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DEVELOPMENT BANKS AND ENERGY PLANNING **ATTRACTING PRIVATE INVESTMENT FOR THE ENERGY TRANSITION**

THE BRAZILIAN CASE

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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

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CONTENTS

FOREWORD 6
By Director-General, IRENA 6
By President, Brazilian Development Bank (BNDES) 7

KEY MESSAGES 8

1. INTRODUCTION 9
1.1 The global decarbonisation context: IRENA 1.5°C scenario 10
1.2 The urgency to accelerate investments in renewable energy 11
1.3 The Brazilian pioneering role in renewable energy 12
1.4 The importance of this report in the current context and for investment forums 15

2. THE GLOBAL CONTEXT OF FINANCING RENEWABLE ENERGY 16
2.1 The landscape of renewable energy finance: assessing the gaps 19
2.2 Who is funding? The role of development banks and other players 24
2.3 Key points for scaling up and disseminating funding to renewable energy in EMDEs 25

3. THE BRAZILIAN CASE: A BRIEF DESCRIPTION OF THE INSTITUTIONAL FRAMEWORK OF THE ELECTRICITY SECTOR 34
3.1 Institutional and regulatory framework 35
3.2 System planning and operation 37
3.3 Commercial arrangement: regulated and free markets, distributed generation 39
3.4 Mechanisms for the introduction of renewables: PROINFA and auctions 41
3.5 Current dynamics of expansion via the free market 42

4. THE ROLE OF BNDES IN PROMOTING RENEWABLE ENERGY SOURCES 43
4.1 Relevance of BNDES for the energy sector 46
4.2 Role of BNDES in the introduction of new renewables in Brazil 47
4.3 Importance of renewables in the BNDES strategy 49
4.4 BNDES performance in the development of green finance 49
4.5 BNDES's pioneering role in free market financing 50
4.6 BNDES's impact on related supply chain 51

5. LESSONS LEARNED FROM THE BRAZILIAN EXPERIENCE WITH THE DEPLOYMENT OF RENEWABLE POWER 55

5.1 The crucial role of energy planning in the renewable power expansion in Brazil 56

5.2 Collaboration between energy planning body and NDB to promote renewable energy... 57

5.3 The importance of effective energy auctions..... 57

5.4 The role of DFIs in providing access to low-cost financing for renewables 58

5.5 The importance of DFIs in providing innovative financial solutions 58

5.6 De-risking power contracts 59

5.7 The creation of a pipeline of bankable projects 65

5.8 The promotion of supply chains 65

5.9 The importance of qualified staff in energy planning and NDB institutions..... 65

5.10 Investments in research, development and innovation 66

REFERENCES 67

FIGURES

Figure 1 Wind power installed capacity expansion in Brazil 13
Figure 2 Centralized solar power installed capacity expansion in Brazil 14
Figure 3 Transmission line extension in Brazil 14
Figure 4 Investment in renewable energy by financial instrument 18
Figure 5 Investment in renewable energy by power generation technology (2019-2020 average) 20
Figure 6 Investment in renewable energy, power and fuels, by region of destination in 2022 21
Figure 7 Private investment in renewable energy by investor, 2013-2020 24
Figure 8 Institutional agents in the Brazilian power sector 35
Figure 9 Expansion of solar photovoltaic distributed generation installed capacity in Brazil 40
Figure 10 Infrastructure debenture issuance 45
Figure 11 BNDES financing to new power capacity and transmission lines (2000 – 2023) 46
Figure 12 Top clean energy project lenders, 2004-2023 47
Figure 13 BNDES support to wind and solar power, 2019 – August/2024 51

TABLES

Table 1 Key investment risks for renewable energy projects and how Brazil addressed them 59

BOXES

Box 1 The heterogeneous context of EMDEs 25
Box 2 De-risking currency risk in high-volatility exchange rate countries 31
Box 3 The EPE's role in fostering renewable energy in Brazil 38
Box 4 The Climate Fund 48

FOREWORD

BY THE DIRECTOR-GENERAL, IRENA

A rapid acceleration of the global energy transition is essential to meet both the 1.5°C target of the Paris Agreement and the UN Sustainable Development Goals. To this end, according to IRENA's 2023 *World energy transitions outlook*, USD 150 trillion in cumulative investments will be needed by 2050 to scale up renewable power generation, electrify end-use sectors and deploy the technologies required.

Although significant investment opportunities exist in emerging markets and developing economies (EMDEs), the lack of low-cost capital to support the deployment of clean energy to meet rapidly growing energy demand remains a significant challenge.

Despite efforts to increase the financial resources allocated by governments, public sector finance will be insufficient to meet energy transition investment needs and must be complemented by financing from the private sector.

The Brazilian G20 Presidency has established the 'just and inclusive energy transition' as a priority topic for Energy Transitions Working Group discussions, with special focus on financing the energy transition in EMDEs. Particularly, IRENA contributions are related to the importance of international collaboration on energy planning and finance.

Brazil has achieved notable success in attracting private investment, deploying renewable energy, and strengthening the renewable energy industry supply chain due to a well stablished energy planning and finance strategy. This report, the result of a successful collaboration between IRENA and the Brazilian National Development Bank (BNDES), demonstrates how de-risking of clean energy projects can contribute to attracting and increasing the investments required to advance the energy transition and meet the 1.5°C goal, serving as a key input for enhancing collaboration among stakeholders, with the aim of unlocking low-cost capital financing for energy transition projects in EMDEs.

Francesco La Camera
Director-General, IRENA

FOREWORD

BY THE PRESIDENT, BRAZILIAN DEVELOPMENT BANK (BNDES)

Brazil represents a success story in developing renewable energy, which has given the country the cleanest electricity and energy matrices among the major global economies.

This effort began even before the climate emergency, back in the 1970s, with the introduction of biofuels – particularly ethanol – and large-scale hydroelectric developments.

Since the first decade of this century, energy planning has sought to intensify the development of new renewable sources, such as wind and solar energy, while attracting private investment to accelerate the energy transition.

This joint work with the International Renewable Energy Agency (IRENA), presents examples of how energy planning and development finance institutions can work together to ensure the success of investments in new technologies linked to the energy transition.

Around twenty years ago, through PROINFA – the Brazilian program to encourage alternative energy sources – the Ministry of Mines and Energy, in cooperation with BNDES, designed power purchase contracts suited to the bank's guarantee needs. BNDES, in turn, sought to establish and disclose the financial conditions that would be part of subsequent financing before auctions. These are examples of solutions built together between planners and financiers to mitigate risks in emerging industries and enable private investments and project financing on a competitive basis.

BNDES, as it has done since its creation, played a decisive role in these investment cycles. According to data from BloombergNEF, the Brazilian Development Bank is the world's largest financier of renewable energy, even though it operates exclusively in Brazil.

At this time, Brazil and the world are experiencing increasingly frequent extreme climate events, which serve as warnings of the need to accelerate decarbonisation efforts. After all, the costs of dealing with the consequences of these events may outweigh the investments necessary for the energy transition.

We hope that this report provides learning and inspiration so other developing countries can advance their energy transitions towards a more sustainable, inclusive, innovative and fair global economy.

Aloízio Mercadante
President, Brazilian Development Bank (BNDES)

KEY MESSAGES

1

The scale, pace and distribution of investment required for the global energy transition are substantial yet achievable if there is a collective effort with strong engagement from the private sector, supported by the public sector, to tap into domestic and international financing resources.

2

As the global energy transition accelerates, investment opportunities are expected to rise in emerging markets and developing economies (EMDEs), where the challenge of how to meet the rapid growth of energy demand in a low greenhouse gas emission future remains significant.

3

In addition to catalysing the participation of the private sector, the public sector should step up efforts to widen financing approaches and explore innovative financing instruments and mechanisms, which can aid in scaling up renewable energy investments in those EMDEs that have historically attracted little capital.

4

Blended finance and green bonds offer promising options for attracting private capital to EMDEs by reducing perceived risks through the involvement of multilateral development banks and development finance institutions.

5

EMDEs must prioritise the energy transition as a central component of their development strategy, placing private investors as key partners. The success of this development strategy is dependent on safeguarding that financial mechanisms are aligned with long-term energy planning and environmental considerations.

6

Governments play a crucial role in attracting private investment and reducing financing costs and risks in EMDEs through supportive policies and innovative regulatory reforms and by facilitating the implementation of blended financing and bankable projects in clean energy.

Brazil's success in expanding renewable energy investments and strengthening the supply chain is evidence of the integrated approach of sectoral planning and financial expertise through key institutions like the Energy Research Office, the Ministry of Mines and Energy and the Brazilian Development Bank. This approach attracted significant private capital and highlighted the importance of collaboration, innovation and strategic alignment for energy security and environmental sustainability.

1. INTRODUCTION

Renewable energy investments have experienced a positive trend over recent decades, driven by cost reductions, technological progress, policy incentives, and growing industry expertise. Consequently, renewable energy has become an increasingly attractive investment with significant benefits to society, including gross domestic product (GDP) growth and job creation, with every dollar invested potentially yielding three to seven dollars in fuel savings, reductions in net energy subsidies, and health-positive externalities (IRENA, 2020a, 2023a).

As renewable energy becomes a prime investment opportunity, fossil fuel investments face increasing uncertainty. This shift is partly due to governments worldwide implementing ambitious climate strategies and green recovery plans to avoid the adverse effects of climate change, protect ecosystems and enhance socio-economic and environmental outcomes. Moreover, as renewable power generation technologies have become more cost-competitive than fossil fuel power plants, a strategy focused on renewables can enhance energy security, mitigate the negative impacts of fossil fuel price volatility and make energy more affordable (IRENA, 2023b).

According to IRENA, USD 150 trillion is required to finance the energy transition compatible with the 1.5°C pathway by 2050 (IRENA, 2023a). Even though capital markets have enough money to support such large investment amounts, the central challenge lies in identifying suitable financial instruments and structures to ensure low-cost, long-term financing to support all necessary investments in the energy transition at the required rate, especially in jurisdictions with high perceived or real investment risks.

Furthermore, the transition to renewable energy significantly impacts capital markets by changing the financial structure of power projects. For instance, renewable energy projects typically require more capital upfront than traditional thermal power projects as well as substantial investments in supporting infrastructure. Therefore, the willingness of investors to provide capital for renewable energy hinges on investors' evaluation of the risks versus the potential returns.

As the global energy transition needs to accelerate across regions and countries, investment opportunities are expected to rise, especially in emerging markets and developing economies (EMDEs) experiencing increases in energy demand as well as transitioning away from greenhouse gas (GHG)-intensive energy systems that are not consistent with net-zero emission pledges. Concurrently, a trend can also be observed towards smaller, more decentralised projects that reduce the ticket size. These shifts are transforming the typical size of investment opportunities for financiers.

While some trends can potentially enlarge the available capital, others may demand strategic policy interventions to mitigate risks further. Even though conditions in individual countries may differ, country or policy risk is frequently recognised as a main barrier to international institutional capital flow (IRENA, 2023b). In this regard, for example, the public sector can offer risk mitigation tools for political, currency and credit risks, improving the viability of investments. Infrastructure investment, including grid and electric vehicle charging stations, can boost investor confidence by ensuring scalability and revenue certainty (IRENA, 2021).

Therefore, policy makers, energy planners and regulators play pivotal roles in lowering investment barriers and fostering an attractive environment for renewables. Effective policies should level the playing field for low-carbon technologies through reforms like fossil fuel subsidy cuts, carbon pricing, effective taxation regimes, and supportive governance and institutional frameworks.

It is particularly challenging for EMDEs to attract private investment due to perceived or real higher risks, unpredictable returns and the private sector's preference for investing in low-risk mature markets. Moreover, the current financing environment has become more complex, with increasing macroeconomic risks and higher interest rates to mitigate inflationary pressures (IRENA, 2023b) and with advanced economies offering various incentives and subsidy schemes to support clean energy technologies, such as the US Inflation Reduction Act, REPowerEU and Europe's Fit for 55 package, that EMDEs cannot match.

Brazil has, however, set a valuable example through its national development bank (the Brazilian Development Bank [BNDES]) and its planning authority (Ministry of Mines and Energy [MME]), with the assistance of its energy planning agency (the Energy Research Office [EPE]) and the broader domestic institutional framework, on how to expand renewable energy and infrastructure by scaling up private investments. The Brazilian example also demonstrates how the expansion of domestic industry supply chains can increase jobs and deliver positive local economic impacts via energy transition-related projects. This paper focuses on Brazil's collaborative approach, where financial support is aligned with strategic planning and risk assessment, offering a comprehensive framework for creating a conducive environment for renewable power projects. This report does not cover other decarbonisation solutions, such as biofuels, energy efficiency and demand-side solutions. Other countries looking to advance their renewable power sector can draw inspiration from Brazil's successful example.

1.1 THE GLOBAL DECARBONISATION CONTEXT: IRENA 1.5°C SCENARIO

According to IRENA, a fundamental shift in energy consumption and production patterns is required to achieve net-zero emissions by 2050 to keep the global temperature increase within 1.5°C (IRENA, 2023a).

In the IRENA 1.5°C Scenario global GHG emissions are reduced sharply – supported by energy policies aligned with the Paris Agreement targets, ongoing innovation and substantial investments – reaching negative emissions by 2050 (IRENA, 2023a). Increased renewable power capacity and energy efficiency would account

for the most significant portion of the global emissions reductions. Direct electrification of various end-use sectors (*e.g.*, transportation, heating) and the use of modern bioenergy and hydrogen and its derivatives would also be relevant.[1] Carbon capture and storage technologies would need to be used to remove the remaining carbon dioxide to reach the state of negative emissions by 2050.

The global economy's expansion and the growing electrification of end uses is expected to triple power generation demands in the coming decades, from 27 petawatt-hours (PWh) in 2022 to 90 PWh in 2050. In this scenario, electricity will be the primary energy carrier, accounting for approximately 50% of total final energy consumption. By 2050, renewable energy sources will account for over 90% of the power mix and more than 80% of the total final energy consumption, making them a crucial component of future power expansion. Natural gas and nuclear power facilities will supply the remaining energy, with coal- and oil-fired power stations being phased out entirely (IRENA, 2023a).

The significant expansion of renewable energy sources by 2050 will also increase the share of renewable energy in the total primary energy supply from 16% in 2020 to 77% in 2050. However, due to energy efficiency and the growth of renewables, the total primary energy supply is not expected to change between 2020 and 2050.

The transition to new power systems based predominantly on variable renewable energy will require adequate pricing mechanisms, scaling and management of transmission and distribution systems to handle higher electrification levels and to deliver power to demand centres, updated grid codes, streamlined licensing processes, new energy market products (*e.g.*, flexibility), and incentives for storage technologies, among other factors, without creating unfair subsidisation among customers (IRENA, 2023a).

1.2 THE URGENCY TO ACCELERATE INVESTMENTS IN RENEWABLE ENERGY

To align with IRENA's 1.5°C scenario, countries must set aggressive goals and policies to encourage the vast expansion of renewable energy and energy efficiency. The COP28 presidency, IRENA and the Global Renewables Alliance found that total global renewable power generation capacity must triple, while the energy efficiency improvement rate must double, by 2030 (COP28 Presidency *et al.*, 2023). National strategies to transform climate pledges into concrete actions and investments to bridge this gap need to be put in place immediately, especially while fossil fuel investments and subsidies remain relatively high.[2]

In an ongoing technological revolution, market-driven changes are under way, but advancement is required beyond the current progress to address the urgent climate crisis. It is unlikely that markets alone will be able to advance transition technologies along their development trajectory at the necessary speed (IRENA, 2021).

