energy access.

BOX 4.1

Burundi: Pioneer in Private Sector-Driven Electrification

Burundi, a small landlocked country that is both fragile and one of the world's poorest, faces significant challenges in achieving universal access to electricity. Just 12 percent of its population has access and less than 2 percent in rural areas, one of the lowest rates in the world. To address this, the government signed an interim agreement with the private electricity company Weza Power (a subsidiary of Virunga Power) in 2023 to develop a new electricity distribution utility, given the operational and financial constraints faced by Burundi's existing public utility REGIDESO.

Weza Power, the first private sector electricity distribution company to operate at a national level in Sub-Saharan Africa in over a decade, aims to connect 45,000 households and businesses to the grid under a pilot project supported by the World Bank Group. The ultimate goal is to sign a wider public-private partnership concession that will connect over 70 percent of Burundi's population in the coming years, providing clean, affordable, and reliable power to as many as 9 million people.

IFC is providing $1 million in early-stage development financing which will also support the company in raising additional financing of up to $1.5 billion. The World Bank will also support Weza Power through the ASCENT program, with $10 million earmarked for the pilot project. The World Bank and IFC have also developed an energy sector reform roadmap and identified investments to support both the public and private sectors in scaling up access.

If successful, this support model can be replicated in other markets across Africa, the region most in need of increasing its population's access to electricity. Such a model underscores the critical role creditworthy utilities play in attracting private investment. The project also demonstrates the potential for private sector-led electrification in challenging markets, especially if it leverages available expertise and development partners such as the World Bank Group.

Recommendations

INSTITUTIONALIZE

Cross-Cutting

- Ensure stable and transparent regulatory and procurement practices that set clear market rules which address cost, complexity, and corruption barriers in the sector, complemented with a legal system that enforces contracts on a fair and consistent basis. The more predictable government regulations and policies are, the lower the risks for investors.
- Implement programs to centralize permits and approvals, such as in 'one-stop shops' for energy project development to streamline permitting and licensing procedures.
- Strengthen technical capacity and independence of the sector regulator. Robust regulatory capacity is crucial to a well-functioning power market. It fosters greater independence in tariff design and implementation and stronger enforcement of market rules by national regulatory agencies.
- Create a regulatory framework that incentivizes operational efficiency while also ensuring the financial health of utilities. Utilities with strong financials can more easily invest in system improvements and access capital from private investors at lower interest rates, reducing debt service costs to ratepayers.
- Ensure longer-term financial sustainability of the off-taker(s) through: (a) tariff designs that effectively balance cost recovery and affordability objectives; (b) achievable and enforceable key performance indicators for distribution companies to improve service quality; and (c) least-cost and efficient planning of capacity additions.
- To balance affordability concerns with cost-recovery tariffs, countries can explore options to reduce costs of service delivery, for example through cost-effective procurement of generation, system planning to avoid wastage and oversupply, and managing non-technical losses through pre-paid metering.

Vertically Integrated Utility (VIU)

- Strong regulators are critical to ensure that a VIU is delivering value for money given that VIUs face no competitive pressure from other players.
- Countries considering privatizing their VIU should select the private party through an open and transparent process. They can also consider public listings of state utilities.
- Countries considering transitioning out of VIUs should design a market structure that effectively addresses key barriers to successful private sector entry including addressing the 4Cs.
- Corporatization of state-owned VIUs can be a helpful step toward setting up a market structure with private sector participation. Some highly advanced power markets were launched on the back of corporatization. For example, when Singapore corporatized its VIU in 1995, it helped the sector to gradually transition into one of the world's most liberalized electricity markets.

Single Buyer Model (SBM)

- To attract IPPs, countries with SBM structures should avoid erratic and non-transparent decision making so as to reduce investors' perceived regulatory risk and keep capital costs as low as possible.
- Competitive procurement should be favored. Countries should resist direct negotiations and unsolicited bidding as this can keep experienced qualified investors out of the market. The public contracting authority should assess projects and make awards based on honest contracting practices.

- Strengthening the creditworthiness of the single buyer will attract more private sector investment to the sector and, concurrently, develop the complementary infrastructure needed to meet access objectives.

Wholesale and Retail Competition (WRC)

- Regulators have a complex responsibility of monitoring all wholesale and retail players to ensure effective and fair competition with the objective of delivering the best outcomes for consumers. They should pay close attention to market shares, concentration ratios, customer switching rates, and price-cost margins.
- Continuous improvement in regulatory capacity will help the sector to adapt to evolutions in the market, notably those driven by technological innovation—for example, distributed generation enabling localized retail power markets.
- In countries with some competition at the retail level, regulated tariffs should be designed to enable utilities to recover costs with a reasonable rate of return, maintain the technical health of the electricity system, retain and expand staff as needed, and expand infrastructure to meet growing and unmet demand.
- In countries with full retail competition, the regulator should closely monitor the retail market to ensure costs are efficiently and fairly distributed, prevent undue price discrimination, and reduce risks to consumer welfare (e.g., energy poverty).

Incentivize Private Sector Engagement

The public sector can incentivize private sector participation through a range of measures within each market structure. In challenging country environments, IPPs can be difficult and costly to develop, albeit not necessarily more so than projects of a vertically integrated power company. Policymakers need to provide appropriate incentives including creating targeted procurement and revenue streams to encourage private sector investment, especially for renewable energy. They can deploy a range of risk mitigation tools to lower perceived risks and associated costs for the private sector.

Political buy-in is critical.

Without it, sector policy is little more than a wish list. Execution of power projects is complex and requires coordination and agreement among multiple stakeholders, including during decision-making, implementation, and oversight phases. The objectives of the public and private stakeholders must be aligned. This can be difficult given the existence of often competing objectives: profit and revenues for private investors, cost recovery of the project tariff for the off-taker, affordable tariffs for the end consumer.

Governments consequently need to provide the appropriate incentives. Especially in markets with limited private sector engagement, governments may have unsound expectations about the cost of projects. They often compare projects with the costs of service from existing assets that are fully amortized or were funded by subsidized loans from state banks. Such a comparison is flawed as new assets developed by the private sector face a different cost structure—including financing costs, legal fees incurred in drafting and negotiating contracts, and costs of applying for different permits and licenses. Investors also need to be rewarded for the risks they incur.

In challenging markets, long-term contracts such as PPAs are often used to identify and allocate risks among stakeholders (Box 4.2).

Government guarantees are not usually necessary in markets where the private sector has already been operating, especially if the country has a good track record of meeting its contractual obligations to the private sector with limited retroactive changes to contract terms. In more established markets, the private sector is more willing to take on risks, including wholesale market price risk (Chile, Colombia, Mexico, Philippines), currency risk (South Africa), and technology risk (Philippines, Türkiye). The needs of international and domestic investors can differ. Domestic players tend to be more familiar with the political landscape and have links with domestic banks, especially state-owned ones. They also tend to be more willing to enter into a PPA that international investors would consider non-bankable, and they can leverage comparative advantages by having the means, through local banks, to better manage risks.

To scale renewables, create targeted procurement and revenue streams.

Since 1989, 152 economies have introduced private IPPs to the power generation segment of their market. Countries have differed greatly in the type of technology and energy source deployed by their first IPP and trends have also shifted over time (Figure 4.3). Where previously, IPP entrants were primarily thermal or hydropower generators, since 2021 the first IPP entrants have predominantly been solar. For example, among the 19 countries whose first IPP project is currently under preparation or construction, 15 are solar IPPs.

Policymakers need to optimize compensation models for distributed and utility-scale renewables to accelerate private sector investments. An array of procurement measures under different power market structures have been adopted globally to mobilize private capital for solar and wind (Figure 4.4).

Historically, feed-in-tariffs (FiTs) were widely used by governments to promote the low-carbon generation of electricity by providing price certainty and thus investment security to developers of renewable energy sources. Under a FiT, utilities pay a certain tariff for deliveries of renewable energy. Tariffs are set by law for a defined period. Some include a mechanism by which the tariff declines over time. FiTs have been used under all types of power market structures. Several emerging markets implemented FiTs to kickstart renewables, such as Egypt in 2017 which was supported by an IFC-led $653 million financing package to construct 13 independent solar photovoltaic projects.

The FiT model is becoming less used, however, particularly for onshore wind and solar technologies as their costs have decreased and become more competitive. As competitive procurement models become more favored, contracting authorities are shifting away from FiTs in favor of price competition. There are a few exceptions. FiTs can be useful where the market for renewables is nascent or when the technology has high project development costs not included in auctions.[68] FiT programs should be designed to avoid long-term PPAs based on high tariffs (even if justified by costs), they should have caps on participation, and should entail sector-wide planning and forecasting capabilities to avoid over-contracting.

BOX 4.2

Structuring Power Purchase Agreements to Lower Investor Risk

Power Purchase Agreements (PPA) can make private sector investments more bankable by considering the contractual risks that projects pose, including:

Termination risk: If the purchaser of power—the off-taker—terminates power off-take or a concession agreement, project sponsors may be left without recourse to the market to recoup their investments. Contract terms (the PPA or a concession agreement) should give private investors clarity as regards the obligations of the relevant state entity to compensate them if the contract is terminated for reasons other than the private investor's fault. For example, the contracting entity could provide a termination payment to cover the IPP's outstanding debt to lenders.

Curtailment risk: Curtailment occurs when the off-taker reduces or restricts electricity delivery from the generator to the grid. It can occur for a variety of reasons, including: strains to the network because of variability in power generation (a particular problem with intermittent renewables); system-wide oversupply where the off-taker must curtail some generators to bring the system into balance; and local transmission constraints. Curtailment has significant financial consequences for the IPP, especially if operating a merchant plant or if the IPP is paid based on the amount of electricity delivered rather than available capacity under the PPA. The IPP's debt is structured based on projections of electricity delivery. A gap caused by curtailment creates risks for the lender because the company may struggle to keep up with debt repayments. In countries with a history of curtailment, private investors and lenders may require measures such as capacity payments (a fixed amount paid for available capacity), which allow the IPP to cover its fixed costs (debt service, fixed operating costs, agreed equity return) with the capacity charge.

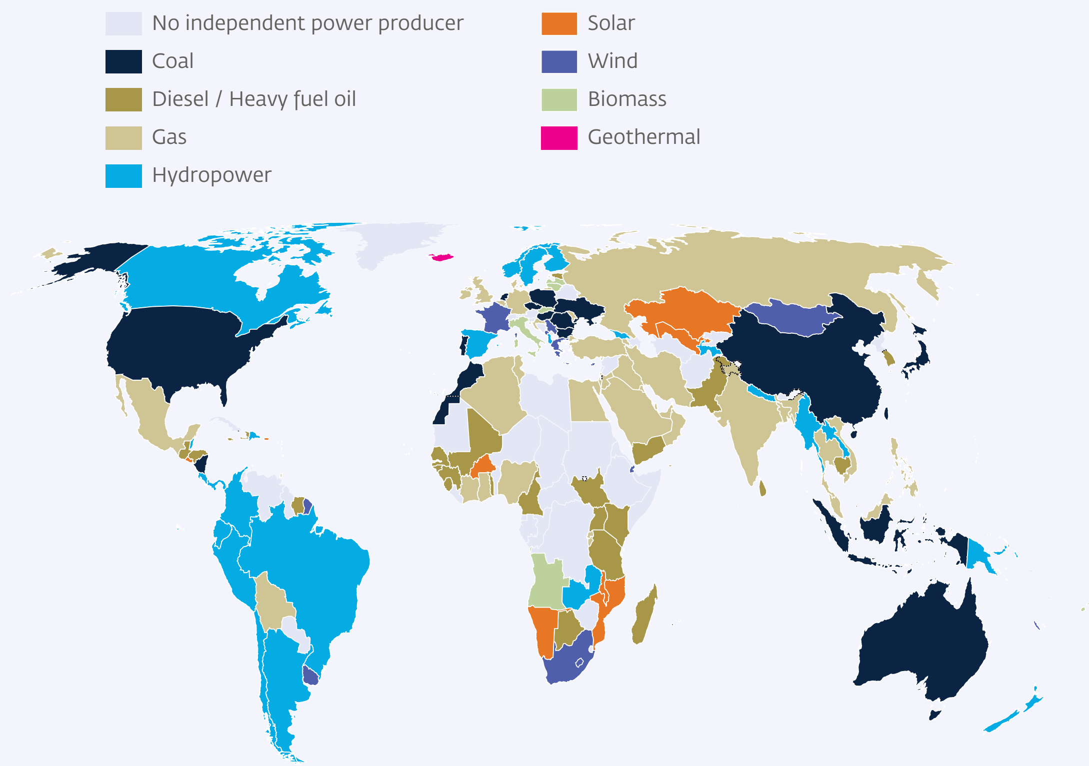
Macroeconomic and currency risks: Both lenders and private sponsors will hesitate to invest in a country with fiscal issues such as high inflation out of concern that their investment could be depreciated. Also, if the project's costs are in a foreign currency but its payments under the PPA are in the local currency, there will be a currency mismatch. To avoid subjecting the power producer to currency risk, investors may ask that fees and tariffs be either denominated in, or linked to, an exchange rate of the currency of the power producer's debt. Some countries do not allow currency guarantees. For example, Ethiopia at the point of transitioning to a Single Buyer Model structure did not allow this, which affected the bankability of its debut solar independent power producers. Others have refrained from issuing such guarantees based on negative experiences—Thailand, for example, after the Asian financial crisis of the 1990s. Such policy positions or practices on guarantees can be deal-breakers from a bankability perspective, especially when illiquid local capital markets prevent borrowing in local currency.

Dispute resolution: International arbitration is usually chosen because of its perceived neutrality and rigor. Insistence on local arbitration can significantly reduce investors' interest as good contracts are meaningful only if they can be enforced. The effect of requiring local rather than international arbitration is evident in Egypt's 2014 debut renewables feed-in-tariff program, which closed only one project despite the high tariff offered.

FIGURE 4.3

Significant Variation Between Countries in Technology Type for Independent Power Producers

Energy source of first independent power producer



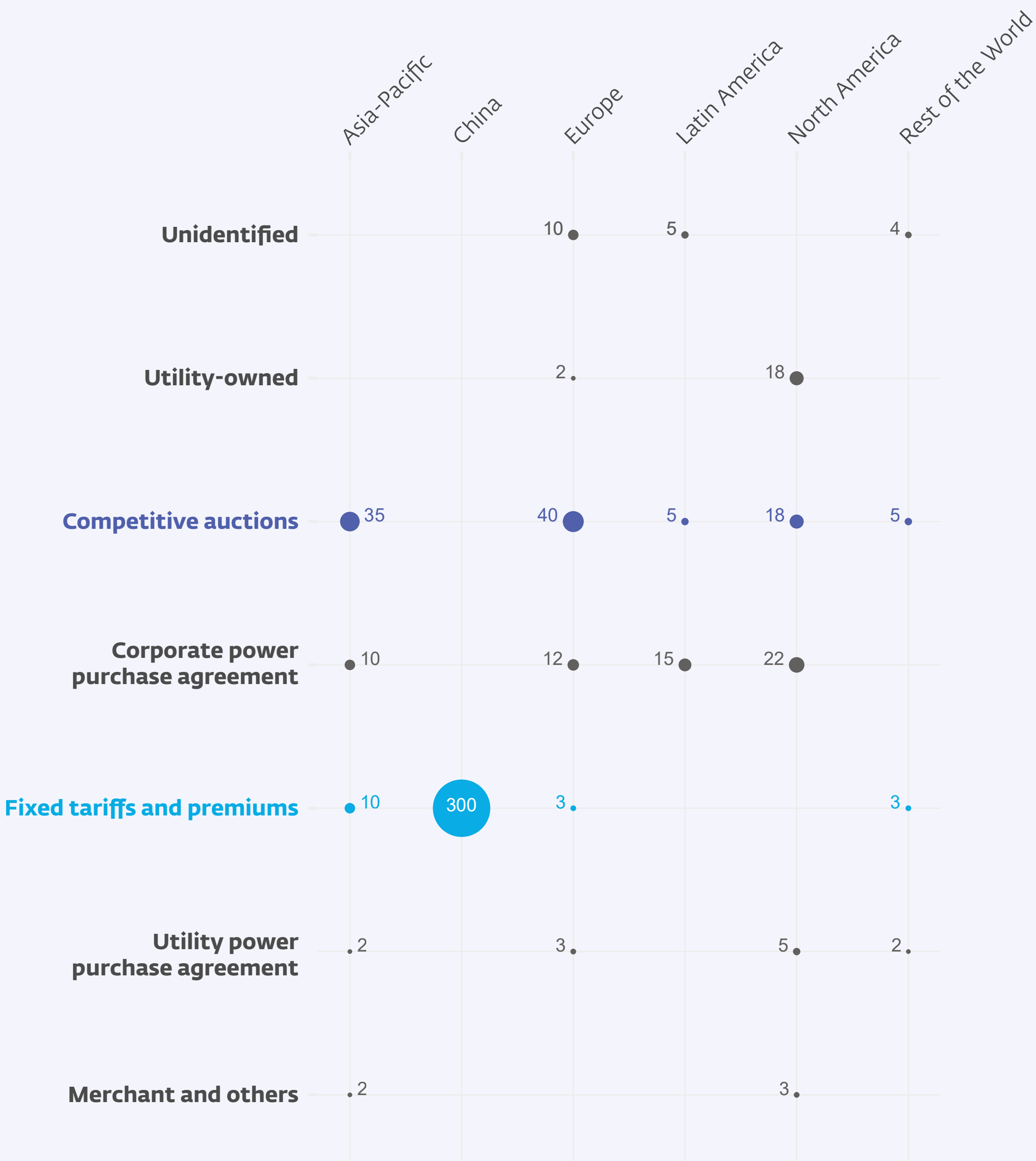
Source: Akcura (2024)

In power markets with an organized wholesale market, an alternative to FiT—a feed-in-premium (FiP)—can be utilized. Under a FiP, producers are paid the market price when variable renewable energy is dispatched and then compensated through a premium for the difference between this market price and the existing FiT. FiPs were adopted in the Turkish wholesale market as a support mechanism for renewable energy investments and are also used in Bulgaria, Croatia, and Serbia. By the end of 2022, 83 countries had in place either FiT or FiP payment policies. Six countries (Austria, Costa Rica, Finland, New Zealand, Switzerland, and Uganda) phased out FiTs in 2022 while another six (Bulgaria, China, Ireland, Mauritius, and South Africa) brought them back again after previously removing them.[69] South Africa announced the reintroduction of FiTs for solar to tackle a series of rolling blackouts.

FIGURE 4.4

Options for Procuring Renewables

Amount of solar and wind procurement, 2023–2024, gigawatts



Source: IEA (2023b)

Thailand introduced a 25-year FiT for solar photovoltaic and solar-plus-storage in 2023.

Renewable energy auctions are becoming more popular in emerging markets.

These auctions have considerable merits over FiT mechanisms, including an ability to produce highly visible price signals that can affect markets more broadly. They have demonstrated their effectiveness as a pass-through mechanism for competitive technology costs in the wind and solar segments in all types of market structures. Argentina, Brazil, Chile, India, Mexico, and South Africa have had success with these auctions, adding a great deal of renewables-based capacity with downward trends in price. In Sub-Saharan Africa, the use of competitive bidding processes to procure grid-scale solar photovoltaic energy is emerging as the preferred mode of procurement. From a baseline set in South Africa about a decade ago, solar auctions have since been implemented in countries including Benin, Ethiopia, Malawi, Namibia, Senegal, Uganda, and Zambia. Other countries are in preparation stages. These auctions have helped lower tariffs from about 8 U.S. cents per kilowatt hour in Zambia in 2016 to 2.6 U.S. cents in South Africa in 2022. Renewable auctions are also becoming a tool for countries to transition from VIU to SBM (Benin, for example) or for allowing countries with nascent SBM structures to gain further experience with IPPs (Malawi).

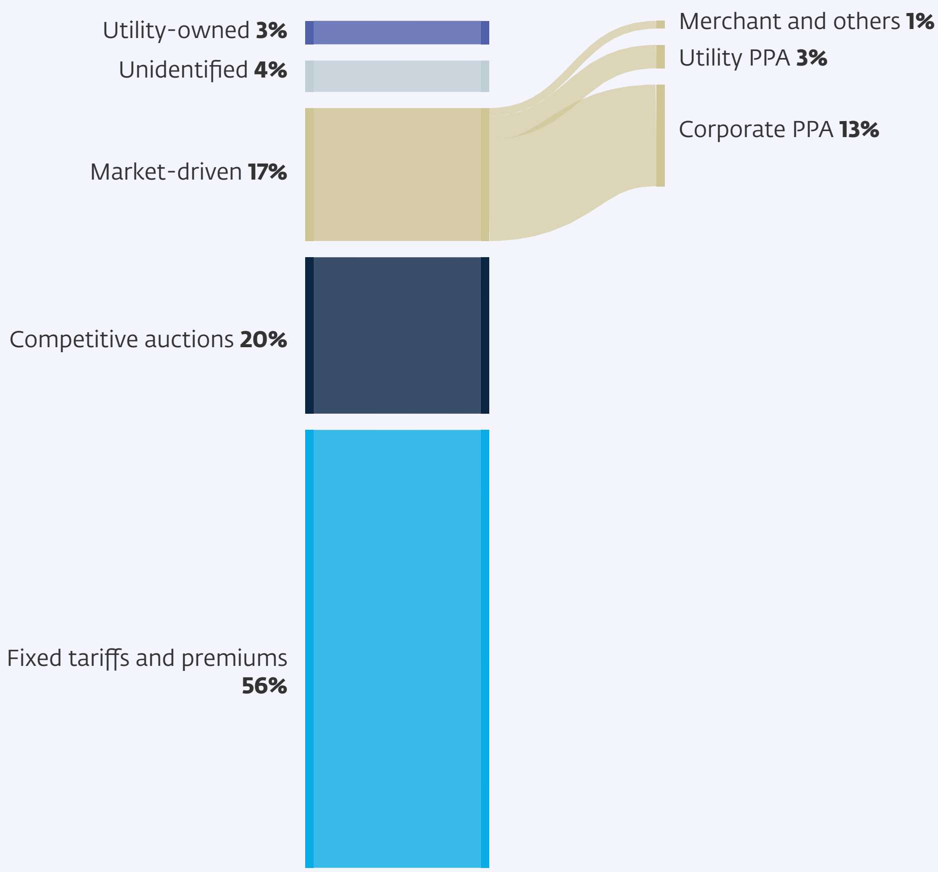
Under the single-buyer model, competitive bidding for IPP contracts can reduce renewable generation costs compared to the alternatives such as bilateral negotiations with a selected generation company or accepting unsolicited proposals.[70] Nontransparent procurement exposes PPAs to risks of renegotiation, corruption allegations, and cancellation, as seen historically in various countries including Guatemala, Indonesia, Pakistan, and Tanzania.[71] Competitive tendering obliges IPPs to earn contracts through demonstrated cost and technical merit rather than connections and this can lower costs. Best practice renewable energy tenders employ two-part PPA tariff structures with payments made for making capacity available combined with marginal cost-based energy rates.[72] Availability charges provide revenue certainty to cover IPP capital and fixed operating expenditures, enabling project bankability. Energy rates based on actual generation align dispatch with system needs, avoiding unnecessary curtailment. Competitive tendering also allows for the discovery of efficient pricing through competition and transparent risk allocation to the parties best able to manage them.[73] The IFC-supported 60 megawatt Kampong Solar project in Cambodia demonstrates the benefits of competitive procurement. Developed through public-private collaboration, it was the country's first utility-scale solar IPP project awarded through a competitive auction. The winning tariff of $0.039 per kilowatt hour was about one-third the previous rate, delivering over $2 billion in projected lifetime consumer savings.

Market-driven procurement of solar and wind generation is becoming more prevalent, especially in countries with organized, competitive wholesale and retail markets. These include modalities such as corporate PPAs between renewable producers and corporate customers, merchant projects where the generators sell on the wholesale spot market, and remuneration through certificate programs. Under a corporate PPA, a renewable energy generator can enter into a bilateral contract with a corporate buyer (off-taker). The various pricing structures for periods are agreed beforehand, including fixed prices and discounts pegged to wholesale prices. The International Energy Agency estimates that these modalities will account for 17 percent of utility solar and wind capacity expansion between 2023 and 2024[74] (Figure 4.5). Corporate PPAs currently are the main market procurement being deployed.

FIGURE 4.5

Feed-in-Tariffs Are Being Replaced by Market-Driven Procurement

Share of solar and wind by primary procurement type, 2023–2024 forecast



Source: IEA (2023b)

Rise of solar and wind requires rethink of compensation mechanisms.

Increasing the share of utility-scale variable renewable energy can create revenue challenges in current organized wholesale market constructs. Solar and wind power generation do not have fuel costs since sun and wind are cost-less thus the marginal cost of producing a unit of their energy is zero. As greater volumes of zero marginal cost wind and solar enter the system, wholesale energy prices decline and wind and solar's declining capacity factors at higher penetration also result in lower capacity payments. Together, these declining revenue streams across energy, capacity, and ancillary services markets create a 'missing money' problem, meaning producers cannot fully recover their costs through current wholesale market structures at higher penetration levels. This missing money manifests as un-bankable merchant risk for new projects beyond initial subsidy and contract periods. Large-scale renewables therefore require supplementary revenue solutions and risk mitigation to attract adequate investment. Policymakers can explore several tracks to address these including implementing clean energy standards to provide guaranteed renewable energy offtake and redesigning payment mechanisms to better compensate renewable capacity attributes.

Policymakers will also need to reevaluate their ancillary services resources as more variable renewable energy sources enter the grid. Ancillary services address immediate imbalances between supply and demand and ensure power system recovery to avoid power outages. These include 'black-start regulation' where in case of widespread grid failure, capacity can be procured from designated power plants producing electricity from a completely unenergized state without needing any external power from the grid; 'contingency' reserves, or capacity procured from standby generators that provide frequency and voltage control to balance the system; and 'synchronization' services that prevent system collapse—for example, system elements that can offset sudden surges in demand. Traditionally, thermal generators and hydropower were the main sources for such ancillary services. Variable renewable energy is technically able to provide essential ancillary services, including regulation and contingency reserves.[75,76] Policymakers can therefore encourage renewables' participation in ancillary services markets. This can provide new sources of revenue for power generators and new options for system operators to manage grid reliability.

Net metering has been pivotal in promoting the adoption of distributed renewables, particularly solar, by enabling consumers to produce their own energy and then providing them with credits on their bills up to the retail rate when they generate more than they consume. However, increasing distributed solar generation under net metering can negatively impact utilities by reducing consumer contributions for grid investment cost recovery. High adoption may also lead to suboptimal solar dispatch by lacking real-time wholesale price visibility. Net metered solar provides less reliable capacity at higher penetration levels. Without visibility into real-time market prices, solar customers lack the price signals needed to optimize dispatch decisions and align production with system needs.

These limitations can be addressed by integrating wholesale markets for distributed resources. Direct participation in energy markets better aligns compensation with real-time value, while providing access to ancillary service markets creates additional revenue streams. To unlock savings made from reduced grid investment needs, portfolios of battery and solar-sourced energy can be aggregated to create virtual power plants that integrate diverse energy sources. Aggregation allows individual power sources that alone are too small to be of interest to utilities and system operators to become so, thus adding viable supply to the grid. However, changes to existing net metering frameworks in countries where they exist should be implemented gradually to maintain investor confidence.

Risk mitigation tools are needed to incentivize investment. To mobilize the capital required to deploy renewable energy at an accelerated rate, these need to be incorporated in emerging power markets to better match investors' risk and return expectations. Renewable energy financiers face numerous risks as these assets have high upfront capital costs. They also face real and perceived regulatory, political, macroeconomic, and counterparty risks in many emerging markets given that these markets are relatively new with limited experience financing renewable energy and a limited track record with IPPs.

Policymakers can incentivize the uptake of risk mitigation instruments, including corporate PPAs or hedging products,[xi] to manage some of these risks. In many countries, corporations are procuring renewable energy under these corporate PPAs as a key part of their sustainability strategy. In 2022, the United States, India, Spain, China, and Bangladesh were the largest markets for corporate PPAs, in descending order.[77] Corporate PPAs can exist under any type of market structure (Figure 4.6). For example, in 2022 an apparel company in Bangladesh, which has an SBM structure, announced the installation of a 2 gigawatt on-site solar facility to provide electricity via a corporate PPA.

Corporate PPAs are an increasingly attractive option, given the growing demand by corporations in both advanced and emerging markets for electricity generated from renewables—both to meet sustainability targets and to allow them to procure cheaper electricity. These new forms of off-take mitigate some of the risks associated with utility off-take by providing cashflow for a share of production, a break-even ratio for lenders, and financial mitigation when the price of electricity drops.

In countries with organized wholesale and retail markets, a stable regulatory environment with tariff structures based on costs and non-discriminatory third-party access can alleviate price volatility-related risks to renewable generators. In addition, the incorporation

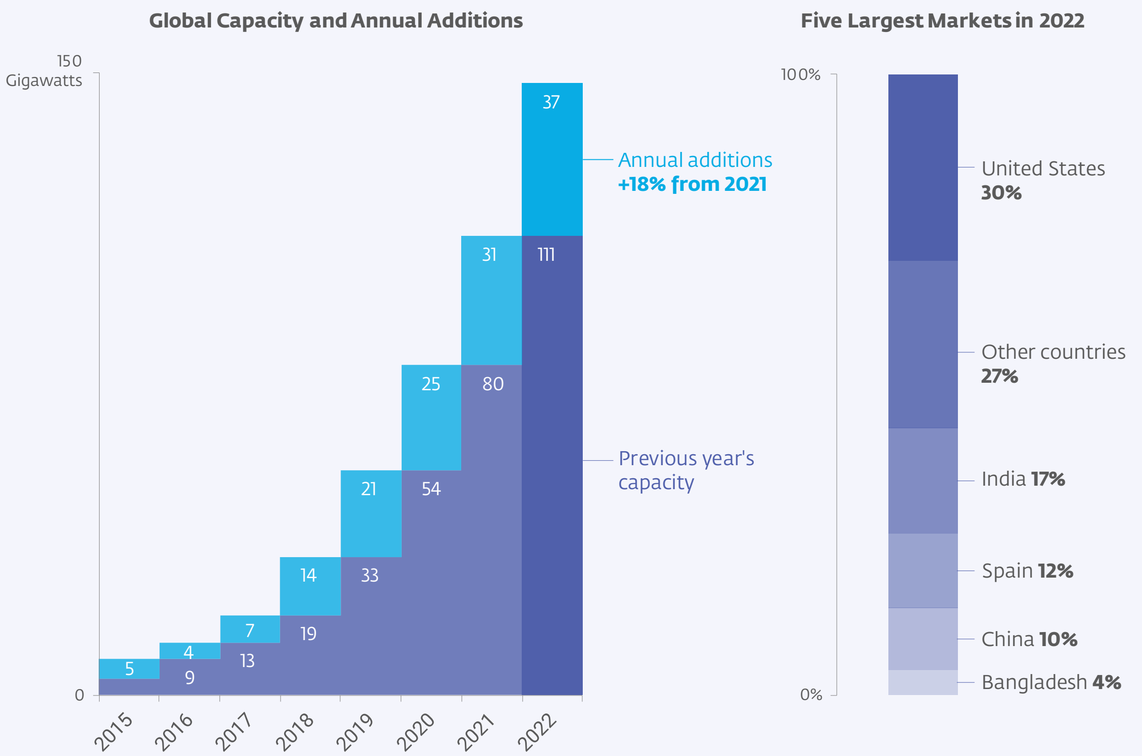
xi An example of a hedging product is a proxy revenue swap which allows the exchange of a fixed payment for the variable value of the project's revenues. This financial product has been used since 2016 for wind and is also becoming more common for solar projects. The swap can help stabilize revenue streams for wind and solar projects and provide increased certainty for investors as it hedges against weather-related risks that impact wind and solar power production. The first use of proxy revenue swaps for solar occurred in 2018 for two projects in Queensland, Australia covering a total installed capacity of 176 megawatts. (Brozynski and Tuenter 2018) of financial instruments such as electricity futures and other derivatives can help market participants to manage, or hedge, price risks in these more competitive market structures.

In the Philippines, price uncertainty has been hedged using voluntary forward contracts. The Green Tiger Markets, the country's forward power market operator, allows participants with bilateral contracts to buy and sell power supply contracts for a specified future date. The price stipulated in the contract is compared to the spot market price as a reference. If the contract price is more than the reference price, the buyer pays the seller the difference. If the contract is less than the reference price, the seller pays the buyer the difference.

FIGURE 4.6

United States and India Are Leading Markets for Corporate Clean Energy Purchases

Capacity increases in corporate power purchase agreements and main markets



Source: REN21 (2023); S&P Global Commodity Insights (2023)

These forward contracts, sometimes called 'contracts for difference,' help reduce price volatility. Consumers can purchase cash-settled forward contracts that provide them with electricity price certainty for months or years in advance. They allow consumers, especially companies, to more accurately forecast electricity expenses which can free up capital for growth initiatives. Power suppliers can use forward contracts to secure better financing by reducing their risk profile. This is especially important for variable renewables. In August 2024, Green Tiger Markets launched 'Solar Specific' forward contracts that only have price exposure to the middle of the day, the period of greatest certainty on solar radiation levels.[78]

Several countries have created official futures markets to accommodate price volatility. For example, Intercontinental Exchange lists futures for Austria, the Baltic region, Belgium, France, Germany, Italy, the Netherlands, Spain, Switzerland, and the United Kingdom as well as options for the German, French, and Italian markets. However, insufficient liquidity is an ongoing issue in these markets.

Recommendations

INCENTIVIZE

Cross-cutting

- Create targeted procurement and revenue streams, especially for renewable energy.
- Optimize compensation models for distributed and utility-scale renewables.
- Increase visibility and transparency of sub-national, national, and cross-country programs such as procurement programs that increase capacity, especially for renewables. Programs should have targets that are enforceable with well-publicized auction dates and portfolio standards (obligations on distribution companies to buy an increasing share of renewable energy over time).
- Implement regulatory reforms that lower off-take payment risks.
- Deploy risk mitigation tools that lower perceived risks and associated costs for the private sector.

Vertically Integrated Utility (VIU)

- Through regulatory incentives, policymakers should incentivize publicly or privately-owned VIUs to accommodate residential solar photovoltaic investments driven by net-metering programs. Countries concerned with potential negative impact that the emergence of prosumers may have on VIU revenues can explore decoupling utility revenues from sales, introducing fixed charges as a part of the final tariff, introducing prosumer charges on generated energy, or providing monetary incentives to the utility to expand distributed renewable energy generation.

- Policymakers should consider allowing corporate power purchase agreements (PPAs) between renewable energy generators and corporate buyers to exist alongside the VIU.
- Countries considering transitioning out of VIU should incentivize private sector entry through measures such as: legal or ownership unbundling of the VIU; designing PPAs that factor in risks private sector firms face when entering an untested market; and exploring risk-hedging instruments that mitigate such risks, including partial guarantees from development finance institutions.

Single Buyer Model (SBM)

- Policymakers should enhance the bankability of PPAs (Box 4.2) given that well-structured PPAs that appropriately consider contractual risks help attract Independent Power Producers (IPPs) when operating an SBM structure.
- Providing well-targeted government guarantees on PPAs is necessary to ensure the long-term commercial sustainability of the sector in the absence of a creditworthy and experienced single buyer. As utilities gain experience with private sector contracting and develop a solid track record of meeting their contractual obligations, such government guarantees can be scaled back.
- Introducing competitive bidding for IPP contracts. This can reduce generation costs compared to contracting via bilateral negotiations or accepting unsolicited proposals.
- Consider allowing corporate PPAs—for example between renewable energy generators and corporate buyers, to exist alongside the SBM structure.