IRENA estimates that the energy system requires a cumulative investment of USD 150 trillion to implement its 1.5°C target by 2050, representing an additional USD 47 trillion compared with the level proposed by countries' current plans (IRENA, 2023a). New renewable power capacity will require investment of USD 39 trillion,

[1] *According to (IRENA, 2023a), modern bioenergy include the use of solid biomass, biogas and biomethane in buildings and industry as well as the use of liquid biofuel in transport and other end uses; traditional uses of biomass refer to the residential total final energy consumption of solid biofuels in non-Organisation for Economic Co-operation and Development countries. Hydrogen accounts for total hydrogen consumption (green and blue), e-ammonia and e-methanol.*

[2] *Renewable energy investments reached a record high of USD 0.5 trillion in 2022. However, investments in fossil fuel projects were almost twice this amount. Fossil fuel subsidies were also at their highest levels as governments tried to mitigate high energy prices for consumers (IRENA and CPI, 2023).*

whilst the necessary enabling infrastructure – such as power grids and storage – will require USD 22 trillion. Combined, this amounts to an additional USD 31.5 trillion than what is currently planned by countries.

Moreover, renewable energy investments have so far been unevenly distributed, with a few countries and technologies receiving the bulk of funds.[3] In addition, as the transition progresses, investment will likely continue flowing to developed countries, leaving behind areas of high risk, real or perceived, where the major development gap resides. New developments and challenges will emerge, varying significantly across countries and technologies. These changes are likely to influence risk perception, thereby affecting the availability and cost of capital (IRENA, 2021).

Therefore, public policies encouraging more private investment through risk mitigation and public funding should also consider diversifying and scaling investment, especially in EMDEs and less established technologies. Effective mobilisation of substantial private capital requires the strategic deployment of significant public initiatives focused on reducing financial risks rather than allocating resources to individual projects.

Meeting global climate goals will require mobilising all sources of capital – private and public (whether equity or debt) from domestic and international sources – to achieve the levels of investment necessary for the global energy transition (IRENA, 2021). Mapping existing experiences and successful cases will help inform and build capacity and knowledge of investors, policymakers and stakeholders interested in expanding renewable power capacity.

1.3 THE BRAZILIAN PIONEERING ROLE IN RENEWABLE ENERGY

Brazil has been a forerunner in accelerating the integration and diversification of renewable energy sources in its energy mix, largely thanks to public policies and regulatory reforms initiated in the 1990s and further developed in the 2000s. Following the energy rationing crisis of 2001, the government implemented Law 10.848 in 2004 to ensure energy supply security and resource adequacy to generate investment through energy auctions, long-term power purchase agreements (PPAs), long-term financial conditions in local currency, and more transparent institutional governance supported by centralised planning.

A pivotal element of the power reform was the introduction of energy auctions, which have been instrumental in the development of renewable energy sources in Brazil. From 2004 to 2022, Brazil contracted 93.3 gigawatts (GW) of installed capacity through power auctions, mostly from renewable energy sources (ANEEL, 2022).

The success of these auctions was mainly due to careful model design and a stable regulatory framework, with some minor adjustments to contractual clauses and the bidding mechanism (Tolmasquim *et al.* , 2021). These auctions were tailored to provide long-term contracts, facilitating project finance and initially without the need for separate tenders for energy and capacity.[4]

One central aspect of project finance for power investors in Brazil was the long-term financial conditions in the local currency offered by BNDES. Investors participating in the power auction are not required to

[3] *IRENA and CPI (2023) reported that just 15% of renewable investments in 2022 were directed towards countries that together represented over 50% of the global population.*

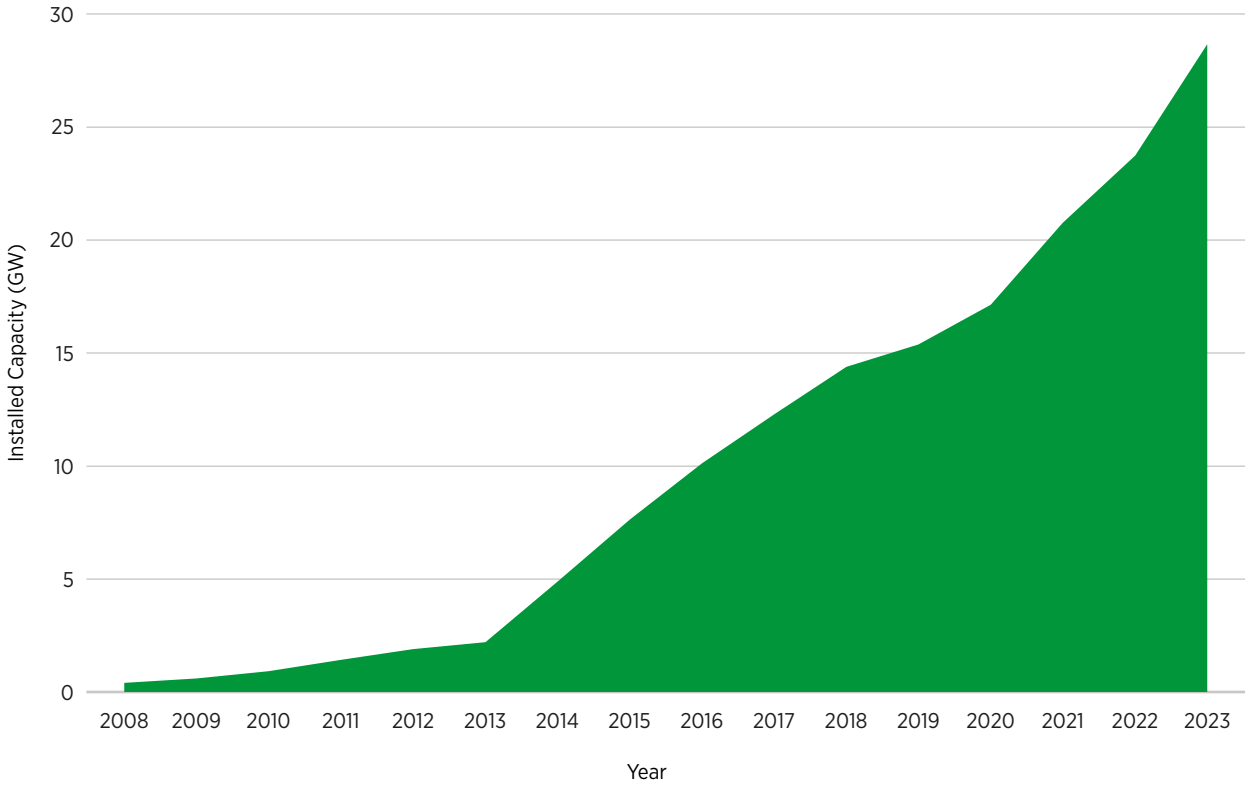
[4] *With the increasing prevalence of run-of-river hydropower, and the predominance of variable renewable energy sources in the expansion, capacity issues emerged. This led to the introduction of the first capacity-only auctions in 2021.*

secure funding through BNDES; they can seek financial support internationally. However, if they choose to use BNDES funding, they must contribute to strengthening the local energy industry's supply chain. In the first decade of implementing power auctions, BNDES funding conditions were revealed before the auctions and helped reduce uncertainties, allowing investors to adjust their bids accordingly.

The 2004 power reform also reinforced the centralised energy planning to reduce information asymmetry in the Brazilian power market. Two central aspects were the provision of a long-term view through the annual publication of ten-year energy plans and the mitigation of risks, especially those associated with the environmental licensing process. The consistent efforts of the Government (and its centralised planning) were also crucial for effectively integrating variable renewable energy sources into the power mix (Tolmasquim, 2012). The expansion of wind and solar power (Figure 1 and Figure 2) has benefitted from the country's large hydropower reservoirs and extensive transmission line system[5] (Figure 3), enabling a smoother integration of these resources. Furthermore, centralised planning in Brazil has facilitated the incorporation of other criteria into its energy policies, such as local development and the creation or expansion of local supply chains.

In addition to power auctions, the successful integration of wind and solar technologies into the Brazilian power system demonstrates the potential performance of adequately funded institutions (like BNDES and the EPE) provided with qualified technical personnel (Tolmasquim, 2012).

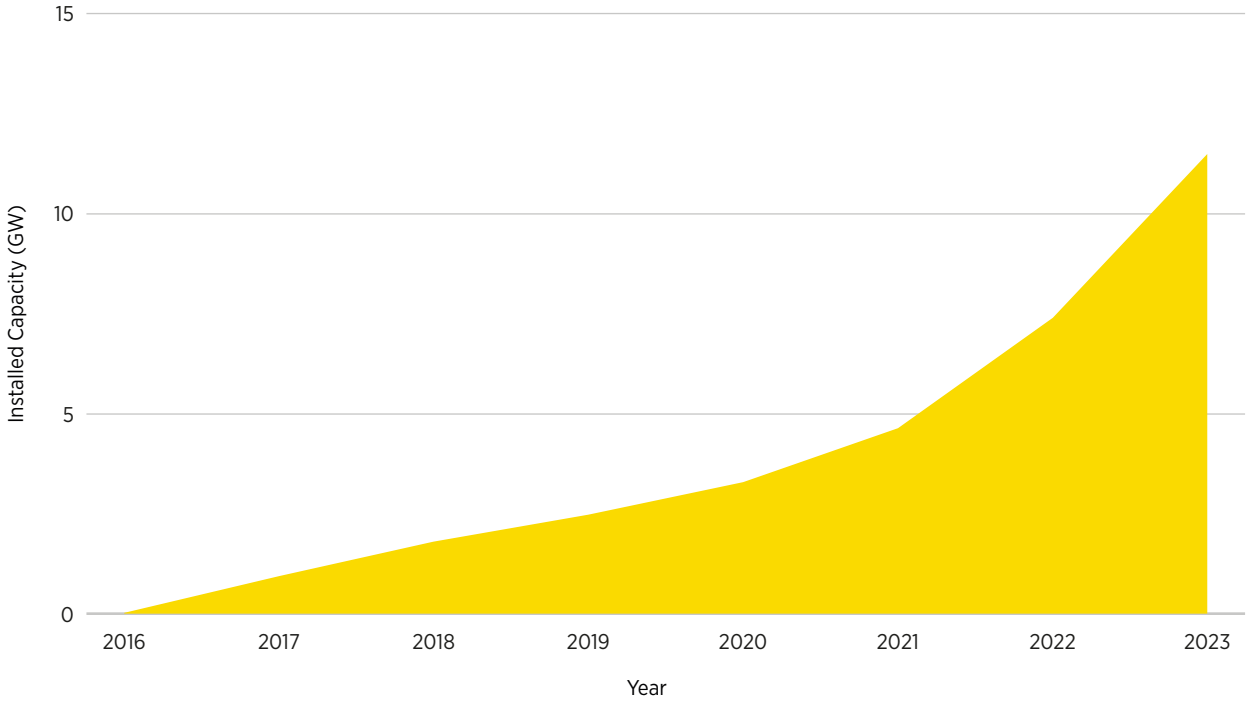
Figure 1 Wind power installed capacity expansion in Brazil



Source: (EPE, 2023).

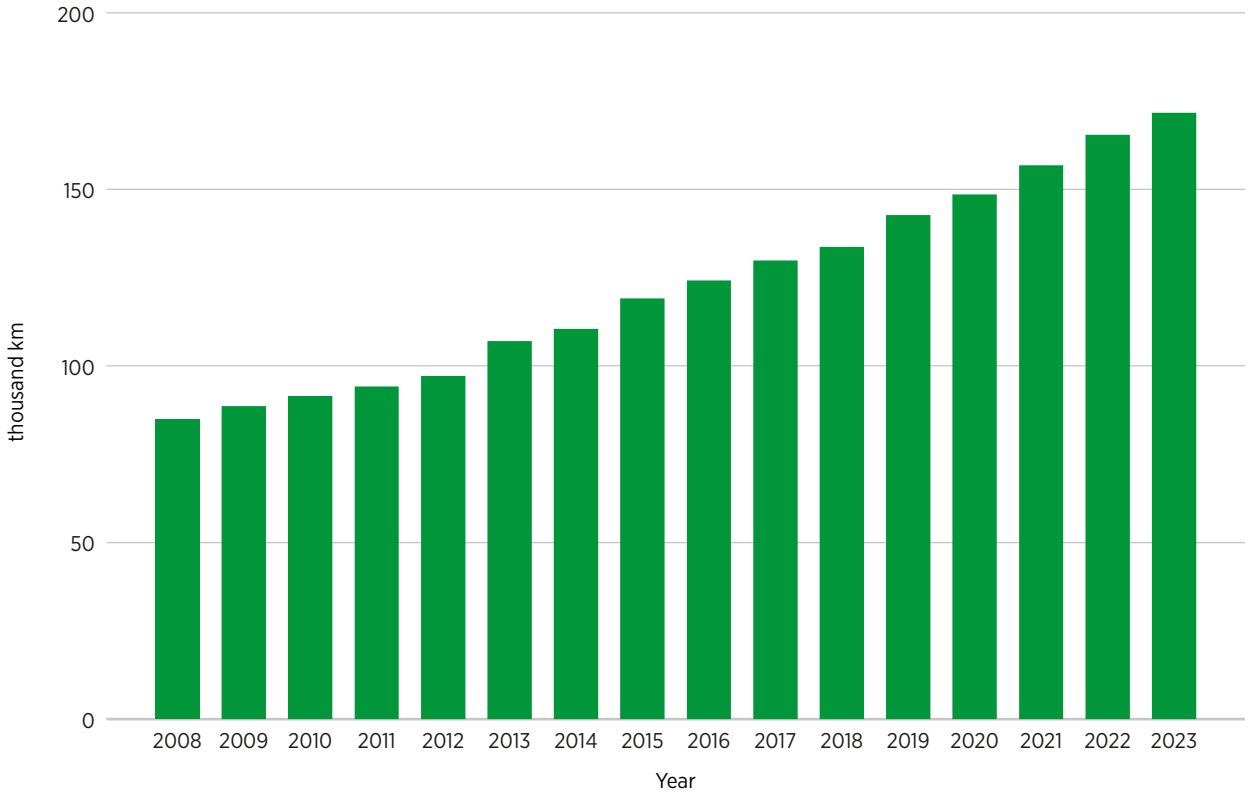
[5] *Over the past two decades, the transmission system has been extended to support the integration of variable renewable energy sources, primarily located in the Northeast Region. Meanwhile, large-scale hydropower plants with reservoirs face increased environmental scrutiny, primarily because their greatest potential lies within the environmentally sensitive Amazon biome.*

Figure 2 Centralized solar power installed capacity expansion in Brazil



Source: (EPE, 2023).

Figure 3 Transmission line extension in Brazil



Source: (ONS, 2024).

1.4 THE IMPORTANCE OF THIS REPORT IN THE CURRENT CONTEXT AND FOR INVESTMENT FORUMS

Beyond the contribution of renewable energy to climate change mitigation, one of the principal discussions in global forums today is using the energy transition as a mechanism for local and regional development and energy security. Examples include the US Inflation Reduction Act, Europe's Fit for 55 package and the REPowerEU plan. Similar mechanisms are becoming more common worldwide, aiming to set a clear path for a green transition while supporting reindustrialisation efforts.

Likewise, there is a burgeoning discussion in EMDEs. With their abundant renewable resources, many Global South countries stand at a crossroads where they can leapfrog into a sustainable industrial era. Brazil is also steering towards green reindustrialisation, aiming to deepen the current supply chain diversification in the renewable power sector with emerging efforts in offshore wind energy, low-emission hydrogen and its products, and nature-based solutions, positioning the country towards sustainable development. Arbache and Esteves (2023) argue that the comparative advantage of Latin American and Caribbean countries in renewable energy sources can support a locational production strategy (*powershoring*) that promotes economic and social development.

These initiatives represent a broader shift in recognising the dual potential of energy transition as a means to combat climate change and as a pivotal driver of local and regional economic transformation, setting a blueprint for other countries to follow.

However, creating the appropriate conditions to scale up investments related to the energy transition requires considerable funding, supported by concerted efforts and international co-operation. The private sector, which accounted for more than 75% of the total investment in renewables from 2013 to 2020, has preferred investing in regions with lower risks, established markets (*e.g.*, Europe, the United States of America), and more consolidated renewable technologies, like wind and solar energy (IRENA and CPI, 2023).

Therefore, in the urgent context of climate change, the challenge lies in rapidly mobilising funds for the energy transition in EMDEs and in less mature low-carbon technologies, which struggle to attract private investment due to their unfavourable risk-return profiles.

The public sector is critical in addressing this imbalance, in terms of both leveraging investment and mitigating risks. Given the challenges faced by public funding, such as the prioritisation of immediate economic issues over long-term investment in renewables, governments and national development finance institutions (DFIs) must adopt a proactive stance, leveraging their unique position to de-risk projects, offering more affordable, attractive and sustainable financial solutions that can unlock the full potential of renewable energy, particularly in underserved markets.

The Brazilian experience shows how a conducive environment for renewable energy projects can be created by ensuring that financial mechanisms are aligned with long-term energy planning and socio-environmental considerations. This successful strategy may inspire other EMDEs to deploy renewable energy at a large scale.

2. THE GLOBAL CONTEXT OF FINANCING RENEWABLE ENERGY

KEY INSIGHTS:

1

The scale, pace and distribution of investment required for the energy transition are substantial but achievable within the capacity of global financial markets. The financing is expected to come predominantly from the private sector, with significant contributions also needed from public funding and DFIs.

2

Renewable energy investments are highly concentrated, often leaving many countries and sectors, particularly in EMDEs, behind. Public sector financing will be crucial to bridging this gap, enabling the scale-up of nascent technologies and addressing the investment shortfall in decentralised projects and less attractive markets, where affordability is a central issue.

3

In EMDEs, the discrepancy between the available financial instruments and the risks of the renewable energy sector necessitates innovative financing structures.

4

In financing renewable energy projects, there is an increased reliance on debt financing supported by PPAs (particularly in G20 countries). Equity financing remains crucial for less mature technologies and higher-risk countries.

5

The emergence of blended finance and green bonds offers new opportunities for pooling capital and sharing risks, attracting private capital by reducing perceived risks through MDBs and DFIs' involvement.

6

EMDEs must prioritize energy transition as a central component of their development strategies, positioning private investors as key partners. The success of such development strategies is based on ensuring that financial mechanisms are aligned with long-term energy planning and environmental and socio-economic considerations.

7

An effective institutional and regulatory framework is necessary to provide legal and regulatory stability, ensure the financial robustness of off-takers, and include appropriate tariff regulation to allow renewable energy sources to compete fairly in the energy market.

8

An integrated approach to energy planning highlights the importance of strategic alignment, collaboration and innovation in achieving energy security, socioeconomic development and environmental sustainability.

9

Policy makers and public capital providers can facilitate the scale-up of renewable energy investments by de-risking projects and mobilizing private capital through blended finance initiatives and supportive policies.

10

Enhancing the attractiveness of energy transition projects to large investors requires the creation of project pipelines that increase bankability and ticket size. Public financiers can mitigate risk by standardising contracts, aggregating projects and using blended finance initiatives.

11

Accelerating the transition to sustainable energy requires a conducive ecosystem for developing renewable projects. Creating such an ecosystem involves establishing effective project accreditation systems, streamlining processes and ensuring the availability of skilled professionals to prepare and execute these projects efficiently.

Determining the optimal financing structure (*e.g.*, project financing, balance sheet financing, grants), financial sources (*e.g.*, domestic public resources, the private sector, DFIs, concessional), and financial instruments (*e.g.*, equity, debt) requires a complex evaluation of multiple variables, including expected return, volatility, investment horizon, liquidity, minimum investment, fee structure, control over the underlying assets, and the time and resources required to manage the investment. In addition, local regulation and capital market development may influence this choice, especially in EMDEs (IRENA, 2020a).

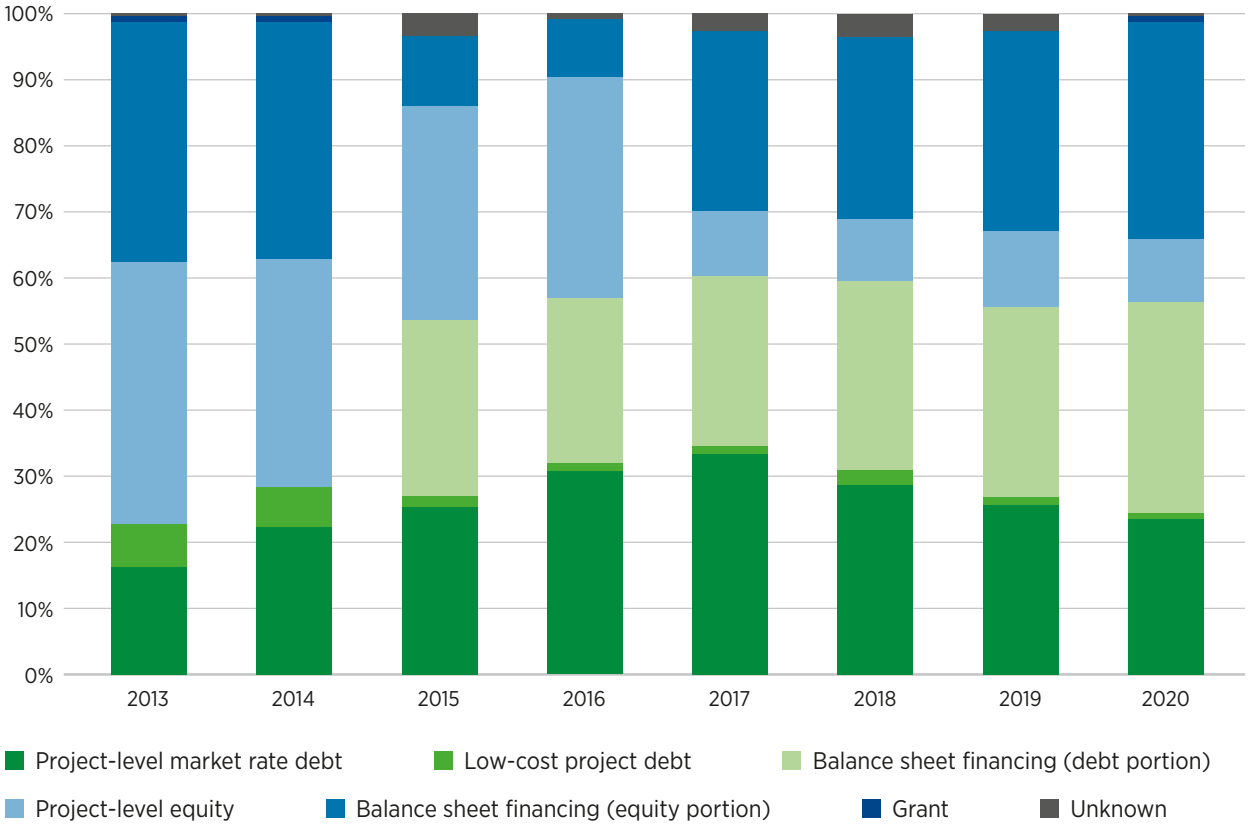
The fundamental challenge facing financial institutions on renewable energy projects is presenting a financial structure that aligns with all parties' interests and risk profiles. This can be particularly challenging in an energy transition context, where risks and cash flow profiles change. Indeed, the shift from fossil fuel technologies, with their higher operational costs, to renewable energies, where capital expenditures are relatively higher, alters the structure of financing and the perception of risk in the energy industry (IRENA, 2021).

Typically, investments in renewable energy projects last between 20 and 30 years, with returns depending on the chosen investment vehicle and the associated risks. Nevertheless, cash flows from renewable projects are relatively stable and more predictable than for energy from conventional sources (which is strongly affected by fossil fuel price volatility) due to the low volatility of input costs, the low and stable operating expenses, and the revenues being generally supported by long-term PPAs (IRENA, 2020a).

Returns on renewable energy projects are affected by several factors, such as the investment's capital structure, the risks associated with the location and size of the project, the capital cost, the technology's maturity stage, and the creditworthiness of the off-takers.

Regarding capital structure, financing renewable energy projects usually involves multiple instruments, predominantly debt (loans or bonds) raised from private sources. In contrast, loans from DFIs and government entities play a smaller role (IRENA, 2021). In general, renewable energy projects are primarily financed through the corporate balance sheets of industry companies and project finance (IRENA and CPI, 2023). Public bond markets, venture capital, private equity, grants, and research and development resources contribute to a lesser degree (Figure 4).

Figure 4 Investment in renewable energy by financial instrument



Source: (IRENA and CPI, 2023).

Financing long-term projects at reasonable rates is linked to successfully de-risking them.[6] High risks, real or perceived, are a frequent obstacle for many energy transition projects, especially in EMDEs (IRENA, 2020a). In this regard, public funds can significantly mitigate project risks (de-risking) and reduce financing costs (*e.g.*, through blended financing) to attract private investment and contribute to developing a portfolio of bankable projects. Finally, although risk mitigation instruments exist in international markets, they may not be available at reasonable costs, making their use in long-term projects financially unfeasible (IRENA, 2020a).

The stage of the technologies associated with the energy transition also influences their capital structure: more mature technologies tend to be financed with long-term debt at lower costs. In contrast, technologies in earlier stages are related to forms of financing with a preponderance of equity (IRENA and CPI, 2023).

Off-takers' creditworthiness may be an additional critical issue for long-term financing for renewable energy projects.[7] In EMDEs, the off-taker is usually the local State-owned utility, which requires significant resources and a total commitment from the government, especially when consumers' ability to pay is low (IRENA, 2020a).

2.1 THE LANDSCAPE OF RENEWABLE ENERGY FINANCE: ASSESSING THE GAPS

The current landscape of renewable energy finance can be defined by the scale, pace and distribution of investments needed for the energy transition and the lack of necessary instruments to finance those investments.

2.1.1 The scale, pace and distribution of the required investment

Significant investments are required to support the shift towards renewable energy in alignment with the Paris Agreement. According to IRENA and the Climate Policy Initiative (IRENA and CPI, 2023), even though investments in renewable energy have increased in recent years, reaching almost USD 0.5 trillion in 2022, they are still well below the USD 1.6 trillion annual investment required to reach IRENA's 1.5°C target scenario up to 2030. While this required financial amount is considerable, it represents less than 2% of the global GDP. This level of investment is within the capacity of global financial markets: for instance, in 2022 global fixed income outstandings represented USD 129.8 trillion, with USD 22.5 trillion fixed income issuance, and global equity market capitalisation reached USD 101.2 trillion, with USD 0.4 trillion equity issuance (SIFMA, 2023).

The private sector (particularly commercial financial institutions and corporations) is expected to finance most of the required expansion of the renewable energy (IRENA, 2023a). Although their participation is increasing, institutional investors still have a limited role in financing renewable energy projects.

Significant public funding will also be needed. IRENA (2021) estimated that under the 1.5°C scenario, DFIs would be expected to increase their financing to over USD 550 billion per year by 2030. Even though it might

[6] *Risks that need to be allocated, mitigated or transferred include political risks in the host country, regulatory or policy risks, currency risks, counterparty risks, transmission and network risks, and liquidity risks (See Table 1). Risk mitigation instruments, such as guarantees and financial instruments to hedge foreign exchange risks, provide solutions to such risks but may not be easily accessible or affordable to market participants.*

[7] *Around 50% of the electric utilities in Asia and 75% in Sub-Saharan Africa are considered uncreditworthy. In those countries, viability gap funding grants can be used to make PPA prices sustainable through capital expenditure or tariff subsidies. Implemented with additional measures (e.g., grid and collection loss reduction), viability gap funding grants can promote affordable renewable energy and encourage development (ESMAP, 2023).*

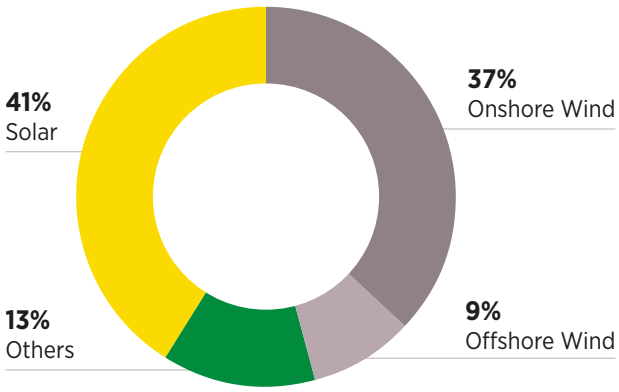
look challenging, this amount would represent about 55% of the balance sheet of multilateral and regional DFIs, which "may be achievable, since DFIs have a lending curve similar to governments and can increase their lending portfolio more easily than commercial banks" (IRENA, 2021).

However, renewable energy investments tend to concentrate on specific technologies, applications, and geographic areas (IRENA and CPI, 2023). This focus leaves many countries and sectors, particularly in EMDEs, facing substantial investment gaps.

One reason for this concentration of investments is technology maturity.[8] Some low-carbon technologies are still in the early stages of development and adoption, entailing more uncertainties regarding the technology itself and its supporting ecosystem, making them comparatively high-risk investments.[9]

While these conditions are attractive for some investors looking for higher returns from riskier investments (*e.g.*, venture capital providers), traditional investors may be reluctant to commit to these technologies at their current stage and may therefore want to wait until they reach a certain level of maturity (IRENA, 2021).

Figure 5 Investment in renewable energy by power generation technology (2019-2020 average)



Source: (IRENA and CPI, 2023).

As a result, public sector financing may be needed to provide the initial investment injection to enable a scale-up strategy of the incipient technology, mirroring the success of wind and solar PV energy in significantly reducing their levelised cost of electricity due to technological improvement, competitive procurement, declining financing costs and a growing base of experienced and internationally active developers (IRENA, 2020a). In particular, reinforcing feedback loops between investments in innovation and the manufacturing capacity of new technology is vital, as seen in the wind and solar energy industries. As the production of renewable energy equipment increases, accumulated experience leads to reduced manufacturing costs, enabling even more equipment production, installations and revenues. This, in turn, fuels further production capacity growth, creating positive dynamics to accelerate the energy transition.