Wholesale and Retail Competition (WRC)

- Most countries with WRC have achieved goals in increasing access to electricity. They can now focus on expanding market-driven procurement of solar and wind generation. These include modalities such as corporate PPAs between renewable producers and corporate customers, merchant projects where generators sell on the wholesale spot market, and remuneration through certificate programs.
- In countries where variable renewable energy generators cannot fully recover their costs on the wholesale market, policymakers can consider requiring supplementary revenue solutions and risk mitigation to attract adequate investment. Such solutions available include: implementing clean energy standards to provide guaranteed renewable energy offtake; designing new capacity market products that better compensate renewable capacity attributes; and evolving ancillary services markets to introduce products suited to renewable capabilities.
- Enable aggregated portfolios of distributed batteries and solar to act as virtual power plants, thereby unlocking the savings made from reduced grid investment needs.
- Ensure a stable regulatory environment, with tariff structures that reflect actual costs and non-discriminatory third-party access as this can alleviate merchant risks to renewable generators.

Invest Alongside the Private Sector

In delivering sustainable and affordable energy to all, the public and private sectors need to work in tandem to develop the requisite power infrastructure. Investments in transmission infrastructure (both national grids and interconnectors with neighboring countries) need to be significantly scaled up, in particular to connect new consumers and renewable generators to grids. Investment is also needed to upgrade existing (often aging) grid infrastructure to meet rising demand, to manage intermittency challenges stemming from incorporating more renewables, and to make transmission lines more resilient to climate change.

Investments in grid infrastructure often lag investments in power generation. The queue of proposed renewable projects waiting for access to transmission infrastructure exceeds installed wind and solar capacity in many countries. Grid enhancement lead times as long as five or ten years hinder the expansion of power generation. Siting, permitting, and construction of major transmission projects often face delays. Insufficient transmission capacity is already resulting in renewable generation being curtailed in some countries. For example, in Chile around 290 gigawatts of wind and solar generation was curtailed in 2022. South Africa's current transmission grid is facing constraints in some renewables-rich provinces resulting in difficulties connecting new utility-scale solar and wind power plants. Nearly three-quarters of the United Kingdom's total power curtailment cost in 2023 resulted from having to activate gas power plants in England and Wales in response to transmission network limitations that prevented the use of cheaper wind power from Scotland.

Although developing countries constructed around 1.17 million kilometers of new power transmission lines in the past decade, the pace of investment has slowed in the last five years, declining on average by 7 percent per year excluding China.[79] Most developing countries rely solely on public funding such as fiscal subsidies, government grants, and preferential rate loans from state-owned banks to develop transmission infrastructure.

Policymakers can deploy various strategies to direct more private capital to transmission infrastructure.

Enhancing transmission infrastructure is essential to achieving sector objectives on access, security of supply, and integration of renewables. While state-owned transmission companies are likely to maintain their critical role in financing transmission assets, private investors can help bridge the significant financing gaps.

To date, what private investment there has been has tended to go toward distribution networks, not transmission networks. More investment in the latter would be welcome, given how stretched state-owned transmission companies' financials are, especially in developing countries. Private institutional investors with long-term horizons may find this segment especially attractive given the stability and predictability of regulated revenues.

Several different business models have been deployed globally to engage the private sector in transmission (Table 4.2). The National

Grid Corporation of the Philippines, a private consortium, in 2007 was granted a 25-year concession to operate, maintain, and expand the transmission sector. The Philippines' state retains ownership of the country's transmission assets. For such a setup to work, a strong regulatory framework needs to be in place to ensure that the private counterpart has the right incentives to provide a quality grid—and service—while realizing a reasonable return on investment.

Argentina, Brazil, Chile, India, and Peru attracted private investment in transmission through so-called build-own-operate-transfer plans, where the private investor finances, builds, and operates new transmission lines under a long-term contract and then transfers them back to the state. Under Argentina's 'public contest method,' a single market participant can propose and develop transmission upgrades. This method allows for cost-sharing with other market participants. In Brazil's transmission auctions, the tender for each transmission project is awarded to the party offering the lowest allowed annual revenue below the maximum set by the Brazilian Electricity Regulatory Agency.

Expanding private investments in networks however faces several challenges. First, with a few exceptions, structural reforms in less advanced markets have retained transmission and distribution as public sector functions. Currently, 137 economies[xii] have not unbundled power transmission in any form, mainly in the regions of Sub-Saharan Africa, Middle East and North Africa, and East Asia-Pacific (Figure 4.7).

Second, investments needed for transmission and distribution cannot be met without raising tariffs. Tariff reform remains a significant challenge in developing countries, where governments and regulators hesitate to increase the network component of the end-user tariff to keep prices more affordable. To manage these challenges, governments and investors can learn from the experiences of several countries including Brazil, Kazakhstan, Peru, and Philippines in attracting private investment in transmission using novel approaches. Several adopted an independent power transmission model where typically the state-owned transmission utility enters a long-term contract with a private company tasked with the design, construction, and financing of a single transmission line or set of transmission lines. These contracts can be structured as transmission service agreements, but can also take other forms such as lease or line concession agreements. The independent power transmission arrangement can be implemented with limited or no regulatory reform and thus provides a potential option for countries to expand transmission infrastructure within a reasonable timeline.

At a policy level, transmission planning and deployment needs to keep pace with access expansion requirements and projected renewable capacity growth. For example, new transmission infrastructure should be expanded to areas where renewable resources are abundant. Processes to site and permit projects must be accelerated. Grid operators can

xii Unbundling is a structural reform that involves separating the core functions performed by power utilities or power companies. In the case of a Vertically Integrated Utility, it involves the separation of generation, transmission, distribution and (sometimes) retail functions.

TABLE 4.2

Business Models to Promote Private Sector Investment in Transmission Infrastructure

	LONG-TERM CONCESSION **The private company obtains a concession to manage and operate existing transmission assets and is responsible for expanding the transmission grid in its area of operation.**	**BUILD-OWN-OPERATE-TRANSFER** **The private company finances, builds, and operates a new transmission line, then transfers it back to the government.**	**FINANCIAL OWNERSHIP** **The private company provides part of the financing for a new transmission line, but it is built and operated by the system operator.**	**MERCHANT LINE** **The private company finances, builds, and operates the transmission line, with revenues coming entirely from short-term wholesale transmission market prices.**	**DEDICATED LINE FOR IPP*** **New line evacuating power from Independent Power Producer (IPP), connecting to the existing grid.**
Contract duration	Long term (30-50 years) or indefinite	Long term (often 25 years or more)	Indefinite, but possibly with a buy-back option for the system operator	Indefinite	Same as IPP, unless the line is transferred at commission
Contract coverage	All existing and new lines in a limited transmission zone (country, region)	New line (or sometimes a package of lines)	New line	New line, often a high-voltage direct current	New line
Revenue/ tariff setting	Regulated revenues, generally defined annually and subject to periodic regulatory review	Majority of revenue defined by winning bid, for the entire contract	The plan is typically applicable to the system operator, e.g., congestion rents or regulated revenue	Revenues from wholesale market prices, sometimes supported by price mechanisms (e.g., cap-and-floor program)	If line not transferred, revenues defined as part of IPP contract payment
Who funds capital expenditure?	Private sector	Private sector	Private sector and system operator	Private sector	Private sector
Applicability to inter-connections	Limited	Yes, if the line in each of the borders is based on a build-own-operate-transfer scheme.	Yes	Yes, but requires restructured markets and a primary model for multilateral power trading	Not recommended since this implies cross-border integration of specific assets instead of grid integration
Global examples	Philippines, parts of Europe	Argentina, Australia, Brazil, Chile, India, Peru, United Kingdom, United States	Denmark and Germany	Australia, Estonia, Finland, United States	Applies globally

Sources: World Bank, "Linking Up: Public Private Partnerships in Power Transmission in Africa," 2017; adapted from International Energy Agency, "Attracting private investment to the electricity transmission sector in Southeast Asia," 2020.

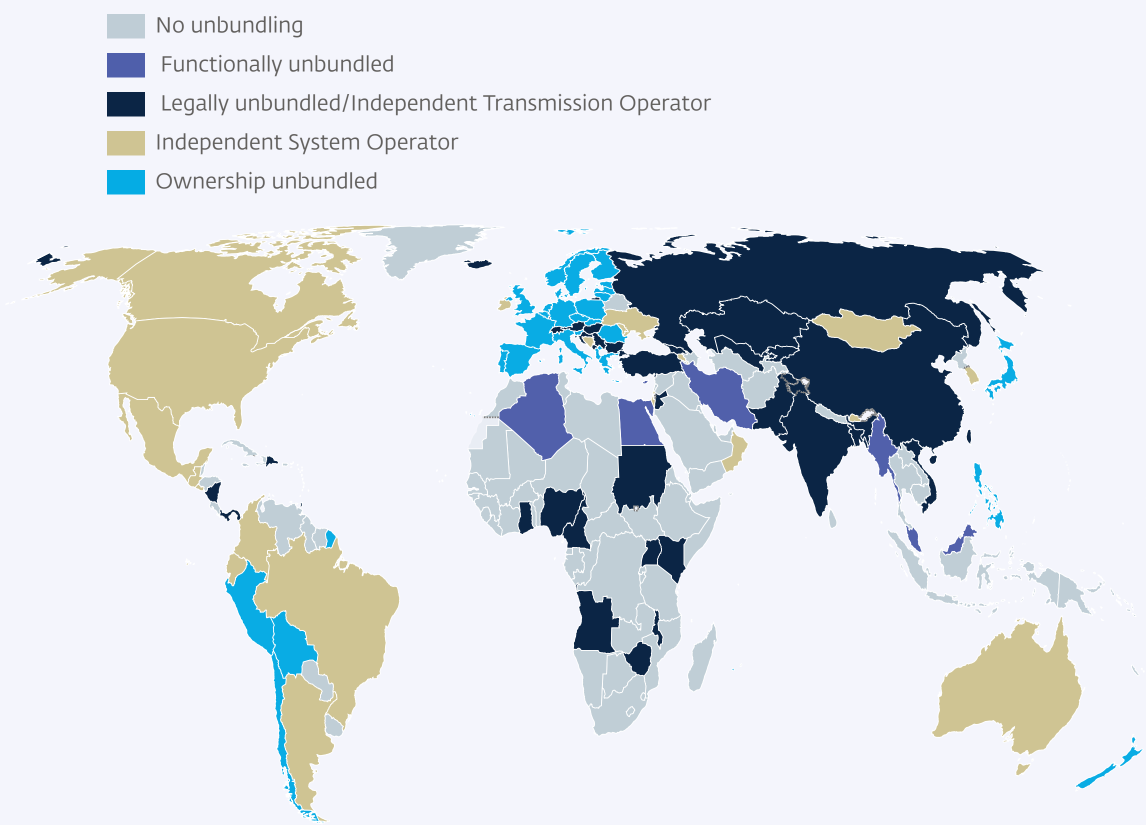
utilize scenario modeling to forecast optimal expansion requirements over the next decade. The optimal path forward requires holistic power system planning and cooperation among all stakeholders. The development of generation and transmission assets cannot continue in silos. Getting the timing right on generation and grid investments will be critical to meet access and decarbonization objectives cost-effectively.

As with power IPPs, investments in transmission infrastructure can leverage corporate off-takers. For example, there could be a new discovery of a commodity or development of an industry in a region of a country with little or no transmission infrastructure. The private sector could be engaged to build a transmission line primarily for this demand center benefiting from the creditworthiness of the industrial companies. An example of this is Zambia and the

FIGURE 4.7

Transmission Operator's Structure Varies by Region

Type of transmission unbundling



Source: Akcura (2024)

Copperbelt Energy Corporation. Another option is to leverage large demand centers such as foreign buyers or regional power pools to generate revenues for transmission investments. The Southern Africa Power Pool example (Box 4.3) illustrates how investments can be anchored in regional demand and electricity traded through a regional wholesale market. These types of innovative financing mechanisms can unlock constraints and crowd in public and private sector financing.

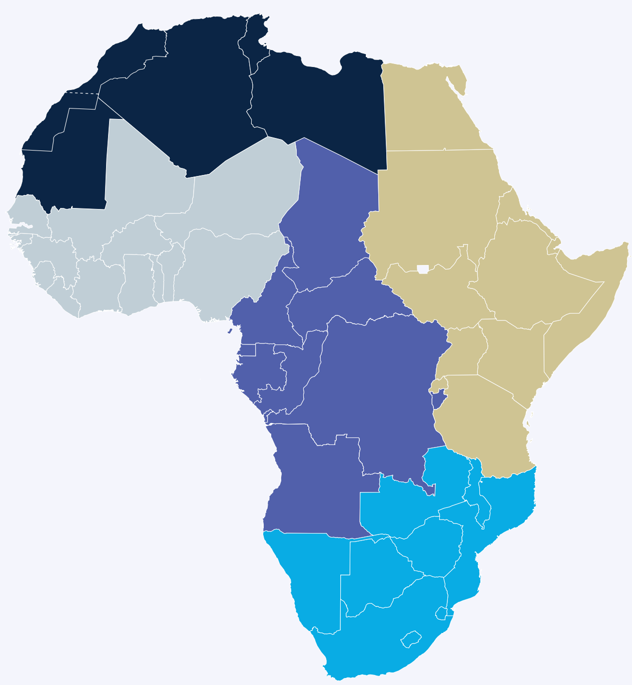
A more traditional approach, one especially common in VIU and SBM structures, is to rely on private financing of publicly owned or managed assets. This can take several forms including: the transmission system operator raising private sector financing to invest in transmission infrastructure; granting a long-term concession to a private company to operate and maintain the transmission network while the public utility maintains ownership; and entering a build-own-operate-transfer agreement with a private investor to develop a single new transmission line. Financing is optimized under this model if the system operator is commercially run and creditworthy.

BOX 4.3

Africa's Experience in Building Regional Wholesale Power Markets

Improving cross-border trade can be a powerful tool to improve electricity access and reliability in emerging markets, while also supporting decarbonization. Africa is home to several regional power pools, founded by economic communities in each region. They support the gradual evolution from uncoordinated bilateral sporadic trading to a more cooperative approach that unlocks new power generation and connection opportunities, improves efficiency, and helps stabilize national grids (Figure B4.2). The level of trade and competition in these power pools varies considerably.

Figure B4.2. African Regional Power Pools



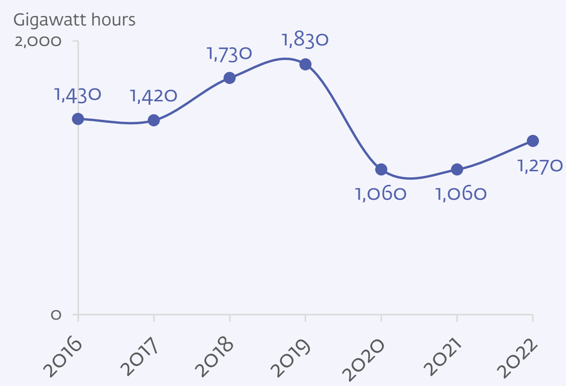
Continued on Page 100

The Southern African Power Pool (SAPP) is the first and the most advanced of its kind in Africa. Since its establishment in 1995, SAPP has advanced beyond bilateral contracting to become a regional competitive wholesale market that includes a day-ahead and intra-day market. It has meanwhile established a sound governance structure at the policy and operating levels and has developed functional multilateral competitive markets. In addition, it has established a coordination center that advises on the feasibility of transmission arrangements for bilateral trade, operates the competitive markets, and monitors the power pool's functioning, including whether it is following the operating rules. Since 2014 the World Bank has supported SAPP through a program that deepens technical, financial, and legal transaction capacity in regional project preparation, funds project preparation, and supports member utilities and regional stakeholders on planning issues like renewables integration and promoting regional power trading.

SAPP illustrates how countries with a small market size where the national off-taker faces creditworthiness issues can leverage a regional market to transition to wholesale markets. Some of SAPP's features make it an ideal candidate to lead the transition to competitive wholesale markets across Sub-Saharan Africa. These include: operating the only functional day-ahead market in the region where none of the national systems have established power exchanges, and operating a dollar-based trading system, one where the trading members have a strong track record of settling bills, making it a creditworthy market. New independent power producers operating in SAPP countries that have financially constrained off-takers can turn to the creditworthy SAPP market to make projects more bankable.

The SAPP day-ahead market is facing liquidity and transmission capacity constraints (Figure B4.3). Several renewable power projects are being built in the region intending to sell on SAPP which will improve liquidity, including the 350-megawatt Mpatamanga hydropower project in Malawi. On transmission infrastructure enhancement, several key interconnections across three corridors (East, Central, and West) have been identified by SAPP. These will require investments of around $2 billion. The World Bank Group, along with the African Development Bank and other cooperating partners, supports SAPP through the regional transmission infrastructure financing facility, a $1.3 billion mechanism that aims to unlock constraints and crowd in public and private sector financing.

Figure B4.3. Volumes of Electricity Traded on SAPP Day-Ahead Market, By Year



Source: Fleming (2023)

Regional power markets are a powerful tool to increase investment.

These markets can make the power sector more resilient to seasonal and short-term supply shocks, lower costs, and expand renewable energy production. Cross-border trade in electricity allows countries to minimize supply and demand imbalances by tapping more diverse resources and by making it easier to manage peak demand timing across geographies. At the same time, these larger markets provide a framework that often works better than smaller individual markets for mitigating investment risks. Policymakers should thus enable their development through institutions and policies.

The key ingredients needed for regional power markets to succeed are a shared infrastructure, appropriate institutions, harmonized policies, and regulations that coordinate cross-border system operation. Managing their commercial, technological, and regulatory complexities requires strong and consistent political commitment and high levels of coordination by the policymakers of participant countries. There are many different regional power market designs from which countries planning to create their own can borrow or adapt (Table 4.3).

Bilateral trade can be an effective way to promote investment. Bilateral trading arrangements between countries allow them to balance supply and demand by drawing on their complementary resources. For example, Georgia's hydropower generators export seasonally to neighboring markets such as Türkiye, where energy demand is high during summer months when Georgia has excess electricity. Occasionally, Türkiye exports power to Georgia in times of peak demand in Georgia. In this way, Georgia takes advantage of its abundant hydropower to generate export revenues from electricity trade while it benefits from import possibilities to maintain system balance in peak demand times. Bilateral trade also occurs between states within a country, India being a good example (Box 4.4). Such structures are straightforward to establish, but they limit the potential efficiency gains that accrue from more flexible multilateral trade arrangements that can better harness advantages of wider inter-regional diversity.