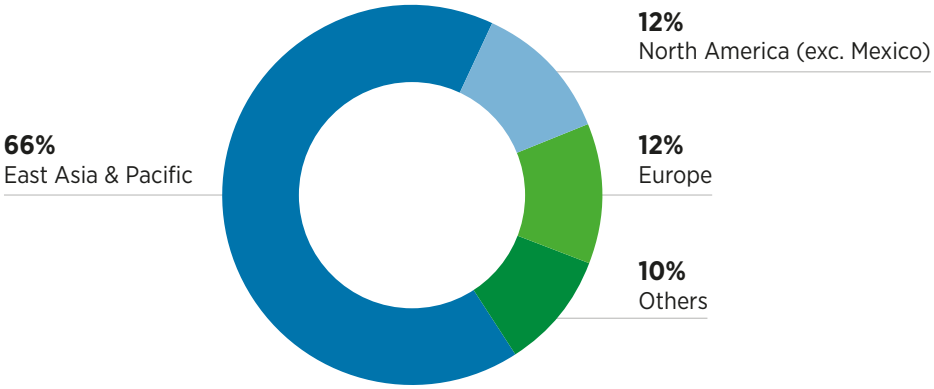
[8] *Over the past decade, renewable energy investments focused on the power sector. Specifically, solar photovoltaic (PV) and onshore and offshore wind accounted for an average of 87% of total renewable energy investments in 2019 and 2020 (Figure 5).*

[9] *For instance, in the case of green hydrogen, the supporting infrastructure (e.g., distribution networks) may not be fully developed by the time of its deployment, and available support schemes may be unsuitable or adjust too slowly to the pace of innovation (IRENA, 2021).*

Another related issue is the smaller ticket sizes of decentralised projects, which reduce their attractiveness to some traditional financiers due to their higher transaction costs (IRENA, 2020a). In these instances, contract standardisation and project bundling through securitisation may represent solutions to the overall ticket size (IRENA, 2021). One example is the BNDES Amazonia solar project. The project issued BRL 60 million (approximately USD 12 million) in local green bonds to fund rooftop solar projects in the Amazon region, replacing diesel generators. Local providers carried out the installation, while fintech companies provided credit services backed by the funds generated from the bond issue (BNDES, 2022a).

In terms of the geographic distribution of investments in renewable energy, power and fuels, the East Asia and Pacific region is predominant, attracting 66% of the total investment in 2022, concentrated in China. North America (excluding Mexico) and Europe each raised 12% of the total investment in 2022, and all the remaining countries raised only 10% in total (Figure 6).

Figure 6 Investment in renewable energy, power and fuels, by region of destination in 2022



Source: (IRENA and CPI, 2023).

Public investments, representing less than one-third of renewable energy investment in 2020, primarily focus on domestic investments. International flows are generally limited: approximately 50% of public sector international investments come from multilateral DFIs, which accounted for only 9% of public finance in renewable energy, power and fuels in 2020 (IRENA and CPI, 2023).

The limitation of public investment can be attributed to the tight fiscal constraints that ensued following the 2008 international financial crisis and were further intensified by the COVID-19 pandemic. In low- and middle-income countries, governments may chronically lack sufficient fiscal space to allocate public resources toward public investments (IRENA and CPI, 2023; Songwe *et al.*, 2022). As a result, instead of providing public resources, governments have been more active in de-risking projects and improving their risk-return profiles to attract private capital for renewable energy investments. Nonetheless, public funds play a fundamental role, particularly in international investments from the Global North to the Global South, in bridging the gap between the risks faced by private investors and the broader economic risks of failing to achieve the energy transition goals (IRENA, 2023b).

2.1.2 The available financial instruments

Reflecting the increased maturity of major renewable technologies and a more extended project developer track record, debt financing has gained ground in financing renewable energy projects, especially in G20 countries, due to PPAs and other policy supports. Although the specifics can vary across different

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countries and technologies, the risk of the project is predominantly reflected in its debt share. Projects perceived as less risky typically exhibit a higher debt-to-equity ratio (IRENA, 2023a).

Debt financing is pivotal for renewable energy projects, with large power projects often relying on co-financing structures, such as loan syndications, where multiple financial institutions participate in the financing solution. DFIs play a significant role in these structures by offering subordinated loans and creating on-lending solutions to provide low-cost funding to local financial institutions, financing local projects on better terms (IRENA, 2020a)

Green bonds have become an increasingly popular debt instrument among investors seeking environmentally friendly projects. Green bond funds have bolstered investments in green bonds, which aggregate various green assets, offering investors diversified exposure to the green sector (IRENA, 2020a).

Although initially pursued by MDBs, the green bond market has since diversified, with issuers now including local and federal governments and varied companies. This approach helps issuers attract investors who have sustainability goals and offers these investors greater transparency regarding the use of proceeds compared to traditional bonds. Europe is the largest regional green bond market, with the fastest growth in the Asia-Pacific region. Among EMDEs, Brazil, China, India and Mexico are notable for their active issuances (IRENA, 2020a).

However, even though the market for these bonds has expanded rapidly, attracting investment globally and catering to a wide range of green sectors, it is still small compared with the overall global bond markets. Moreover, despite their potential, green bonds face market barriers, including limited awareness, regulatory uncertainties and high transaction costs. To overcome this, regulators and policy makers can adopt standards aligned with climate goals, provide incentives, fund demonstration issuances and build financial skills in the industry. Creating mandates for institutional investors could also ensure a steady demand for these instruments (IRENA, 2020a).

Bank loans are also critical and are used almost exclusively during the project's higher-risk construction phase. Once a project generates cash, these loans can be partially replaced with fixed-rate bonds. Syndicated bank loans can be tailored to a project's specific needs to provide for construction cost overruns, delays and other contingencies, avoiding an event of default. The key role of bank lending highlights the need for loan syndicates to involve experienced banks that understand project risks and demonstrate the necessary discipline under adverse conditions, led by a highly reputed agent bank.

Equity financing has been significant in solar PV, especially through balance sheet financing.[10] Equity financing is also essential for less mature technologies, particularly projects in relatively high-risk or credit-constrained environments (IRENA and CPI, 2023). Equity financing differs between private-sector and public-sector renewable energy projects, with private entities typically relying on corporate balance sheets and public projects using the government's budgets.

Additional investment avenues for equity financing include raising capital by issuing common shares in initial public offerings and sourcing funds from venture capital and private equity firms.

One central challenge in structuring the appropriate financial structure for renewable energy projects is that, currently, available financial instruments may not align well with the nuances and risks specific to the renewable energy sector, especially in EMDEs. For example, institutional investors, like pension funds and insurance companies, especially those new to renewable energy investments, reveal a preference for assets that are liquid and tradeable. However, many renewable energy projects do not meet these criteria, as they are typically illiquid and not listed on exchanges (IRENA, 2020a).

More recently, structuring approaches like blended finance have become more attractive, offering significant growth potential (IRENA, 2020b, Convergence, 2023).

Increasingly used by multilateral development banks (MDBs) and DFIs, blended financing – including co-financing, on-lending, subordinated debt, convertible loans, and grants[11] – is a mechanism for pooling capital and sharing risks and knowledge. By leveraging their credit ratings and expertise, MDBs and DFIs significantly reduce actual or perceived risks and attract private capital. In some cases, such as high-interest markets with substantial currency risks, MDBs and DFIs can further enhance risk-adjusted returns and bankability by offering risk mitigation tools for investors less prone to some of the inherent risks of renewable energy projects (IRENA, 2021).

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[10] *In 2019 and 2020, 57% of solar PV investment was made through equity, primarily using balance sheet financing. According to IRENA and CPI (2023), as the renewable energy sector has matured and project developers have expanded their portfolios, balance sheet financing has become an alternative when the cost of non-recourse finance increases and risks are well managed and mitigated, Moreover, solar PV received a significant amount of private investments, making up 83% of its total commitments in 2020 (IRENA and CPI, 2023).*

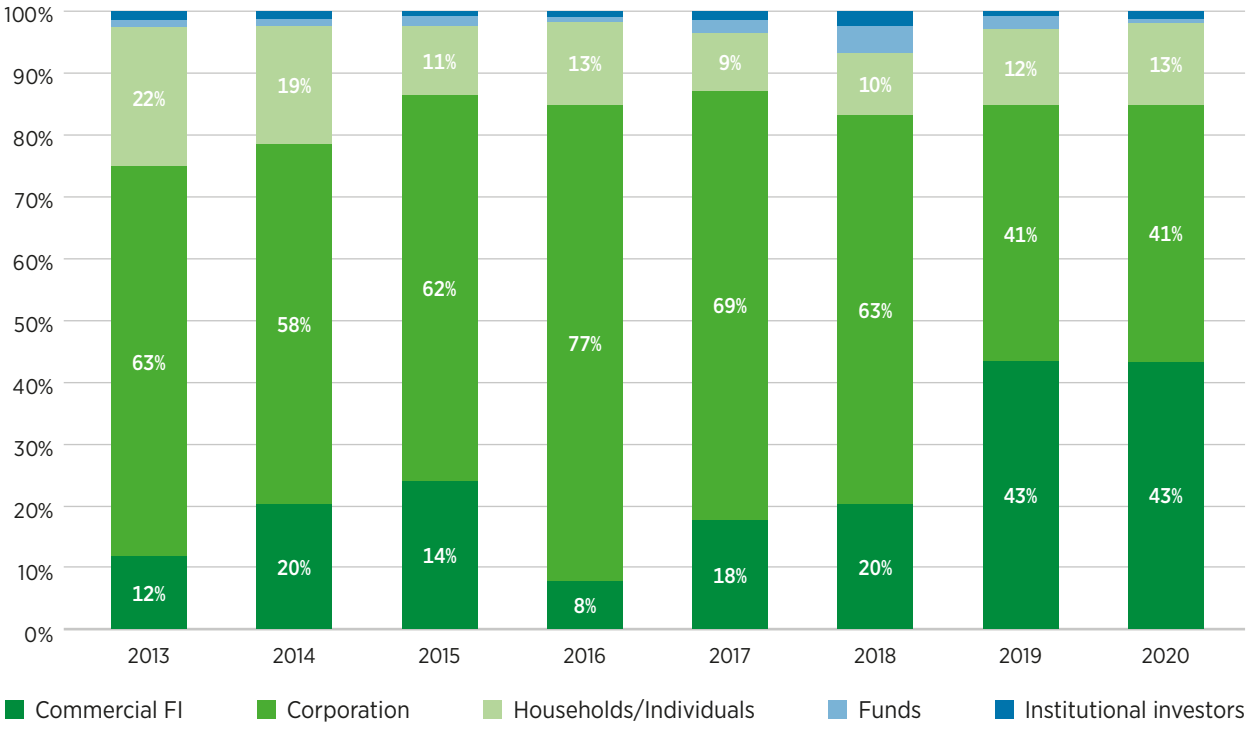
[11] *Convertible loans are financial instruments in which the lender can convert its loan into shares or ownership stakes in the project. Grants are non-repayable funds, usually provided by governments through a competitive process to support renewable energy initiatives, typically based on specific criteria (e.g., technology, innovation, environmental impact).*

2.2 WHO IS FUNDING? THE ROLE OF DEVELOPMENT BANKS AND OTHER PLAYERS

According to IRENA and CPI (2023), the private sector provided almost 70% of total investments in renewable energy in 2020, with commercial financial institutions and corporations being the leading private sector providers. Households represent a lower share of such investments, which are primarily concentrated on solar PV (Figure 7) (IRENA and CPI, 2023).

Although still small, institutional investment in renewable energy projects is on the rise. Historically, institutional investors have preferred indirect investments, even though some pension funds from countries like Brazil, Canada, Denmark, and Canadian and US insurance companies are noteworthy for their direct renewable energy investments (IRENA, 2020a). More recently, sovereign wealth funds have also directly or indirectly engaged in project equity syndicates (IRENA, 2021).

Figure 7 Private investment in renewable energy by investor, 2013-2020



Source: (IRENA and CPI, 2023).
Note: FI = financial institution.

The primary economic drivers for institutional investment (including sovereign wealth funds) in renewable energy are the promise of stable, long-term cash flows and portfolio diversification (IRENA, 2020a). With growing social and regulatory pressures for sustainability initiatives aligned with the Paris Agreement, the mobilisation of institutional investors is vital for renewable energy financing, particularly in EMDEs. This mobilisation can create a self-reinforcing cycle, decreasing financing costs and attracting more investment.

State-owned financial institutions, national DFIs, and State-owned enterprises were the primary sources of public finance for renewables, especially in China. Public investment remains prevalent in developing markets (*e.g.*, Latin America, Sub-Saharan Africa, South Asia), where private investors are lacking. Basically, public

investment is supported by direct policies and instruments that promote renewables domestically, such as concessional financing (IRENA, 2020a).[12]

However, the 2008 financial crisis and the subsequent COVID-19 crisis strained public budgets, reducing government infrastructure spending and limiting the use of other instruments, such as grants and subsidies. Alongside more stringent regulations due to the 2008 financial crisis, commercial banks, especially in Europe, have limited their long-term loans. This shift paved the way for alternative funders such as MDBs, national development banks (NDBs), and DFIs. Multilateral DFIs provided 9% of total public finance in renewable energy investment in 2020 (IRENA *et al.*, 2023).

These institutions have effectively bolstered renewable energy projects through risk mitigation tools, standardisation of contracts, and blended finance initiatives, which combine knowledge and resources between private and public financiers. These approaches have been crucial in directly raising funds, mitigating risks (particularly in the early stages of the project), and reducing capital costs. Additionally, these institutions can offer advisory services to bridge transactional knowledge gaps (IRENA, 2020a).

In addition, new business models, such as corporate sourcing of renewable energy, are emerging, showing the growing trend of companies directly generating or procuring their own renewable energy.[13]

2.3 KEY POINTS FOR SCALING UP AND DISSEMINATING FUNDING TO RENEWABLE ENERGY IN EMDES

To facilitate the discussion in this report, key points for scaling up and disseminating private sector funding to renewable energy in EMDEs were grouped into three main categories: (i) energy policy, planning, and regulatory and governance issues, (ii) de-risking and risk-sharing mechanisms, and (iii) creation of a pipeline of bankable renewable energy projects.

However, EMDEs are a large and heterogeneous group of countries (Box 1). As a result, the renewable energy landscape greatly varies among EMDEs, generating different types of risks and financing costs and hence requiring supportive actions for renewable energy deployment.

Box 1
The heterogeneous context of EMDEs

IRENA suggests that EMDEs can be grouped into three groups:

- Countries where the renewable energy sector is well developed and the private sector is actively engaged, thanks to supportive policy environments that make projects bankable. Examples include Brazil, China and India.