In Asia, several members of the Association of Southeast Asian Nations (ASEAN) trading bloc are working to interconnect grids to advance decarbonization efforts. The Lao People's Democratic Republic-Thailand-Malaysia-Singapore Power Integration Project, which became operational in 2023, kickstarted multilateral cross-border power trade of up to 100 megawatts between Lao and Singapore via Thailand and Malaysia using existing interconnections. Singapore's electricity retailer, Keppel Electric Pte Ltd, signed a two-year PPA with Electricite du Laos, Lao's state-owned VIU, to import 100 megawatts of renewable energy. The agreement is the first instance of multilateral cross-border electricity trade involving four ASEAN countries. It is also Singapore's first renewable energy import agreement.

Market-based models such as explicit or implicit auctions can be adopted to allocate interconnector capacity. For explicit auctions, the transmission rights to cross-border capacity are auctioned ahead of real-time delivery e.g., monthly. Explicit auctions are a good tool for ensuring that capacity is not locked in by a few players while also providing greater certainty to generators on the availability of and access to interconnectors. However, on the downside they can tie up unutilized capacity that could otherwise be used in real time. Implicit auctions avoid this pitfall as they are conducted real time and capacity is allocated consistently ensuring least-cost dispatch. However, they require a wholesale power exchange as the transmission capacity is granted in the order that parties clear the spot market (day ahead or intraday).

TABLE 4.3

Regional Power Markets Come in Many Forms and Sizes

Select models of cross-border trading in electricity

Bilateral, unidirectional power trade	• Thailand imports from Lao PDR
Bilateral, bidirectional power trade	• India Inter State Transmission System (ISTS) • Turkey and Georgia electricity trade
Multilateral, multidirectional trade among differentiated markets	• Lao PDR-Thailand-Malaysia-Singapore Power Integration Project • Southern African Power Pool • SIEPAC
Multilateral, multidirectional trade among harmonised markets	• EU Internal Energy Market
Unified market structure, differentiated operations	• Nord Pool
Unified market and operations	• PJM

Source: Adapted from IEA (2019).

Note: PJM is a regional transmission organization in the United States. It is part of the Eastern Interconnection system serving all or parts of the U.S. states of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia, and Washington, D.C.

Western European countries have integrated their electricity systems by allowing implicit auctions of trading capacity among their electricity systems. Under this approach, cross-border transmission capacity is not explicitly auctioned but implicitly available via power exchanges among the participating countries. Cross-border electricity is traded in real-time across participating power exchanges, allowing for price convergence among countries. Such harmonized trading structures foster more competition and enhance the resilience of the integrated power system. They can accrue significant efficiency gains because regional market price signals enhance the efficient flow of electricity within the borders of the harmonized market. However, these arrangements are highly complex to design and implement. Deepening integration means more market rules must be harmonized between the participating jurisdictions, which can entail harmonization of wholesale market rules as well as potentially ancillary service and capacity markets. Such integrated regional markets require a strong regional mindset among participants, robust institutional arrangements, and sophisticated governance tools to ensure effective market operation.

These different models operate under a range of institutional structures and with varying degrees of integration. For example, multilateral trade can be conducted through a loosely coordinated framework where each jurisdiction retains its autonomy or through more integrated dedicated regional institutions. Overall, the deeper the level of

BOX 4.4

Renewable Energy Auctions of India's Inter-State Transmission System

India's Inter-State Transmission System promotes power-sharing among its states. To support the initiative, India is developing a green energy corridor that connects eight renewable energy-rich states (Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, and Tamil Nadu) to other states that lack renewable generation potential.

The program is a good example of how the different public policy goals of renewables integration, sustainability, and resilience can be aligned. It simultaneously supports interconnection, the achievement of India's renewable energy targets, and greater energy security for connected state grids.

To date, around 19.4 gigawatts of solar and 18.7 gigawatts of wind projects have been auctioned by the Solar Energy Corporate of India (SECI), India's renewables regulator. Winning bidders, in a reverse auction, sign a power purchase agreement with the central off-taker, SECI, which then enters into a formal agreement to sell the electricity to a state distribution company.

IFC supported the development, construction, operation, and maintenance of a 300-megawatt solar farm in India that forms part of the system and continues to evaluate other investment opportunities. Developed in the northern state of Rajasthan, this project will sell power to SECI under a 25-year agreement at a tariff of $0.0316 per kilowatt hour. SECI will then supply the power through the national grid to other states with lower renewable generation capacity.

integration, the greater the potential benefits and the organizational complexity to manage the system and alleviate risks. Policymakers can utilize the power of regional power markets to meet sustainability, accessibility, and affordability goals, but they need to invest in the requisite infrastructure (interconnectors, transmission lines) and institutions to manage regional trade effectively (Box 4.4).

Recommendations

INVEST

Cross-cutting

- Co-develop national grids and new interconnectors with neighboring countries.
- Upgrade existing (often aging) grid infrastructure to meet growing demand, address the issue of growing intermittency of supply stemming from more variable (renewable) energy sources coming onto the grid, and make transmission lines more resilient to the effects of climate change.
- Develop business models that engage the private sector in power transmission systems, including through concession agreements, build-operate-own-transfer agreements, and financial ownership and merchant options.
- Enable regional power markets. To integrate power systems across borders (both between and within countries), the following elements are essential: investment in enabling infrastructure such as interconnectors, grid components, and grid synchronization; development of appropriate institutions and harmonized policies to co-ordinate how the system functions across borders; and deploying risk mitigation tools like capacity auctions to manage grid congestion.
- Ensure these assets are economically viable. Detailed cost-benefit analysis is needed on each project and participating countries should agree upfront how to share costs. One option is a 'beneficiary pays' principle, where costs are distributed according to each participant's expected benefits. Alternatively, costs can be allocated based on political agreement. Having a central body that can facilitate cost allocation negotiations will increase the chances of establishing the necessary supporting infrastructure.

Vertically Integrated Utility (VIU)

- VIUs can consider allowing private sector investment to build new transmission capacity or to rehabilitate existing transmission assets using a range of options, each one entailing a different degree of investment management by the VIU.
- For those considering transitioning to another market structure, they should consider unbundling transmission from the VIU and creating an independent transmission operator or an independent system operator with a separate balance sheet.
- When feasible, improving cross-border trade can be a powerful tool to mobilize financing while alleviating VIUs' challenges with extending access and improving reliability. Regional trade, whether bilateral or through regional wholesale markets, presents opportunities to strengthen system governance and leverage economies of scale.

Single Buyer Model (SBM)

- Countries with SBM structures can deploy a range of methods to attract private investment in transmission infrastructure (Table 4.2).
- By participating in regional power pools, SBM countries can use trade to advance their green energy transition and improve energy security. Conducting least-cost power system planning optimized at the regional level helps ensure the appropriate design and development of the power pool. Policymakers should also ensure their utility is adequately prepared to trade through the power pool, including having the processes, systems, and personnel needed to establish trading units in the trading entity (this can be the single buyer).
- Sovereign guarantees and development finance institutions or donor support can help utilities to engage in, and harness the benefits of, regional trade and thereby contribute to strengthening creditworthiness. Currently, financial weakness and operational inefficiency in a single buyer engaging in cross-border trade can inhibit development of regional trade and make it challenging for them to raise the necessary debt financing.
- Allow third-party access to cross-border infrastructure to sector participants like independent power producers. Not allowing such access can significantly lower the economic viability of the infrastructure.

Wholesale and Retail Competition (WRC)

- Policymakers in countries with WRC structures have a range of options for mobilizing private investment in transmission and interconnectors (Table 4.2).
- Ensure efficient and equitable allocation of cross-border capacity as this enables cross-border trade in electricity. Ideally, develop harmonized allocation rules or market tools to support coordinated capacity calculation and allocation mechanisms. Market-based models to consider include explicit and implicit auctions.

Identify Opportunities to Leverage Development Partners

Development finance institutions (DFIs) such as IFC play a crucial role in unlocking investment and supporting infrastructure development in power markets in lower- and middle-income countries. They provide long-term funding that helps bridge financing gaps, especially in countries with limited access to private capital. DFI financing flows to the power sector from 2010–2023 totaled $709 billion (Figure 4.8). Investment totals from DFIs are increasing, with financing to the sector peaking in 2023 at $78 billion.[80]

Over the past decade, DFIs have increased financing for renewable energy, from $12 billion in 2010 to a record $55 billion in 2023. Renewables' share of total DFI funding for power markets has correspondingly grown from 27 percent to 71 percent over this period, reflecting the prioritization of clean energy projects (Figure 4.9). Renewables financing, which includes large hydropower, accounted for 54 percent of total financing during this period. DFI funding for conventional thermal power generation has conversely declined—from $28 billion in 2010 to $7 billion in 2023—reflecting a shift in support away from fossil fuels. Financing for transmission and distribution networks has fluctuated between $2 billion and $18 billion annually. DFI financing continues to be crucial in catalyzing expansion of renewable power capacity. To fully achieve development goals, it is essential to further enhance DFI support for modernizing electricity grids and expanding access.

As a champion of private sector investment in new markets for seven decades, IFC is expanding its role beyond financing individual projects, as are other development partners. The enhanced role recognizes the increasing need to help policymakers and other investors to finance projects that enable and mobilize private capital at the scale necessary to drive impact. The 2023 World Bank Evolution Roadmap outlines how IFC, partnering with the other World Bank Group institutions (IBRD, IDA, MIGA) will ramp up efforts to enable private sector solutions, mobilize private capital, and strengthen private sector development. [81]

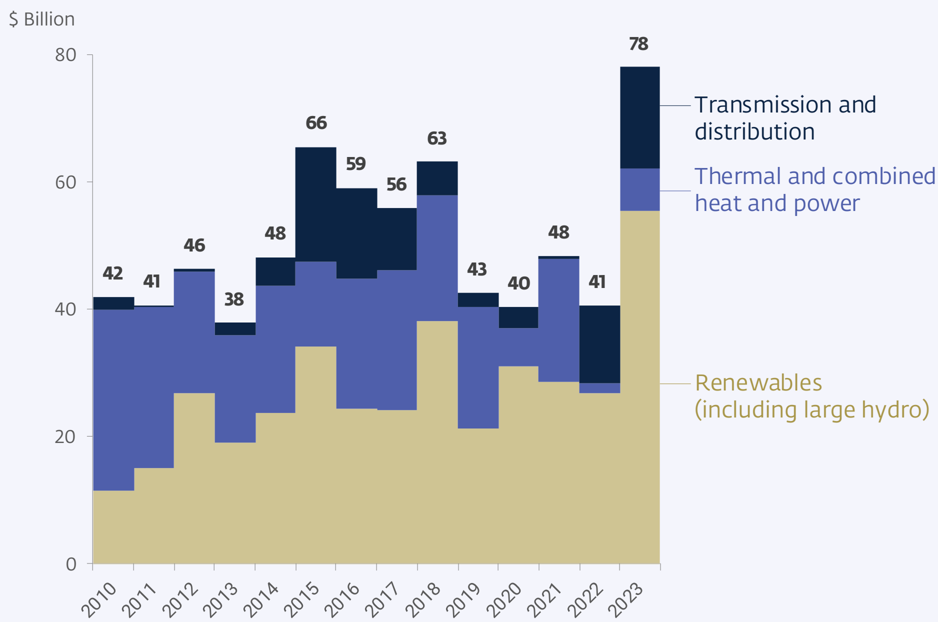
DFIs increasingly are helping utilities to manage their power sectors better.

Much of the support DFIs provide focuses on improving utilities' cost recovery through better planning, reform of tariff systems, minimizing losses, and enhancing bill collection.

FIGURE 4.8

Most Development Finance Today Supports Renewables Expansion

Global trends in DFI financing to the power sector



Source: IFC based on IJ Global (2023)

Countries can especially benefit from advisory assistance on sector management and private procurement. Development partners can also support efforts to establish missing institutions and plug gaps in complementary infrastructure by addressing transmission bottlenecks, network redundancy, and system resilience (Box 4.5). Aligning sector-level interventions with investments supported by private investors creates synergies between public and private activities and encourages follow-up investments in pioneering projects.

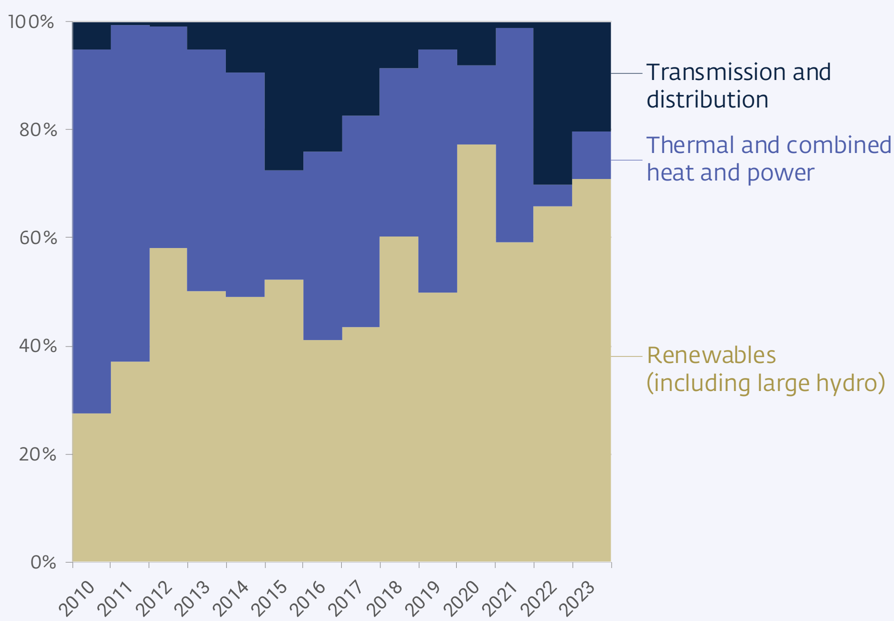
Mobilizing early-stage capital is critical.

One major constraint to attracting private capital to developing countries, particularly low-income and fragile and conflict-affected ones, is lack of early-stage private capital. Such capital is essential to support a project's development—for example, for conducting risk assessments, environmental and social impact studies, and project structuring to bring the project to financial close—and to pilot novel business models. DFIs can bridge the gap in early-stage support, supplementing the

FIGURE 4.9

Investments Shift from Thermal to Renewable Power Generation

Share of DFI financing to power sub-sectors



Source: IFC based on IJ Global (2023)

BOX 4.5

IFC Future Grids Alliance—Helping Energy Utilities Navigate the Energy Transition

The Future Grids Alliance is an IFC initiative that supports energy utilities in emerging markets in navigating the complex challenges of implementing a just energy transition, with a focus on achieving universal energy access and managing climate risk. As the cornerstone of power systems, utilities are the key player in leading the transition toward affordable, clean, reliable energy. However, they must contend with increasing impacts from climate change, new energy supply and demand patterns, and a global push for universal energy access, all the while operating in complex political and regulatory environments.

The IFC-led alliance offers a comprehensive suite of solutions to help utilities overcome these challenges. Members gain access to a global network, featuring IFC-organized events with technical experts and influential business leaders. These events foster collaboration and knowledge-sharing among major power utilities in emerging markets. Additionally, IFC provides a range of advisory and project co-development services, covering technical, climate, social, and sustainable finance aspects, and it offers innovative financial products, including sustainable debt, equity, mezzanine debt, local currency, and risk mitigation instruments. This financing supports investments in renewable energy, storage, network digitalization, and grid expansion, empowering utilities to lead the charge toward a sustainable energy sector.

resources of sponsors, and provide upstream advisory support. Resources may include a concessional or grant component that pays for the extensive work needed to (partially) de-risk infrastructure projects and initiatives and bring them to a stage where they can be financed. It may also involve seed money to pilot technologies and approaches in new markets, or financing of early activities that support project development. For example, IFC's InfraVentures fund makes early-stage investments in private and public-private partnership infrastructure projects. It helps pilot projects to provide proof-of-concept.

It is not always feasible to hedge project risks in developing countries because of underdeveloped hedging markets or low liquidity. Certain risks cannot easily be borne by any counterparty. Political risks—expropriation of assets without indemnity, political force majeure, breach of contract by the state and state entities—cannot easily be borne by the private investor and is often transferred to the state through sovereign guarantees and undertakings. Some risks are embedded in the public-private partnership contract, while others are institutionalized.

Blended finance is a useful risk-mitigation tool in the DFI kit.

Blended finance can play an essential role in reducing project risk, both through risk-mitigation instruments and subordination[xiii] (Box 4.6). IFC has increasingly been

xiii This refers to structuring a financing arrangement so that some investors, often development finance institutions, agree to take on a lower repayment priority, absorbing first losses to protect senior creditors.

BOX 4.6

Scaling Up Renewable Energy in Egypt Through Risk Mitigation and Partnerships

In 2022, IFC and various partners announced a $1.1 billion financing package for twin solar and wind construction projects involving independent power producers in Egypt. The planned 560-megawatt Abydos solar photovoltaic plant and 505-megawatt Amunet wind farm are Egypt's largest renewable energy projects to date. They will generate over 4,000 gigawatt hours annually once operational, enough to supply clean energy to over 1 million Egyptians, and will reduce the country's greenhouse gas emissions by 1.7 million tons annually. Power from the solar park and wind farm will be priced at $0.02 and $0.03 per kilowatt hour, respectively, the lowest rates in Africa and among the least expensive globally.

To enable competitive pricing and attract private investment on such an ambitious scale, as the mandated lead arranger, IFC was able to structure a tailored solution for Abydos and Amunet using interest rate swaps. This hedging instrument exchanged variable interest rate debt for fixed interest rates, thereby capping financing costs over the long term. With the interest rate risk mitigated, IFC could then extend sizable, long-tenor loans to the project companies. IFC provided $145 million in direct debt financing and helped mobilize an additional $660 million in loans from development finance partners and commercial banks.

The combined funding allowed the projects to optimize their capital structure with maximum leverage and minimal financing costs. It also resulted in record-low renewable energy tariffs for the region. The project demonstrates how innovative risk management tools combined with collaborative partnerships can unlock climate finance for emerging markets.

deploying different forms of blended finance to promote the development of renewable energy in high-risk frontier markets. For example, subordinated blended finance debt has helped meet the debt service cover that senior lenders require when offering non-recourse project financing.[xiv] 'Stapled' senior concessional loans—offered as part of a package that includes commercially priced debt—enable credible developers to take part in renewable energy auctions in countries with no track record. This is enabling affordable tariffs in pioneering projects that stand a better chance of being commercially sustainable in the face of rapid technological advances. There are also nascent risk-mitigation instruments (liquidity support or political risk insurance) in renewable energy. Between 2009 and 2023, IFC made about 200 investments in grid-scale solar and wind energy projects of which about 13 percent have a blended concessional finance co-investment. The nature of IFC's support has evolved in line

xiv A non-recourse financing instrument permits the lender to receive repayment only from the profits of the project the financing is supporting. The lender is only allowed to seize the collateral specified in the project's financial agreement, even if its value does not cover the entire debt.

with solar and wind market trends, from a focus on enhancing returns in early adopters that faced high technology costs, to reducing risk.

Government guarantees and undertakings are not always adequate to make projects bankable, especially when fiscal sustainability or governance is weak. In contexts where capital markets are deep and the potential risk manageable, project sponsors can tap the commercial insurance market for total or partial coverage. When such conditions are absent, DFIs can take on this role. Among the World Bank Group institutions, the International Development Association, which works with the poorest and most fragile countries, and International Bank for Reconstruction and Development can mitigate risks through partial risk or payment guarantees. The World Bank Group's Multilateral Investment Guarantee Agency can provide insurance for political risks, while IFC can mitigate risk through a blended finance-based facility. Collectively, these insurance products build investor confidence, widen the base of potential lenders, and lengthen the tenor of loans available to the project from lenders (Box 4.7).

New platforms help scale private sector investments.

Over the past few years, IFC has prioritized a more holistic, scaling-based approach that aims to increase bankable private sector infrastructure opportunities. Instead of focusing on developing a single asset, this approach creates a pipeline of infrastructure projects. It relies more on platforms to scale up private capital mobilization as they tend to trigger greater standardization and competition in power markets. Platforms deployed by IFC in the power sector include:

> Scaling Solar, which is focused on creating a virtual marketplace for solar energy by standardizing project documentation. It utilizes subsequent rounds of auctions in smaller markets to achieve scale.

> RenovAr, a program aimed at expanding Argentina's electricity capacity through development of a bankable structure and organizing an auction. The program has successfully deployed a comprehensive risk mitigation package.

> Egypt's Feed-in-Tariff (FiT) program, which supports wholesale procurement for renewable energy projects. IFC supported it by consolidating multiple transactions into a streamlined process through standardization of financing and security documentation.

The World Bank complements investments in such platforms by initiatives aimed at minimizing risk in the sector through: regulatory reforms; enhanced planning of capacity additions; facilitating the use of its digital auction platform; building the capacity of public implementing entities; management of legacy contracting modalities; and specific measures to enhance the credit position of the off-taker. Platforms enable countries to spread overhead costs of their engagements and create the scale needed to make investing in power market value chains economically feasible.

DFI collaboration and engagement is growing.

Recently, there has been an uptick in collaboration between development finance institutions in pursuit of the UN Sustainable Development Goal 7 of more affordable, reliable, sustainable energy for all. In April 2024, the World Bank was one of 10 DFIs to announce their joint commitment to work more effectively in concert and at scale on these issues.[82] One focus of efforts will be to help deploy large amounts of private capital through local currency lending and foreign exchange hedging solutions. A digital co-financing portal is also being developed, to be hosted by the World Bank, through which multilateral development banks will share information and better identify opportunities to co-finance.

BOX 4.7

Deploying Risk Mitigation Instruments: Djibouti Ghoubet Wind Project

Djibouti, strategically located at the convergence of the Red Sea and the Gulf of Aden, faces challenges in meeting its electricity needs due to limited natural resources. Less than half its population (42 percent) has access to electricity and the country relies heavily on electricity imports from neighboring Ethiopia and aging fossil fuel generators. Despite abundant wind, sun, and geothermal potential, the country has struggled to attract foreign private investment, with prospective investors often citing lack of electricity as the primary constraint.

In 2020, the Multilateral Investment Guarantee Agency—the World Bank Group's division for insuring against political risks—provided $91.6 million in guarantees to two international investors, Africa Finance Corporation and Climate Investor One. The investors were part of a public-private consortium that developed the groundbreaking 58.9-megawatt Ghoubet wind farm, Djibouti's first independent power producer. Operational since 2023, the project's guarantees cover up to 90 percent of investments and future earnings, guarding against such risks as currency inconvertibility and transfer restrictions, expropriation, breach of contract, and war and civil disturbance. Through this investment, Djibouti transitioned from the Vertically Integrated Utility structure it had operated under since 1960 to a Single Buyer Model. The project is a good example of the prominent role that solar and wind power are playing in transitioning countries away from a vertically integrated power market model.

The farm is expected to generate 237,000 megawatt-hours annually, eight times Djibouti's current electricity consumption. Beyond bolstering energy independence, it will reduce carbon dioxide emissions by approximately 154,500 tons yearly. The project can also spur further foreign private investment, especially in renewable energy projects, including additional wind farms near Djibouti's port, and solar and geothermal projects. These efforts align with the government's Vision 2035 plan to develop the country and underscore the vital role of risk mitigation tools in fostering more sustainable energy.

Some examples of DFI-led partnerships and resources that countries can tap as needed include:

World Bank and African Development Bank partnership on electricity access in Africa: This joint initiative, announced in 2024, aims to provide electricity access to at least 300 million people in Africa by 2030. The World Bank will work to connect 250 million people to electricity through distributed renewable energy systems or the distribution grid, while the African Development Bank Group aims to connect an additional 50 million people. Africa remains the continent with the largest gaps to fill on access.

IFC-MIGA-IRENA partnership on energy transition: Unveiled in 2023, the partnership between IFC, the Multilateral Investment Guarantee Agency and International Renewable Energy Agency (IRENA) set up an Energy Transition Accelerator Financing Platform, or ETAF. IFC has pledged $1 billion to the platform that IRENA is managing. IFC brings its expertise by increasing the flow of private capital to ETAF projects, IRENA leverages its membership to attract project proposals, and MIGA contributes via guarantee and insurance instruments that reduce risk for energy transition projects in emerging markets. ETAF will act as facilitator, coordinator, and knowledge hub, providing technical support, mobilizing resources, and fostering collaboration. It will support feasible projects and mitigate investment risks through innovative financing solutions, matchmaking of project partners, technical assistance, and project facilitation. ETAF's current project pipeline is in Africa, Asia, Latin America, and small island developing states.

World Bank's new consolidated guarantee platform: The World Bank in 2024 launched a consolidated one-stop guarantee platform that brings together all of its guarantee products and experts. The intent is to give its clients more transparency and certainty on the guarantee process and to maximize the limited capital available by streamlining these offerings. The platform focuses on innovation and includes off-grid and mini-grid solutions. The Nuru mini-grid solar project in the Democratic Republic of Congo is a good example of where the platform will focus efforts.

Recommendations

IDENTIFY

Cross-cutting

- Pro-actively identify areas where DFIs such as IFC can help tackle investment bottlenecks.
- Consider seeking DFI support in areas like capacity enhancement and private procurement. Development partners can, for example, help establish missing institutions and plug gaps in complementary infrastructure such as transmission bottlenecks, address network redundancy, and build resilience.
- Identify DFI-led platforms and resources that address their needs, including the recently launched World Bank and African Development Bank partnership on electricity access in Africa and the World Bank's new consolidated one-stop guarantee platform.

Vertically Integrated Utility (VIU)

- VIUs can tap DFI risk mitigation toolkits and financing options such as sustainability-linked loans to address local market constraints such as local banks reaching lending limits to the VIU, a limited capital market, or the non-creditworthiness of a VIU.
- Publicly owned VIUs considering partnering with the private sector can benefit from advisory support from DFIs on which approach or model may work best for them.
- VIUs considering transitioning to other market structures can receive advisory and technical support from DFIs, which draws from global best practice but also considers country context.

Single Buyer Model (SBM)

- Countries with SBM structures that have underdeveloped hedging markets or low liquidity can access DFI blended finance products to minimize risk around projects, both through risk mitigation instruments and subordination.
- In countries that recently transitioned to SBM or where the single buyer does not yet have a good track record, DFIs can help bridge financing gaps through risk mitigation instruments (liquidity support or political risk insurance), early-stage support (including seed money to pilot technologies and approaches), and concessional financing or grants.
- To create bankable private sector infrastructure opportunities, SBM countries can participate in platforms that DFIs create to mobilize private capital at scale, especially for renewables.
- Policymakers can draw on DFI financing or technical support to develop regional power markets.

Wholesale and Retail Competition (WRC)

- Policymakers in countries with a WRC structure can get technical and advisory support from DFIs to repurpose wholesale and retail markets in ways that respond to the overarching sector trends of decentralization, digitalization, and decarbonization. These could include investments or technical support to: develop demand response, for example using smart meters and smart grid investments; create tariff structures that incentivize the participation of prosumers in retail markets; and address supply bottlenecks by scaling up intermittent renewable energy generation and transmission, which can be done through policy support on permitting and licensing procedures and by scaling up investments in networks connecting renewables to the grid.
- Policymakers can benefit from DFI financing or technical support to develop regional power markets.

5

Conclusion and Recommendations

This report has charted how power markets have evolved over the past four decades and presented countries with options for repurposing them to better leverage the private sector to provide more sustainable, reliable, and affordable electricity to all. This chapter distills the key recommendations for policymakers, investors, and development finance institutions.

Policymakers

Policymakers should carefully assess how they can advance in each of the six areas of action—innovate, integrate, institutionalize, incentivize, invest, identify (6Is)—in a way that works best in their country context. They should leverage technological and financial innovations emerging from the private sector, incorporating the range of technologies available while tailoring them to country and sector context. By engaging the private sector, countries can accelerate the uptake of smart grid technologies, renewable energy-based distributed generation and off-grid solutions, battery energy storage, and hybrid solar systems. Mobilizing private capital with financing instruments such as green bonds, sustainability-linked loans, and securitization can bridge the massive investment gap in clean energy infrastructure.

The private sector can help integrate renewable energy and unelectrified communities.

The falling costs of energy storage technologies and rise of solar-plus-storage hybrid systems is enabling greater penetration of intermittent renewables. Distributed renewable energy solutions such as mini-grids and off-grid systems offer a complementary pathway to extending access to electricity to remote, underserved areas and the private sector can play a vital role in scaling up such technologies.

To increase private investment, policymakers may need to modify how their power market structures are designed. Specifically, they should institutionalize more investor-friendly practices that remove the key barriers to private entry—cost, complexity, corruption, and lack of cost recovery (the 4Cs). Stable and transparent regulatory and procurement rules and practices are essential, as is a legal system that enforces contracts on a fair and consistent basis. Developing appropriate procurement and revenue streams that incentivize private investment in renewables and extending access is critical.

The public sector should continue to invest alongside the private sector in critical infrastructure and institutions, especially in transmission infrastructure. This dual investment approach is indispensable to achieving goals on access, security of supply, and integration of renewables generation. Policymakers should also develop regional power markets by making the necessary investments and establishing the appropriate enabling institutions and policies. Public utilities will continue to play a critical role in developing and managing transmission networks and interconnectors. However, with public resources increasingly strained, policymakers should consider some of the strategies presented in Chapter 4 to encourage private investors to invest alongside them.

Policymakers should reflect and identify how Development Finance Institutions (DFIs) can support them in meeting their goals. Countries should take full advantage of DFI toolkits and resources, as presented in Chapter 4, mobilizing private capital at scale to drive impact. While the precise measures countries take will vary depending on their power market structure, policymakers and regulators should continually reassess and repurpose market designs in an open and transparent fashion with appropriate levels of consultation.

Summary recommendations for policymakers, listed by market structure, are presented below (for more detailed recommendations, see Appendix A):

Vertically Integrated Utility (VIU)

> Transitioning out of a VIU structure can improve sector outcomes in certain contexts. Improvements in access rates and power generation capacity have been observed under more competitive power market structures. Policymakers should evaluate whether such a transition would work in their market's specific circumstances.

> Countries planning to transition out of VIU should design a market structure that removes the key barriers to successful private sector entry: cost, complexity, corruption, and lack of cost recovery (4Cs).

> Policymakers operating under VIU should consider renewable energy auctions or other types of transparent competitive bidding for independent power producer contracting. This will attract private sector financing at scale and allow discovery of efficient tariffs, in turn enabling bankable projects.

In certain country contexts, for example small island states or fragile countries, there may be intrinsic inhibitors to moving away from the VIU model at this stage. In these cases, policymakers can consider other forms of engagement with the private sector such as putting the VIU under private management or incentivizing private sector solutions in the off-grid segment (for example, mini-grids).

Single Buyer Model (SBM)

SBM has generally been a successful structure for increasing electricity access. However, historically, improvements on access came at an environmental cost. Each additional year in the SBM structure was associated with a 3.92 metric ton per capita increase in carbon dioxide emissions. This downside occurred mainly because until recently renewable energy generation (especially solar and wind) was not cost effective for most countries. As a result, most countries that transitioned from VIU to SBM mainly relied on thermal generators.

This is changing as solar and wind generation costs have significantly declined. In countries with SBM, policymakers should utilize competitive auction mechanisms and a range of market-driven procurement modalities including corporate power purchase agreements to scale up renewable capacity cost effectively.

Countries should avoid locking power systems into a high carbon pathway through rigid long-term power purchase agreements with thermal generators.

Countries using SBM should scale up blended solar and storage power purchase agreements to ensure more continuous supply of electricity from intermittent renewable sources and enable round-the-clock availability of electricity.

Wholesale and Retail Competition (WRC)

The WRC structure is observed to be the most conducive to expanding renewable energy and overall electricity supply. Each additional year in WRC is associated with a 3.27 percent increase in total installed capacity of electricity. This underscores the potential of competitive electricity markets to attract investment, increase efficiency, and boost generation capacity.

In designing WRC structures, policymakers should respond to the three overarching trends: decentralization, digitalization, and decarbonization. Doing so will help them meet UN Sustainable Development Goal 7—affordable, reliable, sustainable energy for all.

To address the revenue challenges that adding more renewables into systems poses, policymakers can consider the following: implementing clean energy standards that provide guaranteed renewable energy offtake; designing new capacity market products that better compensate renewable capacity attributes; evolving ancillary services markets to introduce products suited to renewables' capabilities; and implementing locational marginal pricing to better reflect the value of congestion relief from strategically sited renewables.

Policymakers should create appropriate revenue streams to commercialize evolving technologies such as variable renewable energy and battery energy storage systems. In countries with organized wholesale markets, markets for ancillary services can be created. Adoption of time-of-use and net metering policies can create opportunities for participation in battery energy storage systems.

In countries with wholesale and retail markets, policymakers can accelerate the transition from feed-in-tariff structures to more market-based instruments especially for utility-scale solar and onshore wind where the technologies are now cost competitive.

Investors

Effective partnerships between policymakers and private investors are essential to realizing Sustainable Development Goal 7, especially given the growing scarcity of public financing. Private investors should engage more with developing country governments and clearly communicate what they need to enter new markets. Such engagement will provide policymakers with the market insights they need to plan and may prompt them to remove entry barriers and alleviate sector risks. Investors should also actively engage with DFIs to identify areas of potential support.

Investors should deploy their know-how, capital, and experience in developing countries to integrate unelectrified communities and variable renewable energy sources. Business models and technologies need to be adapted to developing country contexts. They should consider non-traditional sources of financing and risk mitigation tools to make renewable energy projects more bankable and affordable. These include sustainability-linked financing instruments such as green bonds, green loans, corporate bonds, asset-backed securities, and venture capital. In countries with deep capital markets and the where potential risks are manageable, project sponsors can tap insurance markets for total or partial coverage. Investors can utilize corporate power purchase agreements to diversify their revenue streams and hedge off-taker risks. Investors can also participate in futures power markets and utilize other derivatives to manage or hedge price risks in countries with organized wholesale market structures.

Development Finance Institutions

The many financial instruments and risk mitigation tools that DFIs have created should be scaled up. DFIs should deploy their cumulative resources, financial and credit enhancement tools to help developing countries at both national and regional level to crowd in investment in clean energy technologies. When tapping these resources, they should require proof-of-concept, especially for new technologies and business models in new markets.

DFIs need to identify how they can best support policymakers in scaling up private sector investment. They should create their own pipeline of scalable, bankable private sector infrastructure projects, making full use of multi-participant platforms. They can also help reduce risk on investments by assisting and advising on regulatory reforms, planning capacity additions, digital auctions, bolstering the capacity of public implementing entities, managing legacy contracting modalities, and enhancing off-takers' creditworthiness.

Appendices

Appendix A

Consolidated 6I Recommendation Cards for Repurposing Each Market Structure

Cross-Cutting

Innovate

- Leverage innovative financing tools (green bonds, sustainability-linked loans) that align financial incentives with sustainability objectives to scale up greater private sector investment for clean energy projects.
- Diversify the pool of financiers through venture capital, institutional investors, capital markets, and securitization, to expand the funding available for clean energy projects.
- Deploy innovative financing methods (e.g., outcomes-based finance) to improve affordability.
- Countries with growing intermittent renewable energy, need to scale up smart grid technologies to allow their electricity systems to run more efficiently, reducing the need for spinning or backup generators to handle demand fluctuations.
- Carefully consider the shifting role of traditional baseload generators (such as coal and gas power plants) in future power systems to align with decarbonization ambitions. The intermittent nature of renewable energy poses grid integration challenges that underscore the continued near-term need for flexible baseload assets to balance fluctuations and meet peak demand.
- New investments in non-renewable energy (especially thermal-fired power plants) baseload generation should be reviewed as part of a country's holistic least-cost power model to ensure these projects are economically viable under scenarios with rising renewables generation and prevent over-investment that could lead to stranded assets.