[12] *Concessional financing comprises an array of mechanisms and financial supports through below-market-rate products (e.g., loans, grants) provided by development banks and multilateral funds, with the aim of accelerating a climate or development objective. Concessional financing is usually designed to bridge the investment gap to the private sector. However, it represented, together with grants, only 1% of total renewable energy finance in 2020.*

[13] *In 2023, corporate PPAs reached 46 GW of solar and wind power contracts. See: (BNEF, 2024a).*

- Countries that have attracted significant private investments in renewable energy in specific technologies but now face challenges due to technical constraints (grid access, curtailment risk, *etc.*) and bankability risks (predominantly off-taker risk). These issues call for policy adjustments and risk mitigation measures to maintain investor interest and project viability. Examples include South Africa and Viet Nam.
- Countries that struggle to attract private investment due to macroeconomic and political challenges. Even if some renewable energy projects have been completed with the help of MDBs, investments have not scaled up. In these cases, public finance, particularly from MDBs, is vital in shifting the focus from a project's bankability to its ability to have a positive impact, emphasizing investments that align with broader climate, environmental and socio-economic goals. Examples include Mali and Zambia.

This report focuses on the pivotal roles that governments and DFIs play in attracting private investments in renewable energy power projects. However, it does not explore situations where engaging the private sector is exceptionally difficult, thereby justifying a reliance primarily, if not exclusively, on public funding.

Source: (IRENA, forthcoming).

Given the diverse contexts of EMDEs, the discussion in this section does not represent a one-size-fits-all approach. Instead, it draws on successful experiences from certain EMDEs, providing insights that can help increase private sector capital participation in renewable energy expansion.

2.3.1 Energy planning, policy, regulation and governance issues

a. Issues related to energy planning and energy policy

The increasing impact of climate change has made it necessary to prioritise the shift towards renewable energy in development agendas, promoting sustainable growth, economic resilience and social justice. Countries that are still developing can learn from international experiences (IRENA, forthcoming) and take the unique opportunity to bypass traditional carbon-intensive development models.

In this regard, prioritising the energy transition should be at the core of the government's development strategy (Songwe *et al.*, 2022). This strategy should be supported by a compelling narrative that aligns with the Paris Agreement's goals, inspiring stakeholders to commit to a sustainable future.

For that, it is necessary to establish a clear vision and a predictable pathway that positions private investors as critical partners in the development strategy (IRENA, 2023b). It is essential to ensure that the risks associated with energy investments are distributed accordingly, providing rational and transparent justifications for the risk allocation among consumers, taxpayers, financiers and investors to encourage private investment while protecting the public interest.

Setting a timely process for the energy transition under a coherent and comprehensive energy policy is also essential to its success. It requires careful planning and co-ordination of the implementation process, alignment of key milestones, synchronisation of parallel processes to ensure the timely achievement of milestones, and avoidance of significant disruptions.

In addition, finding a balance between decarbonisation targets and immediate priorities is crucial to gaining support from local communities (IRENA, forthcoming). For example, in countries with significant coal or natural gas production, entrenched interests, fuel subsidies, and agreements with independent thermal power producers can impede the adoption of clean energy technologies despite the economic benefits. To accelerate progress towards long-term decarbonisation targets and secure the necessary buy-in from local communities in those cases, a comprehensive approach, including institutional reforms, retraining of the workforce, financial incentives and social initiatives, is necessary and must prioritise early actions that address immediate concerns such as energy security, energy affordability and job creation. In large coal-based economies, this strategy will require offering more concessional financing from international sources to make renewable energy more attractive (ESMAP, 2023).

Another important point of attention for EMDEs is the alignment of energy policy with other governmental policies, such as financial and industrial policies.

Collaboration between financial and energy planning areas (or through their respective entities) is essential to integrate renewable energy sources effectively. It ensures that financial mechanisms are aligned with long-term energy planning and environmental considerations under an effective development based on energy transition. When designing the governmental and financial incentives, this integrated approach must consider each technology's development stage and market readiness, as well as the broader economic and environmental implications of their deployment, including potential competition with other mature renewable energy technologies. In particular, the approach must foster complementary rather than competitive industrial policies and tax benefits for different renewable energy sources in different stages. Furthermore, such an approach can lead to innovative financing models, research and development of new technologies, and policies that support sustainable energy projects.[14]

As environmental, social and governance (ESG) factors become increasingly integral to sustainable finance initiatives, they pave the way for more significant financial support for energy transition. Governments can foster the creation of new green financial instruments and expertise in sustainable finance by establishing universal definitions, standards and regulations for green finance and encouraging financial innovation, while avoiding potential greenwashing (Songwe *et al.*, 2022).

Moreover, governments can direct financial capital toward environmentally sustainable assets. Aligning investment management, risk management and internal training with sustainability targets and adopting best practices can set the stage for enduring success. These practices emphasise supportive good governance, accountability, transparency and internationally accepted climate-related risk analysis and disclosure standards. To drive capital towards sustainable and developmental goals, the financial system must be aligned with these objectives by standardising and streamlining processes such as issuing green investments, incentivising their issuance and certification, and co-funding demonstration issuances. Policy makers and public capital providers can facilitate this alignment through blended finance initiatives that de-risk projects and standardise documentation (IRENA, 2021).

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[14] *According to IRENA (forthcoming), El Salvador's long-term energy planning has played a pivotal role in shaping public policy instruments and regulatory reforms to attract over USD 1.5 billion in investment, with significant private sector and foreign investor participation. These investments are expected to reach more than USD 2 billion by 2026.*

An effective industrial policy is vital when local economic conditions support the creation or expansion of a supply chain associated with renewable energy investments. Fostering local supply chains can lead to significant regional and industrial development but selecting industry sectors carefully based on market forces and regional comparative advantages is critical. When comparative advantages are lacking, strategic decisions must be made to focus support where it can have the most significant impact.

Such a policy should be coordinated across various levels of government and policy areas, including environmental regulations, education and labour, macroeconomic stability, research, development and innovation, and regional development. This integrated approach ensures that the energy sector's transformation is supported by a comprehensive ecosystem, fostering innovation, sustainability and social opportunities. Focusing on positive social impact and synergy with industrial and regional development is essential for achieving a more inclusive and sustainable transition to renewable energy.

As developed countries roll out ambitious energy transition programmes, such as the US Inflation Reduction Act and REPowerEU, the implementation of substantial fiscal incentives in developed countries may trigger demand for similar industrial policies in EMDEs. This could lead to unintended outcomes, including market distortions and the potential for competitive disadvantages for domestic industries that do not directly benefit from these incentives. Moreover, this approach must be adaptable, allowing for continuous evaluation of policy impacts and the flexibility to adjust measures in response to evolving technological landscapes and international market dynamics.

b. Regulatory and governance issues

The institutional and regulatory framework is vital for developing renewable energy investments. An effective institutional and regulatory framework should have legal and regulatory stability, a transparent and accountable regulatory body, financially robust off-takers and appropriate tariff regulation. These elements are fundamental to achieving a sustainable energy transition and meeting global renewable energy targets.

A robust legal framework provides the long-term assurance investors seek when committing to renewable energy projects. Establishing clear, comprehensive laws and regulations with appropriate incentives and consistently applying them ensures legal security for long-term investments and contracts.

Appropriate tariff regulation or market pricing mechanisms are necessary to integrate renewable energies into the broader energy market. Adequate pricing ensures that renewable energy can compete with traditional energy sources and that the pricing reflects the actual cost and value of energy, encouraging more efficient and sustainable energy consumption patterns.

An effective institutional governance framework that clearly outlines the roles and responsibilities of institutions is crucial for the energy industry. It ensures that laws and regulations can adapt to changing conditions and are enforced effectively. In particular, regulations should be flexible enough to adapt to technological advances, consumer preferences and market conditions (IRENA, 2020a). The strength of this framework lies in its ability to minimise the risks associated with policy shifts and regulatory uncertainty, which can hinder investments and slow down the growth of renewable energy.[15] The Energy Sector Management Assistance Program (ESMAP, 2023) argues that inadequate government planning and lack of co-ordination between government entities are among the obstacles to harnessing the socio-economic advantages of adopting a renewable energy strategy.

[15] *According to IRENA (forthcoming), Ghana's energy planning process is an example of how strong governance and broad stakeholder engagement play a critical role in advancing the clean energy transition.*

An effective institutional governance framework generally includes a decision-making body that establishes the primary guidelines for the energy industry based on long-term objectives; an executive body that implements these guidelines; and specific institutions responsible for system operation, market operation and system planning in the case of the power system. While some countries have consolidated these responsibilities into a single agency, others, such as Brazil, have separate institutions for each function. In such a case, clearly defined roles and responsibilities are crucial.

Additionally, the presence of a transparent and accountable regulatory body is essential. Such an entity balances the interests of investors and consumers, ensuring that both parties' needs and concerns are adequately addressed. This balance is vital for maintaining investor confidence and ensuring consumer protection, contributing to a stable and conducive investment environment.

Moreover, environmental licensing agencies equipped with technical staff who possess expertise in energy and environmental planning, as well as in the formulation and execution of public policies, are fundamental to fostering sustainable development in the energy sector. Robust, transparent and streamlined processes for environmental assessments that are compatible with international environmental standards and complemented by transparent and efficient monitoring procedures help align energy projects with social expectations and regulatory requirements.

Sound and transparent statistics and energy planning can provide necessary guidance for (renewable) energy projects. The coordinated evolution of the power system through long-term planning is essential for fostering a sustainable, reliable and efficient energy landscape.

Disseminating information on energy statistics and divulging long-term energy plans can facilitate informed decision making among policy makers, investors, industry players and other stakeholders by offering a clear understanding of the evolution of the country's energy industry.[16] Adequate statistics and long-term energy plans enable a coordinated approach to energy policy, ensuring that development strategies are economically viable and environmentally responsible. Such initiatives significantly mitigate information asymmetry within the market and align market expectations, advancing a more transparent and predictable environment for energy stakeholders (EPE, 2018).

Ranking projects by grid access risk helps environmental licensing bodies adjust to the energy planning strategy and mitigate the environmental risk of projects. Additionally, projects considered in the government's energy planning can be prioritised in terms of environmental licensing or access to fiscal benefits.

Including public consultations and stakeholder engagement in the planning process enhances the legitimacy of the energy strategy and its acceptance (IRENA, forthcoming).[17] This participatory approach ensures that the views and concerns of a broad spectrum of society are considered, leading to more equitable and effective energy policies.

This holistic, integrated energy planning framework not only supports the transition towards a more sustainable energy power mix but also underscores the importance of collaboration, innovation and strategic alignment in achieving energy security and environmental sustainability.

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[16] *Costa Rica's 2019 energy plan, based on transparent open data and scenario modelling, together with the close participation of the financial ministry at an early stage, was critical to mobilizing over USD 2.4 billion from international concessional financing in 2022 (IRENA, forthcoming).*

[17] *In the Philippines, the Department of Energy conducts multiple consultation periods during the development of its energy plan to gather feedback from stakeholders, build consensus and increase participation from society (IRENA, forthcoming).*

For EMDEs lacking the institutional capacity or know-how to manage energy sector data or tackle the technical aspects of regulation, contracts or business models in clean energy sectors, co-operation and technical assistance from international organisations (*e.g.*, institutional multilateral agencies, DFIs, MDBs) can ensure transparency, sound data-driven decision making, and robust policy and regulatory frameworks, ultimately reducing capital costs (IRENA, 2020a).

2.3.2 Setting an appropriate risk-return balance for renewable energy power investments

Without proper risk management strategies, renewable energy projects may involve elevated financing charges, which result in high energy costs for consumers. Risk mitigation (de-risking) of renewable energy projects is particularly significant for EMDEs, where the burden of these increased costs is more pronounced.

Policy makers and public capital providers (*e.g.*, DFIs) can help lower barriers to a greater scale-up of investments in energy transition assets by acting to de-risk projects and mobilise private capital via blended finance initiatives (IRENA, 2020a). Additionally, governments play a crucial role in areas related to supportive policies, stricter regulation, targeted financial support for new technologies, and infrastructure.

Renewable energy project financings are highly structured transactions designed to navigate the risks at different stages of a project's life cycle. During construction, risks include delays, cost overruns and technical acceptance issues. Operational phase risks involve cash flow shortfalls due to weak demand, unexpected operating costs, production disruptions, and force majeure events. Sovereign, country or political risks, such as increased taxation, regulatory changes or expropriation, are present throughout the project's life and more pronouncedly in lower-rated emerging market countries, regardless of the nature of government involvement in the project financing (Walter, 2016). According to (IRENA, 2023b), country and off-take risks are the largest barriers to raising capital to accelerate the energy transition in several G20 countries.

Contractual agreements are central to risk mitigation, with sponsor completion guarantees and fixed-price turn-key engineering, procurement and construction contracts used during construction. Risk management tools may also include a positive and long-term track record of successfully delivering comparable projects and comfort letters, which indicate the sponsor's intent to maintain interest in the project despite a formal guarantee.

Once operational, market risks are addressed through mechanisms like take-or-pay contracts, where purchasers commit to payments regardless of delivery, and insurance contracts. The risk of payment delays can be reduced, for example, by using credit enhancement mechanisms to secure payments or obtaining a DFI guarantee. In some jurisdictions, sponsors or governments can also be required to provide a guarantee to cover losses in case of default (ESMAP, 2023).

Addressing sovereign risk involves including multilateral banks and sovereign lenders in the capital structure and obtaining political risk insurance. In EMDEs, guarantees by international financial institutions, DFIs or governments to mitigate political, policy or regulatory risks, as well as currency risks (see Box 2)[18] and off-taker non-payments, can efficiently leverage private investment, and their availability from public finance institutions is recommended to be increased (IRENA, 2020a).

[18] *The Infrastructure Working Group, one of the seven technical groups in the G20 Finance Track, is discussing the theme of mitigation of exchange rate risk as one of its agenda priorities. This working group is responsible for identifying innovative instruments for mobilizing financial resources for investments (see https://www.g20.org/en/tracks/finance-track).*

Box 2
De-risking currency risk in high-volatility exchange rate countries

Currency risk, stemming from unexpected changes in foreign exchange rates, can significantly reduce the value of investments in renewable energy projects. This risk is substantial when project revenues are earned in local non-convertible currency while debt financing is in hard currency. As a result, the unpredictability of local currency value can lead to variable repayment amounts, increasing credit risk and deterring steady investment, particularly in countries with high interest rates.

Large-scale renewable energy projects are particularly sensitive to exchange rate fluctuations due to their significant upfront capital expenditures and extended return periods. Various risk mitigation strategies are employed to mitigate currency risk and lower the cost of capital. These strategies include government guarantees, currency hedging (via swaps and forwards), and arrangement of financing in local currency or with coverage in PPAs.

Public capital can offset these risks by supporting suitable de-risking strategies, for example providing first-loss capital tranches to absorb currency shocks or offering local currency swap facilities to protect investments from exchange rate volatility. Blended finance with the capacity to mitigate currency risks can thus attract more cautious private investors to renewable energy projects.

MDBs and DFIs can also develop local currency de-risking products to mobilise domestic investors and can design innovative financial instruments to leverage private investment. Partnerships with national banks are essential, enabling MDBs and DFIs to align strategies with local climate plans and amplify the impact of localised efforts.

Currency hedging mechanisms can be prohibitively costly in countries with highly volatile exchange rates. In such cases, MDBs, leveraging their strong credit ratings, can facilitate low-cost currency hedging solutions that might otherwise be inaccessible due to a country's high risk.