Cross-Cutting

Integrate	▶ Leverage the private sector to scale up energy storage technologies and hybrid renewable energy systems to provide stable, reliable, and cost-effective clean energy. ▶ Utilize private sector solutions for integrating unelectrified communities both through centralized grids as well as renewable energy-based distributed generation and off-grid solutions. ▶ For the hardest-to-reach populations, renewable energy-based mini-grids and micro-grids can be scaled up. The private sector can play a vital role in scaling up these technologies, acting as a supplement to public investment to accelerate access and sustainability. ▶ There are many countries where mini-grids are more cost effective than grid extensions but are still unaffordable for poor people. Countries can seek support from development finance institutions (DFIs) for upfront investment capital to improve the affordability of these options. Financial innovation can also support affordability—for example, through the adoption of flexible payment options. National rural energy agencies can consider including mini-grids in their existing subsidy programs. For example, Tanzania adjusted its incentive program for rural electrification to accommodate mini-grids by providing a per-connection subsidy for mini-grids.
Institutionalize	▶ Stable and transparent regulatory and procurement practices are needed that set out the rules of the market to address cost, complexity, and corruption barriers in the sector, complemented by a legal system that enforces contracts on a fair and consistent basis. The more predictable government regulations and policies are, the lower the risks for investors. ▶ Implement programs to centralize permits and approvals, such as in 'one-stop shops' for energy project development to streamline permitting and licensing procedures. ▶ Strengthen the sector regulator's technical capacity and independence. Regulatory capacity is crucial to building well-functioning power markets, and greater independence in tariff design and implementation and enforcement of market rules by national regulatory agencies is essential. ▶ Create a regulatory framework that incentivizes operational efficiency while also ensuring utilities' financial health. Utilities with strong financials can invest in system improvement and borrow capital from private investors at lower interest rates, reducing debt service costs to ratepayers. ▶ Ensure the longer-term financial sustainability of the off-taker(s) through: tariff reforms to ensure prices reflect the full cost of energy services; setting achievable and enforceable key performance indicators for distribution companies to improve service quality; and implementing least-cost and efficient planning of capacity additions. ▶ To balance affordability concerns with cost-recovery tariffs, countries can explore options to reduce service delivery costs—for example, through cost-effective generation procurement, system planning to avoid wastage and oversupply, and managing non-technical losses through pre-paid metering.

Cross-Cutting

Incentivize

- Policymakers need to provide appropriate incentives, including creating targeted procurement and revenue streams to incentivize private sector investment, especially for renewable energy.
- Policymakers need to optimize compensation models for distributed and utility-scale renewables to accelerate private sector investments.
- Investors benefit from the 'visibility' of sub-national, national, and cross-country programs, including announced procurement programs of new generation capacity (especially for renewable energy) with enforceable targets, including auction dates, portfolio standards (obligations on distribution companies to buy an increasing share of renewables over time), and supporting regulatory reforms to lower off-take payment risks.
- Governments can deploy a range of risk mitigation tools to lower perceived risks and associated costs for the private sector.

Invest

- The public sector should invest alongside the private sector in existing (often aging) grid infrastructure to accommodate increasing demand, manage intermittency resulting from expanding variable renewable energy generation sources, and enhance the resilience of transmission lines to climate change.
- Policymakers can pursue several types of business models to engage the private sector in transmission, including through concession agreements, build-own-operate-transfer, financial ownership and merchant options.
- Policymakers should prioritize the development of requisite investments as well as institutions and policies to enable regional power markets. Cross-border (both inter- and intra-country) power system integration requires several elements to function and to effectively manage the risks associated with integration. The main elements include: investment in enabling infrastructure (e.g., interconnectors, grid components, grid synchronization); development of appropriate institutions and harmonized policies that co-ordinate system operation across borders; and acquiring a set of tools to mitigate risks that arise from integration such as utilizing capacity auctions to better control grid congestion.
- Robust planning and project assessment need to be undertaken to ensure these assets are economically viable. A detailed cost-benefit analysis is needed to assess the project and to split the costs between the participating countries. Costs can be allocated according to the 'beneficiary pays' principle, where the costs are distributed in proportion to each participant's expected benefits. Alternatively, costs can be allocated along lines that are based more on political agreement than economic efficiency. The existence of a central body to support cost allocation negotiations can enhance the chances of the development of the necessary infrastructure.

Identify

- Policymakers should identify areas where DFIs such as IFC can play a role in helping to unlock investment bottlenecks.
- Countries that have strained capacity in sector management and private procurement can consider seeking support from DFIs. Development partners can support efforts to establish missing institutions and plug gaps in complementary infrastructure such as transmission bottlenecks as well as network redundancy and resilience.
- Policymakers can utilize DFI partnerships to mobilize DFI resources that are relevant to their needs, including the recently launched World Bank and African Development Bank partnership on electricity access in Africa and the World Bank's new consolidated one-stop guarantee platform.

	Vertically Integrated Utility (VIU)
Innovate	▶ By issuing debt securities such as corporate bonds or asset-backed securities, VIUs can access more financing than is available from commercial banks and potentially with better financing terms. ▶ Institutional investors such as pension funds, sovereign wealth funds, and insurance companies can be good sources for refinancing brownfield renewable energy assets of VIUs. ▶ By integrating bi-directional smart meters, VIUs can enable distributed renewable energy generation such as residential rooftop solar to sell their unused, locally generated power back to the grid and prepare for their transition to a more competitive market structure if desired in the future. ▶ VIUs or private sector off-grid operators can benefit from innovative approaches to off-grid energy financing including peer-to-peer lending and results-based financing.
Integrate	▶ Countries with VIUs need to provide a supportive regulatory environment that ensures energy storage developers can align their plans with national energy goals and targets including renewable energy and storage mandates (Table 3.1). ▶ VIUs facing access and reliability issues can scale up renewable energy-based distributed generation and off-grid solutions. ▶ For the hardest-to-reach populations through grid-based access extensions or where grid extension is prohibitively costly, VIUs can utilize renewable energy-based mini-grids and micro-grids. ▶ Countries with VIUs that have access deficiencies can consider allowing the private sector to enter off-grid space to provide services to hard-to-reach rural communities. To enable private sector entry into rural power service delivery, policymakers should: develop an appropriate tariff framework; define key performance indicators and an incentive framework; and define the appropriate investment framework.
Institutionalize	▶ The role of regulators is very important in countries with VIUs as there is no competitive pressure on the VIU from other players. Strong regulators are critical to monitor the VIU and ensure it delivers value for money. ▶ Countries that want to retain the VIU structure but are considering privatizing their VIU should select the private party through an open and transparent process. They can also consider public listings of state utilities. ▶ Countries that are considering transitioning out of the VIU structure should plan to design a market structure that effectively addresses key barriers to successful private sector entry including addressing the four main constraints—cost, complexity, corruption, and lack of cost recovery (4Cs). ▶ The corporatization of state-owned VIUs can be helpful as a step toward setting up a market structure with private sector participation. Some highly advanced power markets were launched on the back of corporatization. For example, Singapore's corporatization of its VIU in 1995 helped the sector to gradually transition into one of the world's most liberal electricity markets.

Vertically Integrated Utility (VIU)

Incentivize	▸ Policymakers through regulatory incentives can incentivize the publicly or privately owned VIUs to accommodate residential solar photovoltaic investments driven by net-metering schemes. Countries that are concerned with the potential negative impact of prosumers (producer-consumers) on VIU revenues can explore decoupling utility revenues from sales, introducing fixed charges as a part of the final tariff, introducing prosumer charges on generated energy, or providing monetary incentives to the utility for expanding distributed renewable energy generation. ▸ Countries that want to maintain a VIU structure can consider allowing and incentivizing private sector investments in off-grid including renewable energy-based mini-grids. ▸ Policymakers can consider allowing corporate power purchase agreements between renewable energy generators and corporate buyers, to exist alongside the VIU. ▸ Countries that are considering transitioning out of the VIU structure should take necessary steps to incentivize private sector entry. These could include: legal or ownership unbundling of the VIU; designing power purchase agreements that consider risks of private sector entry into an untested market; and exploring risk hedging instruments to mitigate risks to private investors. These could include partial risk mitigation guarantees from DFIs.
Invest	▸ VIUs can consider allowing private sector investment to build new transmission capacity or to rehabilitate existing transmission assets of the VIU through a range of options that entail different degrees of investment management by the VIU. ▸ VIUs considering transitioning to another market structure can consider unbundling transmission from the VIU to create an independent transmission operator or an independent system operator with a separate balance sheet. ▸ When feasible, improving cross-border trade can be a powerful tool to mobilize financing while alleviating access and reliability challenges for VIUs. Regional trade, whether bilateral or through regional wholesale markets, present opportunities to strengthen system governance and leverage economies of scale.
Identify	▸ VIUs can tap DFIs' risk mitigation toolkit and array of financing options such as sustainability-linked loans to help address any local market constraints (for example, local banks at their limit to lending to a VIU, limited capital markets, a non-creditworthy VIU) to raise the requisite investments for advancing access and sustainability objectives. ▸ Publicly owned VIUs that are considering private sector partnership—for example through introducing a strategic private partner, privatization, or public listing—could benefit from advisory support from DFIs. ▸ VIUs that are contemplating transitioning to other market structures can consider accessing advisory and technical support and guidance provided by DFIs, which draws on global best practice and is tailored to country context.

Single Buyer Model (SBM)

Innovate

- System operators in SBM markets can use the wealth of data collected by smart meters to improve the management of the electricity system, which affects decisions on energy procurement, operation control, and risk management.
- SBM structures that are integrating renewable energy-focused independent power producers (IPPs) need to consider the role of flexible generation assets like energy efficient combined cycle gas turbines that can offer rapid load-following capabilities to offset sudden wind and solar output variability, particularly in countries that still rely on coal.

Integrate

- Storage technologies provide valuable ancillary services such as spinning reserve (supply that is ready to generate but not currently in use) and voltage support. Countries operating under SBM structures need to ensure energy storage developers are appropriately compensated for their services, benefit from clear and transparent procurement processes, and legally integrate with other energy assets.
- To procure hybrid systems, countries with SBM can utilize competitive auctions tailored to the business model, with selection criteria based on least-cost capacity or energy bids over the contract duration. Contract structures must align incentives between producers and buyers.
- Standalone renewable energy-based systems should emanate from a government-supported off-grid strategy that incorporates local characteristics, innovative financing structures, and incentives for solar home system providers (such as tax, VAT, and import duty waivers).

Institutionalize

- To attract IPPs, countries with SBM structures should avoid erratic and non-transparent decision making to reduce investors' perceived regulatory risk and contribute to keeping the cost of capital low.
- Competitive procurement should be prioritized. Countries under SBM should resist direct negotiations and unsolicited bidding which can keep experienced qualified investors out of the market. The public contracting authority should assess projects and make awards based on honest contracting practices.
- Strengthening the creditworthiness of the single buyer is vital to attract private sector investment.

Incentivize

- Well-structured Power Purchase Agreements (PPAs) that appropriately consider contractual risks are essential to attract IPPs and policymakers should thus enhance their bankability (Box 4.2).
- Targeted use of government guarantees on PPAs in the absence of a creditworthy and experienced single buyer is necessary to ensure long-term commercial sustainability of the sector.
- Competitive bidding for IPP contracts can reduce generation costs compared to bilateral negotiations and a selected generation company or unsolicited proposals.
- Policymakers can consider allowing corporate PPAs—for example between renewable energy generators and corporate buyers—to exist alongside the single buyer structure.

Single Buyer Model (SBM)

Invest	▶ Countries with SBM structures can institute a range of methods to attract private investment in transmission infrastructure (Table 4.2). ▶ By participating in regional power pools, countries can enhance power trade to advance energy transition and improve energy security. Conducting least-cost power system planning optimized at the regional level is critical to ensure the appropriate design and development of the power pool. Policymakers should also ensure utility readiness to trade via the power pool, including processes, systems, and personnel requirements to establish trading units in the trading entity (this can be the single buyer). ▶ The financial weakness and operational inefficiency of the single buyer in cross-border trade can be a key inhibitor for development of regional trade. It will be extremely challenging for single buyers in precarious financial situations to raise the necessary debt financing. Lenders may require sovereign guarantees to provide financing. DFIs and donor grants can also be used to support financing. ▶ Consider allowing open third-party access to cross-border infrastructure. Barriers to access cross-border infrastructure by wider sector participants such as IPPs can significantly lower the economic viability of the infrastructure.
Identify	▶ Countries with SBM structures that have underdeveloped hedging markets or low liquidity can consider accessing development finance institution's blended finance products to minimize risk around projects, both through risk mitigation instruments and subordination. ▶ In countries that recently transitioned to SBM or where the single buyer does not yet have a good track record, development finance institutions can help bridge the gap with risk mitigation instruments (liquidity support or political risk insurance), early-stage support (including seed money for pilot technologies and approaches), and concessional financing or grants. ▶ To create bankable private sector infrastructure opportunities, countries can benefit from development finance institution-managed platforms that aim to mobilize private capital at scale, especially for renewables. ▶ Policymakers can also benefit from development finance institution financing or technical support to develop regional power markets such as power pools.

Wholesale and Retail Competition (WRC)

Innovate

- There is a growing need to scale up financing in networks to enable renewable energy integration as well as incentivize participation of demand response in the market.
- Smart grid technologies are essential to scale up localized retail power markets, enabling prosumers to participate in the market and expanding localized power retail markets.
- Flexible baseload generators such as hydropower and efficient combined cycle gas turbine plants have a role to play as backup energy supply to balance out intermittent renewable energy to maintain grid stability. Baseload power generation will be exposed to far greater volatility in seasonal, daily, and intraday load—while the importance of reliability will increase. This may require further mechanisms, such as capacity markets to pay for backup power sources that can quickly start up to supply electricity when demand is high or when renewable sources are not generating enough power.

Integrate

- The creation of an ancillary services market (which includes services like frequency regulation and spinning reserve to support grid stability) alongside a competitive wholesale market can be instrumental in scaling up batteries. Batteries can participate in this market segment to provide frequency regulation and spinning reserve, creating another revenue stream.
- Time-of-use and net metering policies can incentivize utilities and consumers to optimize their energy usage and integrate renewable energy, creating opportunities for participation in battery energy storage systems.
- Utility-scale hybrid storage projects are growing in countries with organized wholesale/retail markets. However, market and system operators are facing challenges in finding efficient and reliable ways to integrate and operate these technologies. Hybrid generators need to be effectively represented in the software and models used to manage market transactions and schedule electricity generation.
- Behind-the-meter policies, which include regulations that encourage energy generation and storage at the consumer's premises such as rooftop solar panels or home batteries, can incentivize the scaling up of renewable energy-based distributed generation under organized retail market structures. Distributed generators can be integrated into the wholesale and retail markets by allowing the establishment of localized retail markets through peer-to-peer trading.

Wholesale and Retail Competition (WRC)

Institutionalize

- Regulators in WRC markets have the complex responsibility of monitoring all wholesale and retail players to ensure effective and fair competition with the objective of delivering the best outcomes for consumers. Regulators should pay close attention to market shares, concentration ratios, customer switching rates, and price-cost margins.
- Continuous improvement in regulatory capacity is critical, especially to adapt to evolutions in the market caused by technological innovations such as distributed generation-enabling localized retail power markets.
- In countries with partial retail competition, regulated tariffs should be designed to ensure that utilities are able to recover costs with a reasonable rate of return, maintain the technical health of the electricity system, retain and expand necessary staff, and expand infrastructure to meet growing and unmet demand.
- In countries with full retail competition, the regulator should closely monitor the retail market to: ensure costs are efficiently and fairly distributed; prevent undue price discrimination; and reduce consumer welfare risks (for example, energy poverty).

Incentivize

- Countries should expand market-driven procurement of solar and wind generation. These include modalities such as corporate power purchase agreements between renewable producers and corporate customers, merchant projects where the generators sell on the wholesale spot market, and remuneration through certificate programs.
- Countries where variable renewable energy sources are unable to fully recover their costs through the wholesale market may require supplementary revenue solutions and risk mitigation to attract adequate investment.
- Policymakers can explore several tracks to address these including: implementing clean energy standards to provide guaranteed renewable energy offtake; designing new capacity market products that better compensate renewable capacity attributes; evolving ancillary services markets to introduce products suited to renewable capabilities; and implementing locational marginal pricing (a pricing method that reflects the cost of delivering electricity to a specific location, accounting for factors like congestion and losses on the grid) to accurately reflect the value of reducing congestion on the grid by strategically placing renewable energy sources in areas where they are most needed.
- Enabling aggregated portfolios of distributed batteries and solar to act as virtual power plants can unlock savings from reduced grid investment needs.
- A stable regulatory environment, with cost-reflective tariff structures and non-discriminatory third-party access, can alleviate merchant risks to renewable generators.

Invest

- Policymakers can consider a range of options to mobilize private investment in transmission and interconnectors, including merchant options (Table 4.2).
- Ensuring efficient and equitable allocation of cross-border capacity is critical to enabling cross-border power trade. Developing harmonized allocation rules or market tools supports coordinated capacity calculation and allocation mechanisms. Policymakers can explore market-based models to allocate interconnector capacity, for example through explicit or implicit auctions.

Wholesale and Retail Competition (WRC)

Identify

- Policymakers can seek technical and advisory support from development finance institutions to repurpose their wholesale and retail markets to meet the challenges posed by decentralization, digitalization, and decarbonization (3Ds). These could include investments or technical support to: develop demand response (for example, smart meters and smart grid investments); advance tariff structures that incentivize the participation of prosumers in the retail market; clear bottlenecks to scale up intermittent renewable energy generation (for example, through streamlining permitting and licensing procedures for both renewable energy and transmission, and scaling up investments in networks to connect renewables to the grid).
- Policymakers can benefit from development finance institution financing or technical support to develop regional power markets.