Another option to mitigate currency risk exposure is to provide local currency-denominated loans via public investors. This would insulate projects from exchange rate fluctuations and foster the participation of domestic investors. As a strong domestic currency market is not always present in EMDEs, ESMAP (2023) suggests that a partial indexation of PPAs is a way to promote local currency debt and create a market for infrastructure financing (ESMAP, 2023).

Donor-funded mechanisms are indispensable in regions where hedging instruments are unavailable. The Bridgetown Initiative,[19] a climate mitigation trust supported by special drawing rights and donor guarantees exemplifies such initiatives (Convergence, 2023).

[19] *The Bridgetown Initiative is a proposal led by Barbados to restructure development finance by pressing global leaders to act immediately to support developing countries in fighting climate change by providing emergency liquidity in times of natural disasters, expanding multilateral lending to developing countries for climate resilience to USD 1 trillion, and mobilising private sector savings for climate mitigation and reconstruction after a climate disaster (IRENA, 2023a).*

Accessing risk mitigation instruments is often a more significant barrier than lacking instruments (IRENA, 2020a). Over 100 entities, including the Multilateral Investment Guarantee Agency and various development banks, provide such support. Liquidity risks can be managed through escrow accounts or letters of credit.

Other risk mitigation products include support from export credit agencies, local currency lending, currency hedges, and local (or mixed) currency PPAs (IRENA, 2020a) stand. Sellers of equipment for the project and/or their export credit agencies may also be willing to provide specific guarantees.

Another important issue for EMDEs is the insufficient and unreliable grid infrastructure, aggravated by high transmission and distribution losses. High and unanticipated curtailment risks can severely affect the financial sustainability of renewable energy projects. Moreover, the curtailment risk, real or perceived, may delay project development until the grid is reinforced (ESMAP, 2023).

Even when renewable projects are sufficiently de-risked and standardised and have adequate grid access, investors rarely finance entire projects themselves (IRENA, 2020a). In this regard, blended financing, involving a mix of providers – including institutional investors, developers, commercial banks, and multilateral, regional and national development banks – has proven effective in sharing risks and returns. These arrangements are particularly beneficial for institutional investors new to the renewable sector. These investors can leverage the financial and legal expertise and access to low-cost capital of more seasoned parties, such as DFIs.

For public capital providers, blended finance structures attract private investment and stimulate local commercial markets. Risk mitigation solutions often complement these structures to enhance transaction risk-adjusted returns.

2.3.3 Setting a pipeline of bankable projects

According to ESMAP (2023), the limited availability of viable renewable energy projects poses a greater challenge than financing them. Therefore, increasing the number of bankable projects is a necessary step for a sustainable future.

Project pipelines must be developed to make energy transition projects bankable and increase their ticket size, making them more attractive to large investors. Achieving this involves providing more risk mitigation instruments from public financiers, standardising contractual agreements, aggregating projects into larger transaction blocks, and expanding the use of blended finance initiatives between public capital providers and institutional investors.

Creating a positive ecosystem for a pipeline of good renewable projects is essential for accelerating the transition to sustainable energy. Such an ecosystem requires adequate conditions for project developers to prepare and execute renewable energy projects. A concerted effort is needed to develop an effective project accreditation system, streamline processes through a one-stop shop, and ensure the availability of skilled professionals.

Having an entity or mechanism that can analyse and accredit projects based on well-defined criteria is crucial. This entity should be capable of assessing projects from various critical perspectives, including engineering, environmental, social and financial. In Brazil, the EPE ensures that projects that will bid in the government power auctions meet the highest sustainability and feasibility standards through a clear and transparent qualification process. This helps prepare projects more likely to succeed and builds confidence among investors and financiers in the renewable energy sector.

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The concept of a one-stop shop plays a pivotal role in simplifying and streamlining the process for investors by reducing transaction costs and bureaucratic hurdles. A one-stop shop would serve as a central point where project developers can obtain all necessary information, approvals and services to take a project from conception to execution. This could include licensing assistance, access to renewable resource data, environmental and social impact assessment guidance, and connections to potential financiers. By making the process more efficient, the one-stop shop facilitates faster and less costly development of renewable energy projects.

Another critical element is ensuring the availability of skilled professionals trained to develop these projects. This includes engineers capable of designing viable and sustainable renewable energy systems, experts who understand the intricacies of licensing processes and environmental regulations, and professionals with the know-how to secure funding for such projects. The lack of qualified professionals can be a significant bottleneck in developing good renewable energy projects. Therefore, investing in education, training and capacity building is essential to creating a pool of talent that can support the sector's growth.

3. THE BRAZILIAN CASE: A BRIEF DESCRIPTION OF THE INSTITUTIONAL FRAMEWORK OF THE ELECTRICITY SECTOR

KEY INSIGHTS:

1

The Brazilian electricity sector is governed by a comprehensive framework involving various authorities, with the National Energy Policy Council setting the primary directives and the MME implementing these directives. This centralised approach ensures coherent planning and regulation to ensure energy security, attract private capital and efficiently manage the country's energy resources.

2

Centralised energy planning is a key aspect of the Brazilian electricity sector. The EPE was created to reorganize and strategically align Brazil's national energy planning to ensure the timely deployment of energy supply and address demand growth with competitive costs and minimal socio-environmental impacts.

3

The EPE has supported the integration of renewable energy sources into Brazil's power system. Through the development of an extensive database, transmission expansion studies and supporting the improvement of PPA conditions, the EPE has significantly contributed to mitigating risks for renewable energy projects.

4

Power auctions have diversified Brazil's energy supply, reducing reliance on hydropower and integrating renewables like wind, biomass and solar through incentives ranging from technology-specific auctions to transmission tariff discounts.

5

The unregulated power market is emerging as a key driver for renewable energy expansion, with significant projected growth in wind and solar power, facilitated by BNDES financial policy changes.

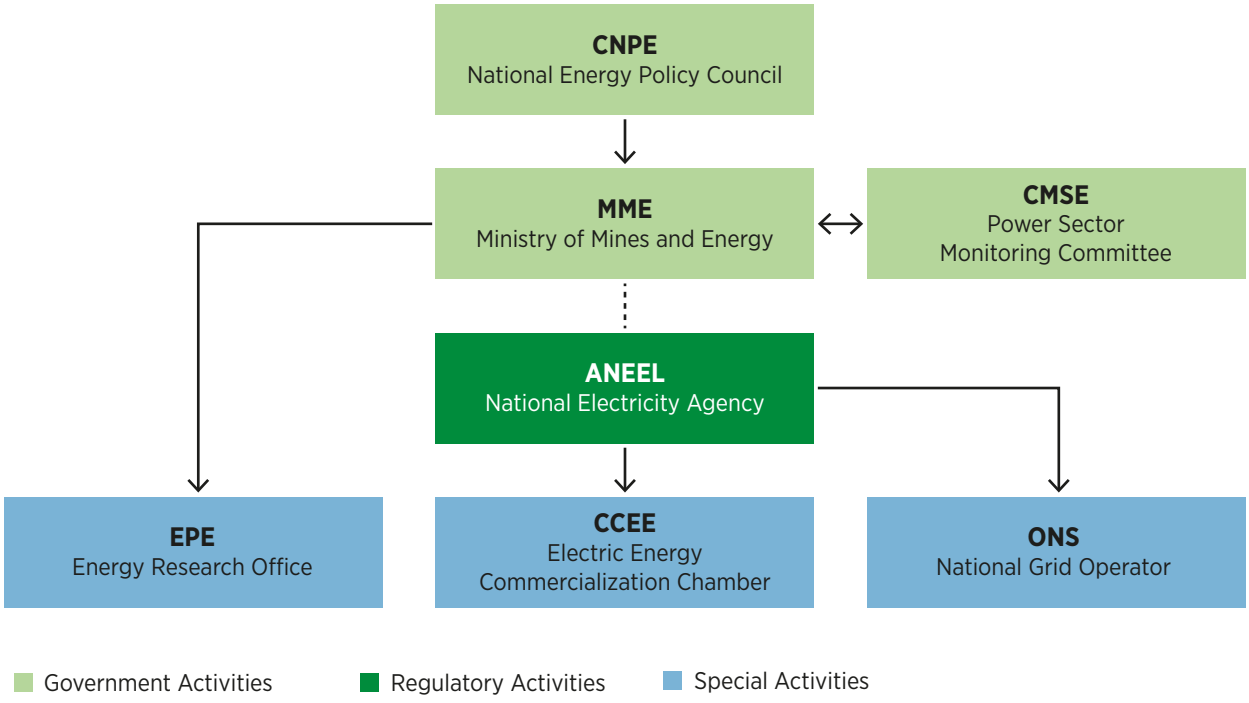
3.1 INSTITUTIONAL AND REGULATORY FRAMEWORK

3.1.1 Institutional framework

Several authorities govern the Brazilian electricity industry (Figure 8).

The National Energy Policy Council (CNPE), a cabinet-level advisory board to the president, defines the primary directives. It is co-ordinated by the Ministry of Mines and Energy (MME), with the participation of other executive and regulatory agency members and senior officials. Among several energy-related issues, the CNPE is responsible for proposing the national energy policy, the country's reliability criterion for the power sector, and indicating power plant projects deemed strategic and public interest.

Figure 8 Institutional agents in the Brazilian power sector



Source: (Tolmasquim, 2015).

The MME is responsible for formulating and implementing the directives approved by the CNPE and planning the energy industry. It is the energy industry's ultimate granting authority, although the MME delegates some of its granting authority to regulatory agencies.

The National Electricity Agency (ANEEL) is the electricity industry's regulator. It is responsible for regulating the federal government's policies and guidelines on the use and operation of electricity services by agents in the sector (*e.g.*, regulated and free consumers, independent producers and self-producers). It is also ANEEL's responsibility to define service quality and service standards, regulate the tariff for regulated consumers, promote power auctions, and provide grants to research and development and energy-efficiency projects that are considered to meet the technological challenges of the electricity sector.

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The National Grid Operator (ONS) defines and oversees the centralised system of power plant dispatch. It is a private institution that acts with ANEEL's authorisation and oversight. The ONS is also in charge of short-term transmission planning.

The Electric Energy Commercialization Chamber (CCEE) is the Brazilian market operator and is responsible for power trading management, promotion of energy procurement auctions when delegated by ANEEL, and the market clearing and settlements in the Brazilian power system.

The EPE is a federal agency linked to the MME. Its primary responsibility is to provide technical expertise to the MME through energy planning studies, such as the assessment of energy potential, technical studies to support power generation expansion and transmission facilities, and consolidation of the national energy statistics. It is also responsible for obtaining the preliminary environmental licence for strategic hydropower plants and granting the technical qualification required for a power project to bid in the power auctions (see Box 3).

The Power Sector Monitoring Committee (CMSE) was created in 2004 to monitor short-term power supply conditions. The committee is an advisory board, co-ordinated by the MME, comprising representatives of the Brazilian power authorities. For energy security reasons, the committee may override ONS power plants' dispatch.

3.1.2 Regulatory framework

Brazil's power sector regulatory framework comprises a collection of laws, decrees and resolutions by the National Congress, the MME and ANEEL. The current regulatory framework of the Brazilian power system has its foundations in the institutional reform that resulted in the new model of the electricity sector (NMSE) in 2004. The NMSE aimed to restore resource adequacy to investment, ensure energy security and attract private capital to the power sector by establishing a stable regulatory framework based on energy supply security, affordable tariffs and energy planning to meet demand growth.

The reform brought about by the NMSE segregated the regulated market for distribution companies from a free market where independent power producers, energy traders and free consumers operate.

Long-term PPAs were introduced in the regulated market to reduce price volatility and provide a stable revenue stream as collateral for financing new projects. According to the NMSE, distribution companies

and free consumers need contractual coverage, and any imbalances should be settled in spot markets. Furthermore, all contracts must be backed by physical coverage (a power plant that can reliably deliver the contracted energy), certified by the MME.

One key aspect of the NMSE has been the procurement of long-term energy and capacity through regular public energy auctions targeted at the regulated market. These auctions have played a vital role in beginning renewable energy source development in Brazil.

To participate in these energy auctions, a power plant project must first obtain the technical qualification from the EPE. This technical qualification involves an analysis of several factors, including environmental licensing,[20] access to the electricity grid, the technical and economic feasibility of projects, and the amount of energy that can be sold.

3.2 SYSTEM PLANNING AND OPERATION

The NMSE revitalised the MME's planning role in overseeing the sector. The EPE, responsible for expansion planning, and the ONS, which handles operational planning, carry out institutional planning functions. Expansion and operational planning activities are complementary, especially in the transmission segment.

Brazil's continental size and the distance of main energy resources from major consumption centres result in large electricity flows across the country. Historically, these flows have reflected hydropower dispatching, which aims to optimise water storage in the reservoirs of hydropower plants to minimise risks during adverse hydrological years. However, with the limitations of expanding the hydropower and thermal power potential, the power mix in Brazil is expected to increasingly reflect the growing importance of new renewable energy (*e.g.*, wind, solar). However, as these resources are also distant from the major consumption centres, expansion of regional interconnection is still required.

Generation expansion is based on contracting new power plants to meet the demand growth of regulated consumers[21] through power auctions, self-production for large consumer needs, and the free market (see Section 3.5).

Transmission network expansion reflects the expected load demand growth, the fact that the main energy resources are far from the most important load centres, and the reinforcements required to improve the reliability and security of the energy supply. Network expansion is defined by the MME, who determines which transmission facilities from ONS and EPE recommendation studies are implemented.

Investment depends on the attractiveness of the Brazilian power sector, which relies on the expected evolution of generation costs and demand growth. The EPE helps reduce information asymmetry among investors through its regular and publicly released studies. Its two main flagship reports are the National Energy Plan and the Ten-Year Energy Expansion Plan.

[20] *Environmental licensing is the administrative procedure designed to license activities (or undertakings that use environmental resources) that may cause environmental degradation or damage according to the National Historic and Artistic Heritage Institute. Environmental licence applications are made to the Brazilian Institute of Environment and Renewable Natural Resources, a federal agency linked to the Ministry of the Environment, which is responsible for checking whether the power plant project follows the legal guidelines of the National Environmental Policy set by the National Environmental Council.*

[21] *Regulated consumption accounted for about 60% of the total load in Brazil in 2023.*

The National Energy Plan 2050 sets the government's long-term strategy for using and expanding the country's energy resources by 2050, with considering energy transition and future uncertainty. The plan highlights the need for continuous monitoring and for flexibility to adapt to unpredictable events, thus ensuring that strategies remain relevant and effective in the face of future uncertainties.

In the Ten-Year Energy Expansion Plan, the EPE analyses scenarios for energy consumption growth and the respective energy industry expansion. Concerning electricity markets, the plan considers such factors as load growth, consequent power generation and transmission expansions, and information from the most recent power and transmission auctions (see Box 3).

Box 3
The EPE's role in fostering renewable energy in Brazil

The EPE was created to reorganise national energy planning to strategically align research, development and the country's energy resources to ensure timely deployment of energy supply (in line with demand growth), competitive costs and prices, and minimal socio-environmental impact (Tolmasquim, 2015).