Appendix B

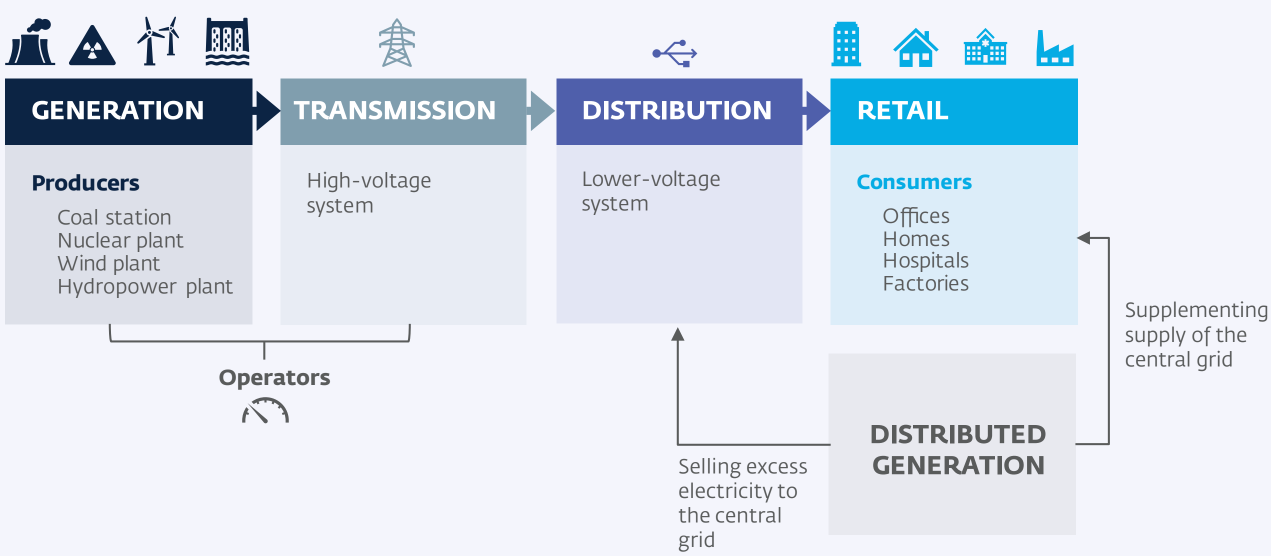
A Primer on Electricity Systems

Electricity (as a "product") has several unique characteristics: it cannot be stored in large quantities at a reasonable cost, while supply and demand need to be in balance at all times. These features have a strong bearing on how markets are structured. This section describes the structure and functioning of power markets, from the beginning of the value chain (power generation) to its end (retail).

The electricity industry is composed of four key parts: generation, transmission, distribution, and retail supply. The first stage of the process, generation, involves the production of electricity in power plants. The transmission of electricity is its transportation, in bulk, from power stations along a high-voltage system known as "the grid". Distribution network is a lower-voltage system used for local delivery of electricity to the point

FIGURE B.1

Structure of a Centralized Power System

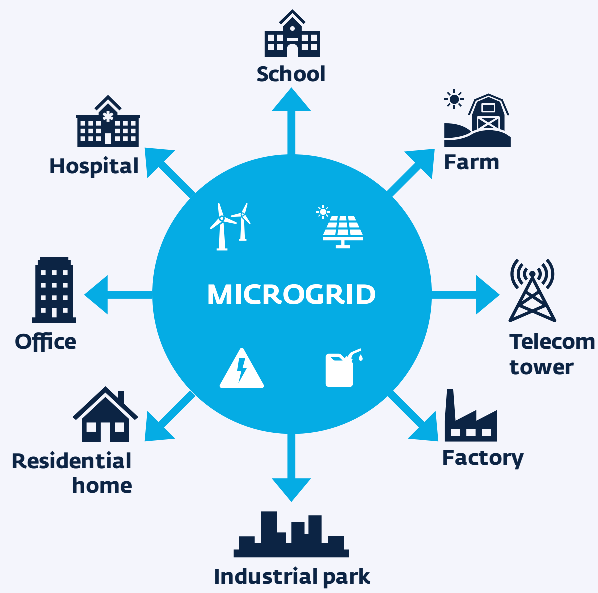


Source: IFC

of demand. The last stage of the process, retail supply, involves the sale of electricity to the final industrial or residential consumers. Figure B.1 provides an overview of the structure of an electricity system and how energy flows through these four parts.

FIGURE B.2

Structure of a Decentralized (Off-Grid) Power System



Source: IFC

Figure B.1 depicts a traditional, centralized structure for the electricity system where generation is located in areas of best resource availability often far from consumers. The electricity generated is then carried through the transmission and distribution networks across the country to consumer load centers. Each component is designed to meet a specific purpose and must work in concert with other components for this integrated system to function. An alternative to this structure is made possible by distributed generation (DG) technologies centered on small-scale generation units built near consumers (Figure B.2). DG technologies include renewable energy such as solar, wind, and small hydro, as well as fossil-fuel-fired (e.g., diesel) electricity generation units. Groups of customers may also establish a localized “mini-grid” to share electricity generated from these distributed generation sources.

Over the last decade, several DG networks have been set up across the globe as the costs of the relevant technologies have been falling. DG can be interconnected to the central grid and used to supplement its supply. This is particularly helpful to commercial and industrial consumers in need of reliable supply, and also where the use of renewables is expanding. In relatively developed markets, consumers with DG assets can also sell their excess electricity to the grid, becoming prosumers. DG can even allow consumers to completely bypass the central grid. This is particularly relevant in a number of developing countries whose central grid does not cover the entire country. Some developing economies have opted for semiautonomous mini-grids to serve rural customers who would otherwise lack access to electricity rather than expand the central grid to serve them.

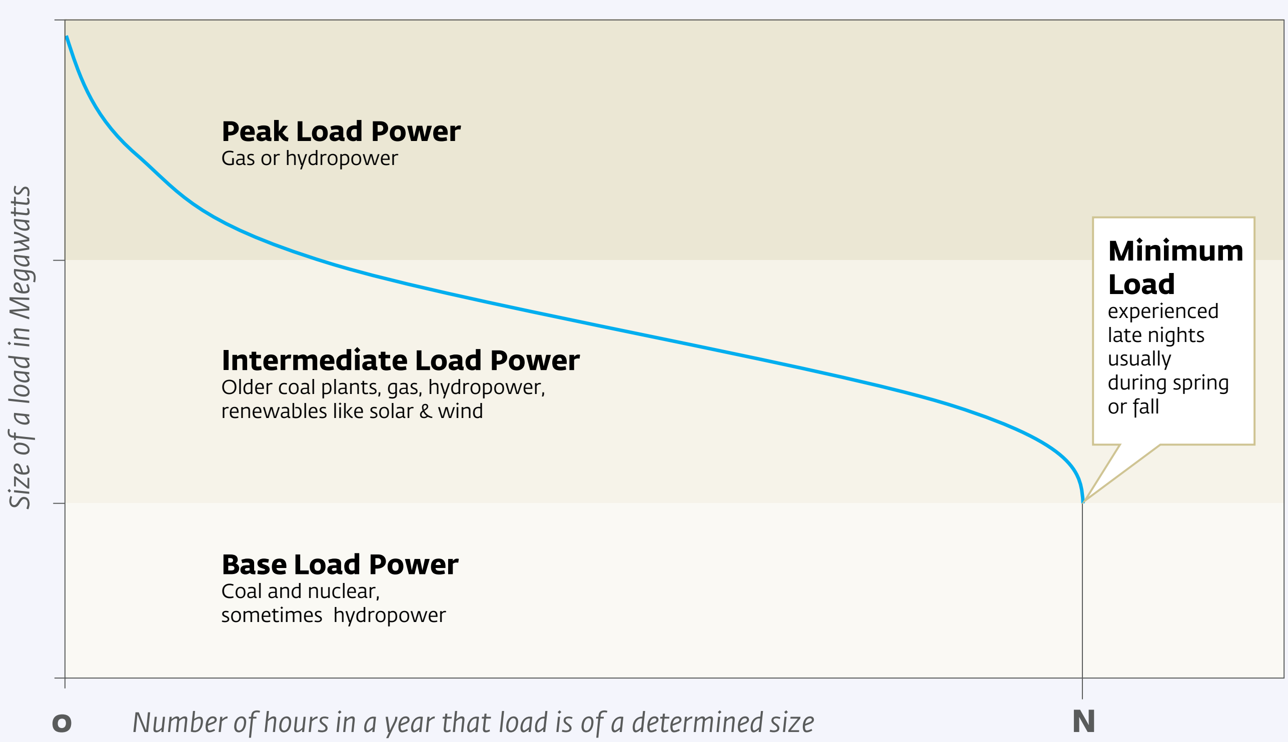
Electricity generation

Electricity is a secondary form of energy that is obtained from primary energy sources. Although electricity is a homogenous product (each electron of electricity is the same), there is significant heterogeneity in terms of the primary energy source, technology, size, unit cost of production, and flexibility (whether and how fast the generator can be dispatched at the request of the grid operator).

Electricity demand (the so-called load) varies significantly over the course of a day, week, and year. The load can be split into three categories: base, intermediate, and peak (Figure B.3). Base load is the minimum amount of electricity demanded in aggregate by users connected to the grid/system. It is met by power plants that run throughout the day and year to supply this demand. Hydropower, nuclear, and thermal plants are typically used to supply base load energy due to their relatively lower operating

FIGURE B.3

Load Duration Curve



Source: Adapted from (Morgan, Apt, and Lave 2005) costs, high-capacity factor (i.e., ratio of actual production to theoretical maximum capacity), and difficulty varying their supply according to demand (either because they are unable to or because doing so is exorbitantly expensive).

Intermediate load is the predictable daily range of energy demand, from the lowest level (e.g., middle of the night) to the highest level (e.g., midday). It can be met by a variety of power plants including those that rely on renewables, gas, or thermal energy.

Peak load refers to the relatively small period of time when the system faces the highest power requirements. Sufficient generation capacity must be available in the system (or from imported energy imported) to meet this demand, or service disruptions will occur. For example, some electricity systems have gas-powered generation units (most often gas turbines) that may be idle during most of the year but have the capacity to quickly switch on and supply energy during times of peak demand.

Many power plants do not operate at their full capacity all the time. Large hydropower, nuclear, and thermal generation plants typically have high-capacity factors and, as was noted earlier, are used to meet base load demand. On the other hand, intermittent generators such as wind and solar plants, whose production relies on weather conditions, have low-capacity factors. The age of the unit, maintenance routine, fuel quality, and technical specifications also affect a generator's capacity factor.

Choosing the best option for a given context depends on the generation unit's cost efficiency, which is best reflected by the levelized cost of electricity (LCOE). LCOE is the cost of building and operating a generating plant during its useful life, expressed per unit of electricity generated. LCOE calculations consider the capital and financial costs incurred in building the plant, fuel costs for generation, operation and maintenance, as well as the capacity factor. LCOE profiles depend on the character of the energy resource. For example, renewable energy technologies do not have any fuel costs as they rely on natural energy. These have relatively low operation and maintenance costs compared to the capital cost of the technology, and typically low-capacity factors. In contrast, conventional energy generators have significant fuel costs, but also benefit from higher-capacity factors.

Investment in technology can be merited to ensure a system's flexibility. For example, gas-fired combined-cycle gas turbines can be turned on quickly to secure electricity supply in the event of unplanned disruptions. Environmental considerations also increasingly play a role in the choice of technology as countries seek to lower the energy sector's greenhouse gas footprint. Energy security may also push countries to strategically develop more expensive sources of electricity that are available locally, for example, geothermal or renewable, or to diversify import routes with potentially more expensive fuel supply sources.

Structure of electricity networks: transmission and distribution

A grid is the system of underground and overhead electricity lines and associated infrastructure used to deliver electricity from generators to end consumers. It is split into transmission and distribution networks. The transmission network is composed of the high-voltage lines used to carry electricity over long distances to distribution networks or large industrial consumers. The distribution network consists of lower-voltage (medium and low voltage) lines used to transport electricity to the end consumer (households and small commercial consumers). Most countries have a designated system operator, often within the transmission company, that oversees the scheduling and dispatch of electricity supply to ensure the system is always balanced in order to maintain system stability. Scheduling and dispatch need to be carefully coordinated to prevent overloading transmission lines, which can cause congestion and result in system failure and widespread blackouts.

Technical and nontechnical losses

Transporting electricity implies some level of technical loss of energy as power flows through equipment such as underground cables, overhead lines, and transformers. This is both a reflection of the physical qualities of energy (the flow of energy via electrical currents loses energy in the form of heat and noise), and a function of the technical characteristics of the electricity system, especially the age of the network, and distance from the load. The regulator that sets (or approves) network tariff components and incentives can put pressure on network companies to reduce technical losses (the requirements can be stricter on high-voltage transmission compared to distribution networks). Nontechnical losses may also result from poor billing, nonpayment, and pilferage. Overall, high losses can jeopardize the quality of service, as they contribute to the sector's failure to recover costs.

Metering

Electric meters are a key element of an electricity system since they make it possible to account for electricity consumption. Electric meters have varying levels of sophistication and

FIGURE B.4

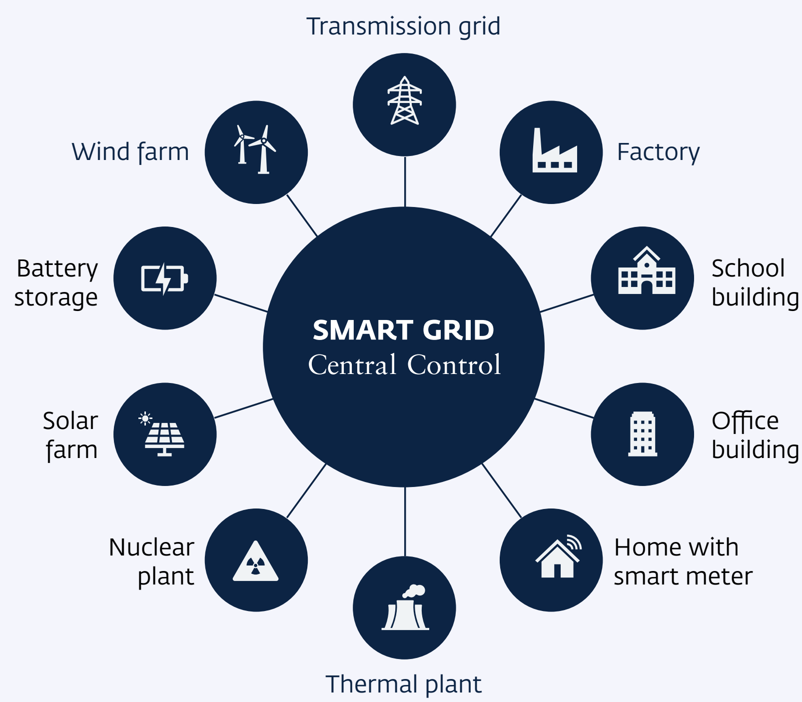
Analog Versus Smart Meter

Source: Photos via Shutterstock

technical abilities, ranging from analog meters that provide data on cumulative electricity usage and need to be read manually, to advanced smart meters that allow for bidirectional interaction between the electricity consumer and distributors/suppliers, and provide for more accurate remote reading (Figure B.4). Smart meters are thus an enabling component of demand response (facilitating demand adjustments based on price signals or instruction/regulation of the system operator, supplier, or aggregator), an important functionality in managing peak-hour loads and a grid's vulnerability to failure. The wealth of data collected by smart meters is also used by system operators to better manage the electricity system, shaping decisions on energy procurement, operation control, and risk management.

FIGURE B.5

Smart Grid Components



Source: IFC

Smart grids

Smart grids integrate advanced communication and control technology (including smart meters) into the grid infrastructure to more efficiently manage the electricity system and offer consumers more transparency and choice in their consumption (Figure B.5). A smart grid allows an electricity system to run more efficiently, reducing the need for spinning or backup generators to handle unanticipated fluctuations in demand. In addition, it promotes the integration of localized distributed power generation due to its ability to measure power in both directions. This allows small, distributed generators to sell their unused, locally generated power back to the grid/system.

Electricity retailing

Retail, the last step in the process, entails the activities of selling electricity to end consumers and collecting payment. It is the last stage in the

BOX A

Creating Tailored Markets to Procure Specific Electricity Services

Electricity markets require the procurement of specialized services to ensure system operability. They include:

Balancing services

A core issue in electricity market design is the necessity of real-time management of electricity flows to prevent any supply-demand imbalances, which could lead to system failures and blackouts. Currently, there is no practical way by which decentralized contracting among market participants can achieve the desired outcome—where demand matches supply to the second—while meeting the physical constraints of the transmission system. Thus, there is a need for a system operator that oversees the scheduling and dispatch of the electricity supply to ensure the system is always balanced and stable. This operator oversees what is known as the balancing market.

Settlement services

A settlement market is one where deviations between electricity forward contracts that market participants may have concluded before dispatch (for example, contracts concluded a day ahead of dispatch) and the actual physical volumes that were bought and sold at the time of dispatch are financially settled.

Ancillary services

A market for ancillary services provides tools needed by the system operator to maintain grid reliability and stability of power supply. These services address immediate imbalances between supply and demand and ensure system recovery from a damaging event such as unexpected power plant failure. Types of ancillary services include "black-start regulation" (where in the event of widespread grid failure, capacity can be procured from designated power plants that can produce electricity from a completely unenergized state without the need for external power from the grid); "contingency" reserves (capacity procured from standby generators for frequency and voltage control to balance the system); and "synchronization" services required to prevent system collapse (for example, system elements that can offset sudden surges in demand).

Capacity services

A market for capacity services enables system operators to secure power supply from generators in order to meet predicted energy demand several years in the future. Capacity services ensure long-term grid reliability by procuring the appropriate amount of power supply resources needed well ahead of time to enable good system planning. This market does not procure physical electricity supply but rather procures from generators the ability to produce electricity when called upon in the future. Payments for capacity services usually cover some or all of the fixed costs of building and operating the procured capacity resources.

physical flow of electricity but the first in terms of finance. Retailing is often undertaken by a distribution company, but in some countries it has been unbundled from distribution and is a separate function undertaken by independent retail supply companies. In some countries, a level of competition has been introduced whereby consumers can choose their electricity supplier from a number of available supply companies (Chapter 2). Consumers can switch suppliers periodically based on the range of tariffs on offer (e.g., fixed tariff, real-time tariff, time-of-use tariff, green tariff) as well as other services that retailers may offer including energy efficiency services, energy advice, or combining electricity with natural gas sales.