The EPE's mandate extends beyond expanding power systems to include the entire energy sector, including oil, gas and alternative fuels, and inform an integrated energy policy that reflects the country's realities and needs. The EPE has been actively involved in major discussions concerning the Brazilian energy sector, from electricity regulatory framework modernization to assessments of oil and gas resource areas, energy efficiency initiatives, and definition of the energy industry's contributions to GHG emission goals for a low-carbon economy (EPE, 2016a).

Besides the long-term energy planning studies, the EPE is also responsible for the methodology design and preparatory studies for power generation and transmission auctions, particularly the definition of price caps by technology (EPE, 2016a).

The EPE has been instrumental in addressing the integration of modern renewable sources – like wind, solar PV and biomass – into the power system. The EPE's contracting models for wind and solar PV generation, which allowed for the intertemporal compensation of production variation, have successfully integrated these sources into Brazil's energy matrix. This "virtual reservoir" accounting concept has been instrumental, especially for the wind sector's expansion (Tolmasquim, 2015).

The EPE has been key in managing information for Brazil's wind power generation sector. It developed an extensive database to process data from hundreds of anemometric measurement stations. This information is crucial to enhancing understanding of wind resources and refining methods and models for integrating non-dispatchable sources into the system grid, as well as improving energy contracting models to mitigate risks for developers and promote prudent contracting, respecting the characteristics of each source. Moreover, the rapid increase in the number of wind power projects interested in participating in the power auctions led to the development of a geo-referenced database, which allows the EPE to identify project interferences and potential socio-environmental conflicts and assists with transmission system expansion planning (EPE, 2016a).

The EPE's studies are critical in the lead up to the transmission network expansion auctions. Unlike generation studies, which indicate future expansion, the transmission projects recommended by the EPE's planning studies are the projects the federal government auctions off.

Designing a transmission system that can move large amounts of energy over long distances while taking social and environmental impacts and restrictions into account is extremely challenging given the continental size of Brazil, the concentration of wind and solar potential in the Northeast Region, and the high energy demand in the Southeast and South Regions of the country. The EPE conducted critical studies on expanding subsystem interconnections, including the evolution of socio-environmental aspects of transmission project corridors to facilitate the integration of significant amounts of renewable energy from the Northeast Region. The EPE also proposed a crucial solution to solve a vital transmission bottleneck by conceptualizing the substation hubs to integrate wind farms into the main grid (Tolmasquim, 2015).

Besides its institutional role, the EPE also played a critical role in improving the financing conditions offered by the BNDES for power generation projects. Upon request from agents of the electricity sector, the EPE acted as an effective mediator with the Ministry of Finance and the MME to bring about significant changes, which included an increase in the amortization period and a reduction in the debt service coverage ratio (Tolmasquim, 2015).

With the (current and expected) increasing participation of new renewable power plants in the Brazilian power system, generation and transmission expansion planning has changed. Generation expansion planning has adopted a new criterion for security of supply in the electricity market to reflect the larger shares of variable energy sources. Transmission expansion planning had to incorporate different scenarios for the generation expansion due to the construction times of wind and solar power projects being shorter than those of transmission facilities (because of more stringent environmental regulation).

3.3 COMMERCIAL ARRANGEMENT: REGULATED AND FREE MARKETS, DISTRIBUTED GENERATION

The NMSE has introduced two distinct markets for power contracting, or "contracting environments": the regulated market and the free (unregulated) market.

In the regulated market, regulated consumers purchase energy through their distribution companies in regularly scheduled government-organised public power auctions, with the most competitive projects securing long-term PPAs. These PPAs allow new power projects to be funded via project finance.

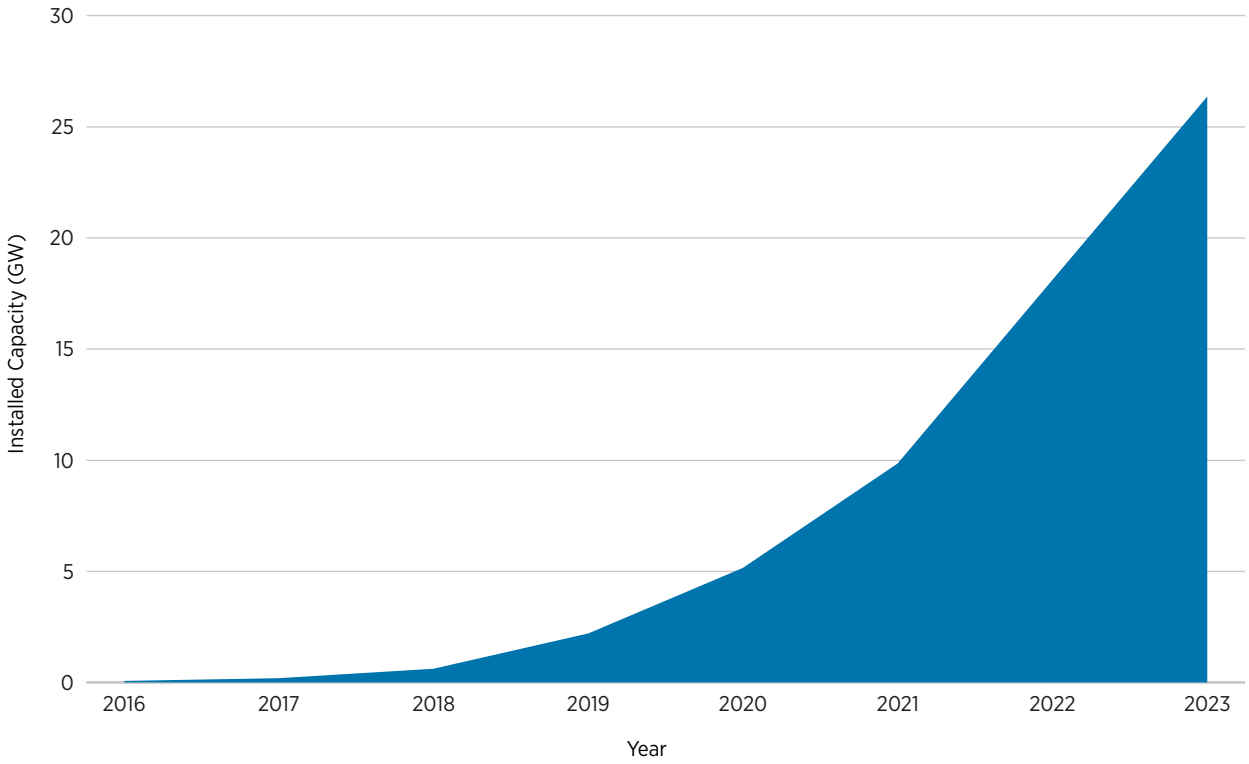
In the unregulated market, consumers are free to negotiate their PPAs with generators or traders, and rates and general conditions are bilaterally agreed on over the counter.[22] Nonetheless, all PPAs must be registered with the CCEE. In Brazil, the agent can generate power for its own use. Large consumers are called self-producers, accounting for approximately 9% of total electricity consumption in Brazil (EPE, 2023). Small consumers, such as households and those in rural areas, can provide their partial or total consumption through distributed generation.

Since ANEEL implemented a net metering system in 2012, distributed generation capacity from renewable resources, primarily solar energy, has soared. Currently, there are 2.2 million distributed generation plants in the country, servicing 3.2 million consumer units and representing 25 GW of distributed generation capacity (Figure 9). Solar energy is now the second-largest source in the national electric matrix, with about 70% of that solar power coming from distributed generation (Canal Energia, 2023).

In Brazil, distributed generation is divided into two subgroups: micro-generation and mini-generation, regulated by ANEEL. These small-scale decentralised generation units are connected directly to the purchaser's distribution system and are not centrally dispatched by the ONS.

In 2022, Brazil introduced a new regulatory framework for distributed generation, maintaining some incentives from 2012 for existing distributed generation producers until 2045.

Figure 9 Expansion of solar photovoltaic distributed generation installed capacity in Brazil



Source: EPE.

[22] *Bilateral contracts have been allowed since the 1990s reforms in Brazil but were limited to large consumers until recently. In the NMSE, for consumers to be eligible to participate in the free market, they needed to have at least 3 megawatts of load and at least 69 kilovolts of tension. These limits have been reduced over time. As of 2023, consumers are deemed free if their load is at least 0.5 megawatt, and there is no limit on tension.*

3.4 MECHANISMS FOR THE INTRODUCTION OF RENEWABLES: PROINFA AND AUCTIONS

The Programme of Incentives for Alternative Electricity Sources (PROINFA) was introduced in 2002 to give cost advantages to renewable energy sources through a levy paid by energy customers, incentivising wind, biomass and small hydroelectric plants. PROINFA was a feed-in tariff programme with additional benefits, such as the reduction of tariffs by 50% for the use of transmission and distribution systems for wind energy and a quota system through auctions to promote renewable energy.

In 2004, Brazil revamped its legal framework for the energy sector with policy directives aimed at expanding and diversifying the energy matrix, securing supply and ensuring access to energy at affordable tariffs.

An auction-based contracting mechanism was introduced, under which distribution utilities signed PPAs with power generators based on the lowest bid prices. These PPAs ensured a fixed-price sale of energy over the long term, indexed annually to consumer inflation, providing a stable revenue stream for energy projects. Moreover, PPA contracts were adjusted to better reflect the generation profile of variable renewable energy sources.

The government arranges a pool of distribution companies for each power auction, and winners sign bilateral contracts with each distribution company, diversifying the risk. In addition, distribution companies must provide an assignment of accounts to the independent power producers, ensuring that the energy purchase contracts are prioritised for payment.[23]

Energy acquisition auctions are characterised by a public tender, with the winning bidder offering the lowest price per unit of energy. ANEEL announces auctions based on the guidelines set by the MME, with the EPE defining eligible generators to participate in the power auctions. The CCEE then conducts the auction and contracting process. Contracting auctions for new power projects commonly work with an energy delivery period of three to six years.

The MME determines the contract modality offered in each auction. Contracts are offered either in the form of quantity or availability contracts.[24] Energy auctions and contracts have evolved to include different risk allocations and delivery obligations for various energy sources.

Until 2017, availability contracts were preferred for renewable energy source projects due to predictable risks; however, these contracts transferred market risks to consumers.[25]

Since 2018, auctions have moved towards quantity contracts for renewables, reflecting the improved ability to forecast renewable generation and the increased technological maturity. These contracts allow generators some flexibility, within specified limits, to match the consumer's load profile. More recently, capacity-only auctions have also been conducted because of the increased participation of new renewables in the energy mix.

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[23] *The revenues from bilateral contracts are deposited into a designated bank account under the supervision of a managing bank, which ensures that energy purchase contracts are paid before the funds are made available to the distribution companies (Tolmasquim et al., 2021).*

[24] *In quantity contracts, consumers pay a known price in Brazilian real (BRL) for the energy (megawatt-hours) agreed to be delivered by the project. The seller should settle any production mismatch in the short-term market. In availability contracts, consumers pay a known price in BRL for the project to be available when needed during the contract term. Additionally, consumers incur the project's operating costs whenever the system operator dispatches the project. Currently, availability contracts are only offered to thermal power plants in the regulated market.*

[25] *Up to 2015, availability contracts with more mitigated risk provisions were offered in special auctions known as "reserve energy auctions". In the reserve energy auctions, the government purchased the reserve energy to guarantee the security of the system's supply. Besides a fixed payment to deliver the contracted energy, the government offered contracts with a tolerance band in which production mismatch would not result in losses for the wind and solar power generators.*

From 2005 to 2023, the Brazilian government conducted more than 40 rounds of greenfield power project auctions, predominantly for renewable energy sources. This reform led to a diversified energy supply, reducing reliance on large hydropower plants and integrating significant contributions from wind, biomass and solar energy.

Besides technology-specific auctions, the government also granted fiscal and cost incentives to less mature renewables, such as tax exemptions on equipment and components, other tax incentives, a reduction in the tariff for the use of the transmission and distribution system, and a band system that ensured revenue within a specified generation range of the energy contracted. Conditions for long-term finance from BNDES were adapted to the industrial supply chain associated with wind energy.

The auction scheme has also promoted the growth of variable renewable sources in Brazil. Notably, wind and solar energy are now very competitive due to technological advances and local investment capacity, despite challenges posed by construction delays, a large local equipment provider bankruptcy and changes in the country's economic conditions (Tolmasquim *et al.*, 2021).

3.5 CURRENT DYNAMICS OF EXPANSION VIA THE FREE MARKET

The regulated market has historically driven renewable energy expansion in Brazil through public energy auctions that offer long-term, publicly traded PPAs. Free market PPAs, on the other hand, are traded over the counter, exposing consumers to the developer's credit risk and much shorter horizons.[26]

Nonetheless, the free market has recently emerged as a fundamental alternative for wind and solar power projects, especially after BNDES implemented essential changes in its financial policies for projects in the free market in 2019.

The power expansion in the free market accounted for 34% of the total expected growth in the centralised system in 2019. An overwhelming 92% of the additional of installed power capacity expected to be operational in the next five years is projected to serve free consumers. Moreover, more than 97% of the forecasted solar PV centralised generation and 91% of the wind farm expansion to start operations in the next five years are intended for free consumers (ABRACEEL, 2023).

The free market is anticipated to be the principal driver for power supply expansion in the coming years, especially as more consumers become eligible to participate. This shift is partly due to consumer migration from the regulated market to the free market, motivated by the high tariffs in the regulated market.

[26] *According to ABRACELL (2023), approximately 31% of PPAs in the free market have a contract duration of less than 10 years.*

4. THE ROLE OF BNDES IN PROMOTING RENEWABLE ENERGY SOURCES

KEY INSIGHTS:

1

BNDES has been instrumental in offering supportive financing conditions and risk mitigation strategies to make renewable energy projects more financially attractive and stimulate private investments in complex, higher-risk projects.

2

BNDES has strategically focused on promoting the decarbonisation of Brazil's energy sector. This effort aims to transform Brazil into a leading manufacturer of green products by leveraging its clean energy capabilities.

3

BNDES has invested around USD 100 billion in renewable energy projects, including new power capacity and transmission lines, from 2000 to 2023. This financial support has been crucial in expanding Brazil's renewable energy infrastructure, positioning BNDES as a key player in the global renewable energy financing landscape. The positive environment created for private investment with the assistance of energy planning authorities has played a significant role in this success.

4

BNDES has pioneered the development of green finance in Brazil. BNDES's innovative financial instruments have set a benchmark for financing renewable energy projects.

5

BNDES has played a pivotal role in attracting leading global wind turbine manufacturers to Brazil, encouraging local production of technology-intensive components, developing a robust domestic supply chain, enhancing timely project development, and creating qualified job opportunities and local innovation.

6

BNDES's adaptive financial and policy frameworks have been critical not only to investment in projects for the regulated market but also in the development of the free (unregulated) market, currently the main source of renewable energy expansion in Brazil.

BNDES was established in 1952 to finance projects to support Brazilian development under federal government policies. Initially focusing on infrastructure, BNDES has expanded its support to include the Brazilian capital goods industry, services and agribusiness sectors, reflecting the country's development goals over the past seven decades.

BNDES's long-term experience in social and environmental initiatives has oriented its financial instruments to accelerate the country's transition to an integrated development model (BNDES, 2022b). BNDES's use of blended finance and match funding instruments to raise private capital for investments has significantly contributed to formulating and implementing impactful public policies in close collaboration with the private sector (BNDES, 2023b).