Market structures in electricity systems

Creating electricity markets requires combining centralized governance systems with scope for competition and choice where possible. It is not an exercise in laissez-faire. Instead, markets are designed in a regulatory process with a strong planning component. They feature a combination of government interventions and market processes. Numerous variations of this combination exist in global electricity markets, reflecting both technical and non-technical considerations in the market creation process.

Beyond delivering core infrastructure (such as power plants and networks), market mechanisms can be used to procure specific services essential for power system operation. Such services are often of a "public good" nature, in the sense that market participants cannot be excluded from deriving value from them. They include balancing, settlement, capacity, and ancillary services (Box A). Market design context shapes how different power systems procure and pay for services. For example, power markets that are vertically integrated utilities use administrative tools such as contracts and internal acquisitions to procure the suite of services required to ensure the balance between supply and demand and maintain grid stability. In contrast, in partially or fully competitive power systems, a range of actors (including power plants, electricity traders, and aggregators) that meet the technical requirements to provide these services can participate in competitive service markets. Services could also be funded through levies on system users.

At the heart of electricity systems are sophisticated, computerized optimization models that may require thousands of servers to run. In competitive markets, bids by generators in the wholesale market provide the input values for these models. The output is a system of prices that optimizes dispatch, where the cheapest generators are dispatched. This type of market, assisted by an optimization program, is often called a smart market.

The electricity industry is also carefully regulated. Regulation ensures the availability of network systems and compliance with adequate frequency and voltage levels. It also mitigates the abuse of market power, especially in monopoly segments of the market (such as networks), and ensures that service parameters (such as access and continuity of service) are respected. In monopoly segments of the market, revenues are also regulated—often through price regulation that is sometimes supported by subsidies. In setting rates, regulators aim to strike a balance between providing incentives for efficiency and ensuring investment and quality of service are adequate.

Having key players, market infrastructure, and a regulatory environment in place is necessary but not sufficient for a market to function. The interaction of market forces, planning, and regulation may not lead to the desired optimum. Market rules (intended to ensure short-term operational efficiency and optimize long-term investments) could be ill-conceived, resulting in unintended consequences. This report analyzes the basic design issues, risks, and options faced by emerging markets in creating power markets.

Appendix C

Impact of Market Structures on Electricity Sector Outcomes

Market Structure	Outcome Variable	Base Model Coefficient (p-value)	Base Model with Co-variates Coefficient (p-value)
Years in WRC	Share of Renewable Energy	0.491*** (0.00163)	0.567** (0.0332)
Years in WRC	Total Electricity Supply	3.270*** (4.64e-09)	1.830** (0.0172)
Years in WRC	Years Since First Private IPP	-	0.340***(0.00276)
Years in SBM	Share of Renewable Energy	-0.309* (0.0574)	-0.560** (0.0198)
Years in SBM	Overall Electricity Access	0.324*** (0.00125)	0.336** (0.0229)
Years in SBM	Rural Electricity Access	0.258* (0.0767)	-
Years in SBM	CO_2 per capita	2.980*** (0.00669)	3.920** (0.0342)
Years in SBM	Total Electricity Supply	-1.920*** (0.00117)	-1.520** (0.0299)
Years in SBM	Years Since First IPP	-	0.359*** (2.85e-05)
Years in SBM	Years Since First Private IPP	-	0.242** (0.0113)
Years out of VIU	Total Electricity Generation	1.410** (0.0118)	
Years out of VIU	Overall Electricity Access	-	0.508** (0.0478)
Years out of VIU	Rural Electricity Access	-	0.749* (0.0655)
Years out of VIU	CO_2 per capita	-	6.280* (0.0501)
Years out of VIU	Total Electricity Supply	1.620*** (0.00996)	-
Years out of VIU	Years Since First IPP	-	0.863*** (5.58e-17)
Years out of VIU	Years Since First Private IPP	-	0.868*** (5.7e-14)

Source: IFC

Note: Significance level: *** = 1 percent, ** = 5 percent, * = 10 percent

Glossary

Account unbundling: Account unbundling consists of breaking down bookkeeping activities between business segments (generation, transmission, distribution). It enables clarification of which costs come from which parts of the business and how much revenue each one brings in.

Ancillary services: A range of support services to the grid that address short-term imbalances between intraday power supply and demand.

Backstopping: Mitigation of the financial and political risks to which the energy project lenders are exposed. These risks may include sovereign payment guarantees, counter-guarantees, and other support mechanisms.

Balancing market: The institutional mechanism that deals with the purchase arrangements to match electricity production and consumption levels during the operation of electric power systems.

Bankable: Agreement structured to provide adequate and predictable revenue streams that are certain to bring profit.

Baseload generation: The amount of electric power that needs to be supplied to the grid at any given time to meet the minimum power demand.

Capacity market: The institutional mechanism wherein participants are paid a per unit of capacity that they offer to the market and make available when called on at any time during the contracted period.

Contingency reserve (energy): Also referred to as the operating reserve, it is the generation capacity available to the system operator within a short interval of time to meet demand in case of a supply disruption.

Contingent liability: A potential liability that may be incurred by an entity, depending on the outcome of an uncertain future event.

Contractual risks: The chances of facing losses due to the buyer not fulfilling the terms of a contract, or the deal performing poorly. In power projects, contractual risks include termination of service agreements, curtailment of supply, or financial instability caused by factors such as inflation or currency fluctuation.

Cost-based pricing: Electricity pricing based on auditable costs. These include the initial capital and the costs of continuous operation, fuel, maintenance, de-commissioning, and remediating any environmental damage.

Curtailment risk: The chance of facing losses when the off-taker (the agent responsible for managing distributed energy) reduces or restricts electricity delivery from a generator to the electrical grid. It can occur for a variety of reasons, including: strains to the network due to variability in generation, which is often a problem with intermittent renewables; system-wide oversupply, where supply exceeds demand and the off-taker curtails some generators to bring the system into balance; and local transmission constraints.

Decarbonization: Phasing out use of fossil fuels to reduce carbon dioxide emissions.

Demand response: A strategy to manage electricity consumption by encouraging consumers to reduce or shift their usage during peak demand times or in response to price changes. This helps balance supply and demand, enhances grid reliability, and reduces costs by lowering the need for additional power generation.

Digitalization: The use of digital technologies to change a business model and provide new revenue and value-producing opportunities. In energy, this can include expanding the use of smart systems and metering where consumers and producers interact with the grid or the power distribution system.

Distributed generation: Describes the generation of electricity that is both for use on-site and can be available for distribution to the grid, rather than transmitting energy over the electric grid from a large, centralized facility.

Electricity system: An interconnected network for delivering electricity from producers to consumers composed of four key parts: generation, transmission, distribution, and retail supply.

Energy auction: A competitive process for procuring electricity, whereby energy project developers bid against each other to supply energy based on rules that determine who wins and the price the winner (energy purchaser) pays.

Energy storage: The capture of energy produced at one time for use later to reduce imbalances between energy demand and energy production.

Feed-in tariff (FiT): A policy tool designed to promote investment in renewable energy sources by providing price certainty.

Financial transmission rights (FTRs): Financial contracts which allow the holder to hedge against the costs of congestion and offset potential losses related to the price risk of delivering energy to the grid.

Functional unbundling: The separation of certain activities within a vertically integrated utility so that each is performed independently by different entities. This includes actions such as dividing up roles and responsibilities in an organization between different parts of the business to ensure that each part focuses on what it does best. It also means having different departments that only deal with certain activities in order to clearly define decision-making power and responsibility.

Green bonds: Any bond instrument whose proceeds are used exclusively to finance or refinance projects with clear environmental benefits.

Grid extension: A network expansion from the national power transmission system to new areas and communities.

Independent power producer (IPP): An entity that is not a public utility but owns facilities that generate electric power for sale to utilities and end users. IPPs, also called non-utility generators, may be privately held facilities, corporations, cooperatives such as rural solar or wind energy producers, or non-energy industrial concerns capable of feeding excess energy into the system.

Independent system operator (ISO): An independent entity that handles electricity transmission network operation and planning. The ownership of network assets can remain in the hands of the integrated firm. The ISO model splits transmission ownership from system operation.

Independent transmission operator (ITO): This is a type of legal unbundling. An independent transmission operator is an independent entity that both owns and handles electricity transmission network operation and planning. Under this structure, the ITO is both the owner and operator of the network.

Integrated resource plan (IRP): An operational strategy that outlines an electric utility's resource needs in order to meet expected electricity demand over a long-term planning horizon. Key IRP items include planned resource additions and retirements, taking on new sources of energy, growth projections, as well as cost and performance assumptions.

Interconnector: A structure which enables energy to flow between electricity networks, including regional and international connections.

Legal unbundling: Legal unbundling requires the transmission network to be operated through separate legal entities within a vertically integrated utility. This can help prevent the implementation of discriminatory practices by creating a separate legal entity that has been tasked with network activities.

Levelized cost of electricity (LCOE): The average net present cost of electricity generation for a generating asset over its lifetime.

Microgrid: A small grid system that serves one or more consumer facilities (such as a neighborhood, office or industrial building, or institution such as a hospital or school). While capable of operating independently, it also has an interconnection to a main grid.

Minigrid: An off-grid system that involves small-scale electricity generation (typically 10 kilowatts to 10 megawatts) and which serves a limited number of consumers via a distribution grid that can operate in isolation from national electricity transmission networks.

Off-grid generation: Standalone electricity systems that are not connected to a central electricity transmission and distribution system.

Off-taker: The off-taker buys power from a project developer at a negotiated rate for a specified term without taking ownership of the system.

Ownership unbundling: This is the ultimate form of unbundling. A company owning and operating a network is not allowed to be active in any competitive segment of the electricity supply chain or have an interest with respect to those activities.

Peak load: The relatively short period when the system faces the highest power requirements.

Peer-to-peer retailing: A localized electricity market where members buy or sell directly with one another without intermediation by conventional suppliers.

Physical network: Also known as the electric grid, this is the system that moves and distributes electricity. It comprises electricity substations, transformers, and power lines that connect electricity producers and consumers.

Power distribution: The final stage in the delivery of electric power, which carries electricity from the transmission grid to individual consumers.

Power exchange: The official market where generators, large energy consumers (supply companies and industrial consumers), and brokers trade electricity.

Power market structure: The overarching institutional, financial, and regulatory structure adopted to organize the provision of electricity services in the economy. This could range from a vertically integrated power market where one company controls all segments of the electricity supply to competitive wholesale and retail market structures where multiple companies compete to supply electricity services to end consumers.

Power pool: An association of two or more interconnected electricity systems with an agreement to coordinate operations and planning for improved reliability and efficiencies of their generating or transmission facilities, or both. Power pools typically have an institution to oversee investments and trade coordination activity.

Power purchase agreement (PPA): A legal contract between an electricity generator and a power purchaser. Contract terms usually last 5–25 years. During that time, the power purchaser buys energy, and sometimes also capacity and/or ancillary services, from the electricity generator. Agreements can include take-or-pay quotas or fixed capacity charges to protect stakeholders from market risks.

Price elasticity of electricity demand: A measure of the change in the quantity of consumed electricity in relation to its price change.

Prosumers: Households, businesses, communities, organizations, and other agents that rely on smart meters and solar photovoltaic panels to generate electricity and/or combine them with home energy management systems, energy storage, electric vehicles, and electric vehicle-to-grid systems.

Retail competition: Allows competition in the retail segment, where end users of electricity (residential, commercial, and industrial customers) can choose their power supplier and other services. The aim is for the sector to offer pricing and service options tailored to customers' needs and facilitate the introduction of beneficial new technologies and processes.

Scarcity pricing: The principle of pricing electricity such that under conditions of scarcity, generating units will receive higher compensation. This additional revenue stream helps to incentivize investment in new generation and promotes overall system reliability. When supply conditions are tight and drop below a predetermined threshold level, the price for an additional unit significantly rises.

Security of supply: Refers to the electricity industry providing appropriate electricity system capabilities (such as generation and transmission capacity) and storable fuel supplies (such as water, gas, and coal) to maintain normal supply to consumers.

Single buyer model (SBM): A model under which electricity legislation mandates an entity to be the sole buyer of electricity in the country. Independent power producers can generate electricity and sell it to the 'single buyer,' often the national power company or the transmission system operator. In turn, the single buyer sells the purchased energy to distributors.

Smart grid: A system of integrating advanced communication and control technologies (including smart meters) into the grid infrastructure to more efficiently manage the electricity system and offer consumers increased transparency and choice.

Smart home technology: A system that monitors and controls home attributes such as lighting, climate, entertainment systems, and appliances.

Smart meters: Technology that provides accurate remote reading by sending electricity usage data directly to a central computing facility. They allow for bi-directional interaction between the electricity consumer and the utility.

Solar photovoltaic (PV): A power system designed to supply usable solar power by means of photovoltaic solar panels to absorb and convert sunlight into electricity.

Third-party access: A policy that requires owners of a natural monopoly-owned electric grid to grant access to the grid to parties other than their own customers, usually independent power providers, on commercial terms.

Unbundling: A structural reform that involves the separation of core functions performed by power utilities or power companies. In the case of a vertically integrated utility, it is the separation of generation, transmission, distribution and (sometimes) retail functions.

Variable renewable energy (VRE): Renewable energy sources that have a fluctuating nature such as wind and solar photovoltaic (PV) power.

Vertically integrated utility (VIU): A utility that owns all levels of the electricity supply chain: generation, transmission, and distribution.

Virtual community power pools (VPPs): A cloud-based (virtual) distributed power plant that aggregates distributed energy resources for the purposes of enhancing power generation, as well as trading or selling power on the electricity market.

Wholesale competition: Allows competition in the generation segment through use of market mechanisms to determine the dispatch of generators and the wholesale price of electricity. This can be done either through an organized market or through bilateral contracting between generators and large energy consumers (supply companies and industrial consumers). Under both wholesale trading mechanisms, the system operator still has the responsibility of physical clearing of the market to ensure system security, congestion management, and reliability. In many countries, both trade mechanisms are utilized.

Endnotes

1. (IEA, IRENA, UNSD, World Bank and WHO. 2024)
2. (World Bank 2022a)
3. (IEA 2022)
4. (IEA 2022)
5. (World Bank 2023c)
6. (World Bank 2023c)
7. ("Renewable Capacity Statistics 2024" 2024)
8. (International Renewable Energy Agency 2024)
9. (IRENA Renewable Energy Capacity Highlights, 2024)
10. Additional charts are available in the chapter appendix
11. IFC calculations, based on IJGlobal dataset
12. IFC calculations, based on IJGlobal dataset
13. (United Nations 2023)
14. (IEA 2023c)
15. (IRENA 2023)
16. (ESMAP 2023)
17. A large body of literature covers the impact of sector reforms on power sector performance and the optimal role of the public sector (Foster and Rana 2020; Gratwick and Eberhard 2008; Jamasb et al. 2005; Joskow 2008; Kessides 2012; Pollitt 2004; Sen 2014; Sen, Nepal, and Jamasb 2016)
18. (Akcura 2024)
19. (Akcura 2024)
20. (Akcura 2024)
21. For more details on each market structure please see a forthcoming working paper: Akcura and Mutambatsere (2024) Global Overview of Power Market Structures. Working paper (forthcoming).
22. (Kiesling 2014)
23. A large body of literature discusses risks related to PPAs and IPPs, such as the cumulative obligations that expose power utilities to financial risks (as in Indonesia, Pakistan, Philippines). Such conditions ultimately led state-owned utilities to default on payments.
24. (Poudineh 2019)
25. (Szabó et al. 2017)
26. Two main model specifications are used: a base model and a model with co-variates. The base model focuses on the direct relationship between market structures and sector outcomes, while the model with co-variates controls for additional factors such as economy size, population, regulatory indicators, and country risk. More details on the econometric analysis will be outlined in a forthcoming working paper: Akcura and Adewole (forthcoming) Impact of Power Market Structure on Key Energy Sector Outcomes. Working paper
27. (Foster and Rana 2020)
28. Table in Appendix C presents the regression results for the main electricity sector outcomes.
29. (Ajadi et al. 2019)
30. (IEA and Imperial 2020)
31. (IEA and IFC 2023)

32. (Amundi and IFC 2024)
33. (IEA 2020)
34. (Ajadi et al. 2019)
35. According to World Bank Data
36. (IRENA 2016)
37. (Bisaga et al. 2017)
38. (Bisaga 2020)
39. (Cogan, Maffini, and Collings 2018)
40. (World Bank 2020)
41. (IRENA 2019)
42. (IFC 2023)
43. (Zerriffi 2011; Guardo 2018)
44. (IRENA 2019; "Market Development of PAYGO - Energypedia" 2017)
45. (Sharma 2017)
46. (Alstone et al. 2015)
47. ("Azuri Technologies" 2024)
48. ("Prepayment Electricity" 2023)
49. (Bureau 2023)
50. (Northeast Group 2023)
51. (Govindarajalu, De Sisternes, and Chavez 2021)
52. (IFC 2021)
53. (IEA et al. 2023)
54. (IEA 2023b)
55. (ESMAP 2020)
56. (World Bank 2005)
57. (Barnes 2007; 2011; Banerjee et al. 2015)
58. (World Bank 2017)
59. (Sievert and Steinbuks 2020)
60. (IFC 2019)
61. (Lighting Global/ESMAP, GOGLA 2022)
62. (GOGLA 2022)
63. (GOGLA 2022)
64. (REN21 2023)
65. (GOGLA 2019)
66. (Acumen 2017; Lighting Africa 2011)
67. (UNIDO 2018)
68. (Rana, Ngulube, and Foster 2022)
69. (World Bank 2024)
70. (REN21 2019)
71. (REN21 2023)
72. (Bellini 2022)
73. (Newbery 2002)
74. (Rudnick and Velasquez 2018)
75. (Newbery 2002)
76. (Rudnick and Velasquez 2018)
77. (IEA 2023b)
78. (Kahrl et al. 2021)
79. S&P Global
80. (Business Wire 2024)
81. (IEA 2023a)
82. In 2023, Development Finance Institution financing to emerging markets reached $20 billion, down from a peak of $35 billion in 2017, while overall Development Finance Institution financing to emerging markets from 2010 to 2023 amount to $325 billion.
83. (World Bank 2023a)
84. (IDB 2024)

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