BNDES's traditional funding sources are quasi-public funds from workers' insurance funds, returns on outstanding loans and equity investments, and borrowing from the federal government,[27] complemented by federal funds, bond issuances in domestic and international markets, and international multilateral institutions.[28]

BNDES facilitates financing through various means, including loans (directly or through commercial banks); grants supporting social, cultural and technological initiatives; and equity investments in State-owned and private companies. It prioritises funding investment projects and exports of large Brazilian firms, which are considered to have the potential to contribute to the economy through positive externalities and social returns.[29]

The bank also uses indirect tools, such as equalised interest rates and credit guarantees for specific loans, available to all banks. However, high interest rates on public debt pose challenges to the cost-effectiveness of these indirect credit mechanisms.

Projects supported by BNDES may require corporate or banking guarantees from the companies participating in the loan, especially during construction, thus encouraging developers and their private bankers to contribute more to the infrastructure funding (Studart and Ramos, 2018). The bank conducts thorough assessments of projects requiring its financial products by evaluating the projects' potential economic contribution, their alignment with strategic public policies, their technical and financial coherence, and the creditworthiness of the project owners. If the loan is granted through commercial banks, the partner bank assumes the credit risk associated with the loan.

Access to BNDES's long-term financial resources allows private banks to expand their services – such as advisory services, collaterals and insurance – to developers and to better assess the industry's credit risk (Studart and Ramos, 2018). This enables the bank to finance the best clients and potentially lead long-term finance consortia. For BNDES, using the financial system increases the geographical reach of its financial products.

Studies have shown that BNDES loans have positively impacted the Brazilian economy through job creation, exports and investments, with less significant effects on overall productivity (Ribeiro, 2018). Evidence shows that BNDES loans can affect investment, exports and economic activity, especially for micro, small and medium-sized enterprises (Barboza *et al.*, 2020).

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[27] *In the 2008 international financial crisis, the federal government emerged as the primary source of the bank's funding. BNDES became the main instrument for Brazil's counter-cyclical fiscal policy because private commercial banks reined in their lending. In less than ten years (2017-2015), the share of the federal government's loans in BNDES funding sources jumped from 6% to 56% (Torres and Zeidan, 2016). After a stringent repayment policy launched in 2016, BNDES reduced that percentage to 7% by 2022 (BNDES, 2023b).*

[28] *In 2022, BNDES funding from multilateral organisations, such as the Inter-American Development Bank, the Japan Bank for International Cooperation, Kreditanstalt für Wiederaufbau, New Development Bank, and Agence Française de Développement, amounted to roughly to USD 7 billion, mainly supporting renewable energy projects, energy efficiency, urban mobility and micro, small and medium-sized enterprises (BNDES, 2022b).*

[29] *BNDES is subject to financial regulations such as Basel indices. It has one of the lowest default rates in the Brazilian financial system (Ferraz et al., 2022).*

BNDES has also contributed to building a financing structure for complex and potentially higher-risk projects. Therefore, by providing favourable financing conditions in relation to maturity and cost, BNDES helps increase the projects' financial attractiveness and reduce energy prices for power projects.

BNDES played a crucial role in developing the infrastructure bond market and increasing private sector participation. In 2011, the Brazilian government started efforts to foster the infrastructure bond market through various measures, including tax benefits for investors.

BNDES supported the initiative by adjusting financing conditions to make infrastructure bonds more attractive. These adjustments included adding guarantee-sharing clauses to reduce the coverage ratio of debt services and equalising the level of seniority of bondholders to loans co-financed by the bank (Studart and Ramos, 2018).

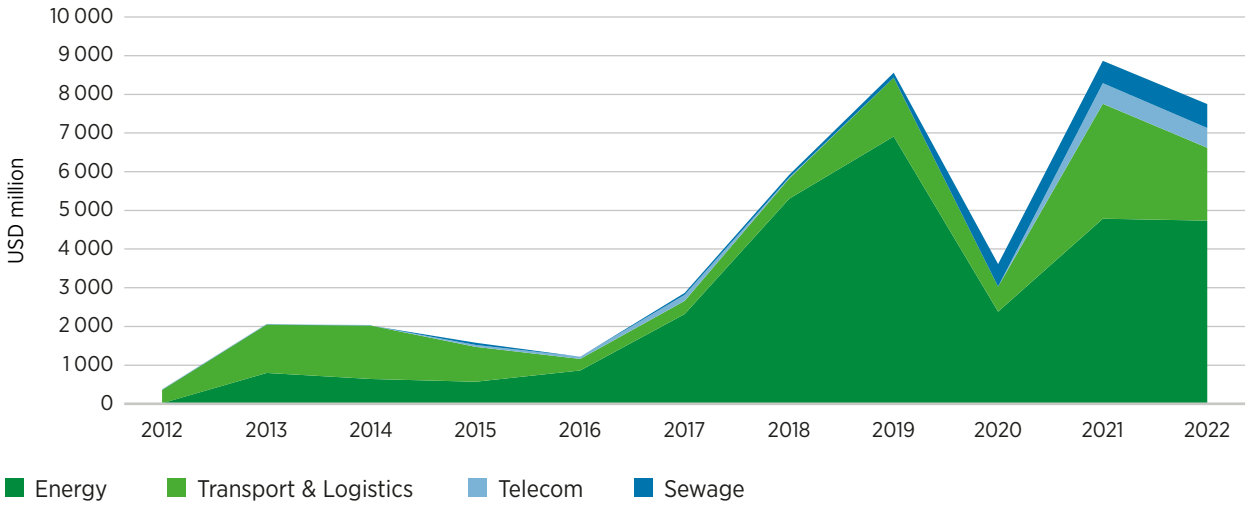
However, in the initial years, the outcomes were not as significant as expected, mainly due to the challenging macroeconomic environment, high corporate debt levels, and steep learning curve for issuers and investors.

In 2015, the context became even more complex due to fiscal adjustments and reduced public investment. As a result, the government halted loans for BNDES, which led to increased efforts by the bank to support the infrastructure bond market through additional risk mitigation and pricing incentives.

These efforts eventually contributed to the development of the infrastructure bond market, particularly for generation and transmission projects (Figure 10). From 2012 to 2022, these projects account for roughly 58% of the estimated capital expenditure for projects that utilized this type of funding (Ministério da Fazenda, 2022).

Nonetheless, institutional investors like pension funds, which have significant assets that could be directed towards infrastructure, still invest only a small fraction of their portfolios in this asset class. This is attributed to uncertainties in project revenues, especially in the early stages; the upfront nature of the infrastructure investment; and the conservative investment preferences of Brazilian pension funds for low-risk assets in a high-interest country (Studart and Ramos, 2018).

Figure 10 Infrastructure debenture issuance

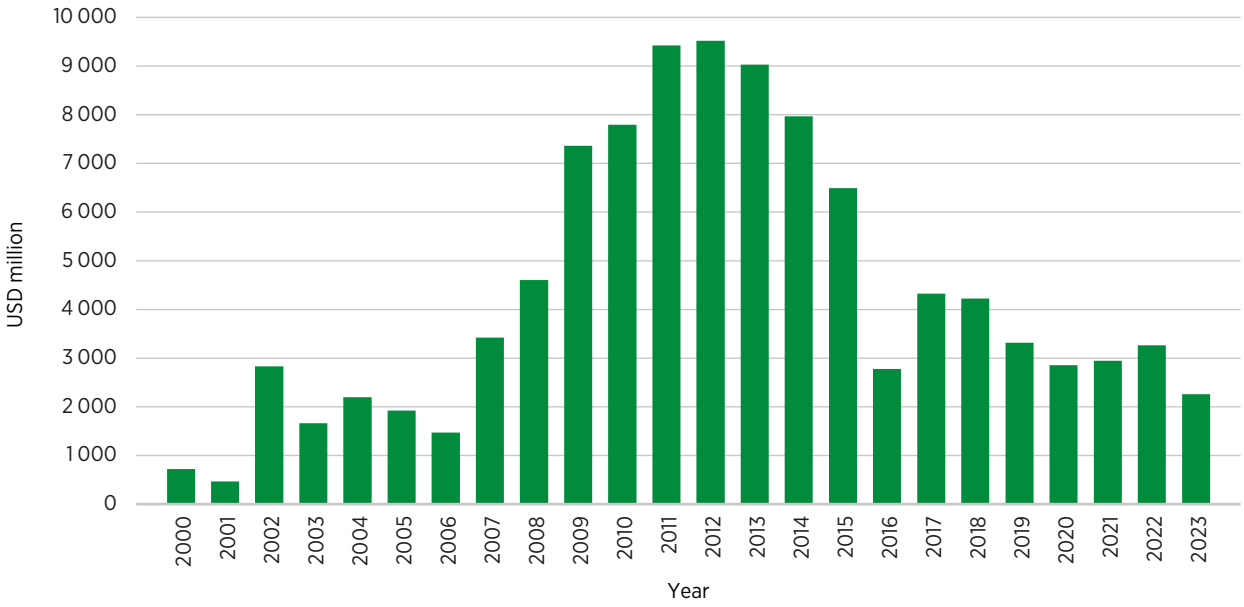


Source: Ministério da Fazenda (2022).
Note: BRL values were converted using the average annual exchange rate.

4.1 RELEVANCE OF BNDES FOR THE ENERGY SECTOR

In its current climate strategy, BNDES has pinpointed crucial sectors for intervention. In the energy domain, the bank supports several initiatives. These include promoting the decarbonisation of Brazil's energy matrix through energy-efficiency projects, supporting the production and use of bioenergy – including ethanol, biogas and biomethane – new sustainable fuels, and encouraging power generation from renewable sources. In addition, BNDES is involved in structuring low-carbon hydrogen projects for domestic consumption and international export. These actions are intended to position Brazil as a leading manufacturer of green products, capitalising on its clean energy capabilities (BNDES, 2023b). In the electricity sector, BNDES has been fundamental to financing the deployment of new power capacity and transmission lines, with a financed amount of approximately USD 102 billion from 2000 to 2023 (Figure 11). In terms of power capacity, this financial amount corresponded to 81.6 GW in additional power capacity (out of 125 GW of total power capacity expansion) and 67 thousand km in transmission lines.

Figure 11 BNDES financing to new power capacity and transmission lines (2000 – 2023)



Source: Authors based on data from (BNDES, 2024).

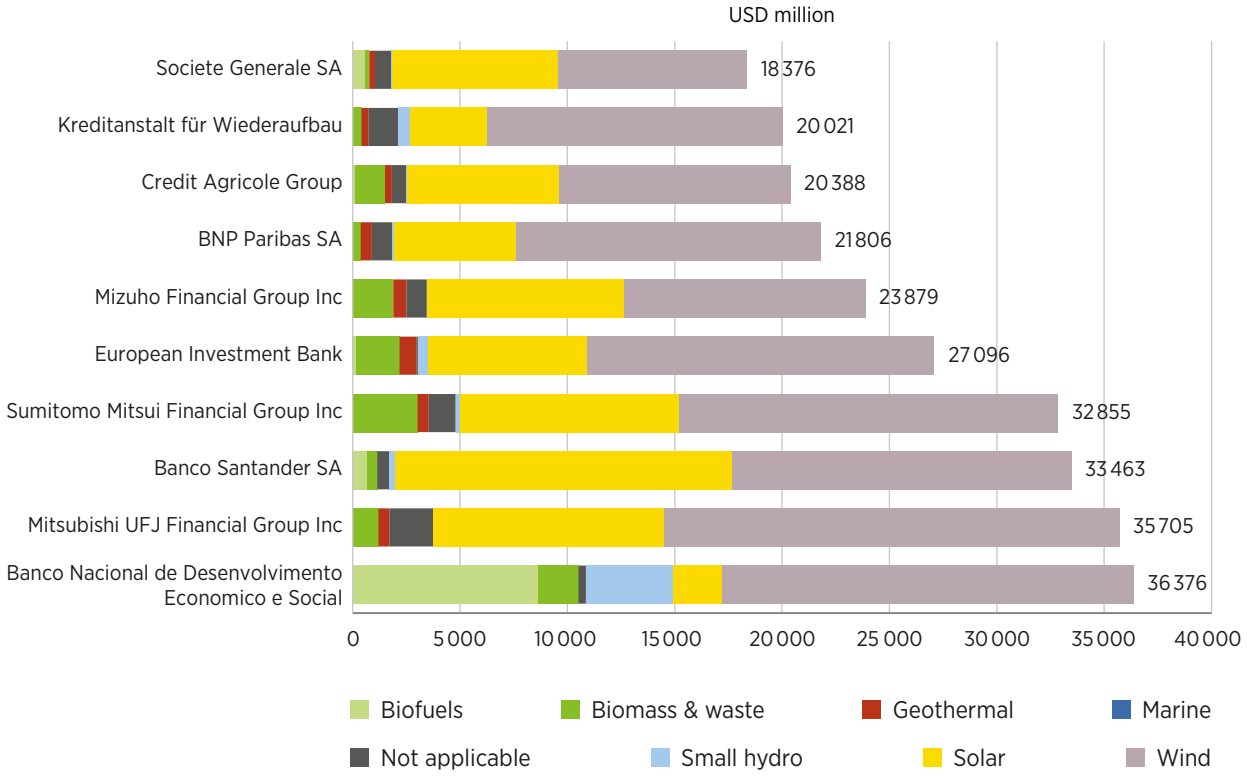
Note: The USD values were calculated by converting BRL monthly values using the average monthly exchange rate and then summing the nominal values for the year.

BNDES has played a crucial role in Brazil's renewable energy financing.[30] Even when compared to international levels, the financed amounts are expressive. According to BloombergNEF, BNDES was the leading international financial institution in terms of lending for new renewables (wind, solar, biofuels, biomass, etc.), providing more than USD 36 billion from 2004 to 2023 (Figure 12) (BNEF, 2024b).

In addition to being a major proponent of renewable energy in Brazil, BNDES stopped financing coal-fired and oil-fired thermal power plants and coal mining for the supply of thermal power plants as of 2021 (BNDES, 2023b).

[30] *Banco do Nordeste do Brasil (BNB), which is responsible for managing constitutional funds directed to regional development in the Northeast Region and the north of Minas Gerais and Espirito Santo, also offers attractive financing conditions for renewable energy sources, particularly for solar power energy and distributed generation, in its area of operation. BNB is Latin America's largest regional development bank.*

Figure 12 Top clean energy project lenders, 2004-2023



Source: (BNEF, 2024b).

4.2 ROLE OF BNDES IN THE INTRODUCTION OF NEW RENEWABLES IN BRAZIL

The expertise from financing the deployment of large hydropower plants that BNDES obtained from 1990 to 2010 had to be adjusted to the typically smaller, less complex and faster-to-implement renewable energy projects when variable renewable energy sources started to gain more importance in the Brazilian power expansion. For example, this adaptation involved changes in project development analysis and contractual agreements.

The first experience with variable renewable energy sources was the PROINFA programme, which introduced a feed-in-tariff scheme and contracted the initial 1.4 GW of wind power projects in 2004, representing Brazil's large-scale introduction of wind technology (Losekann and Hallack, 2018).[31]

BNDES was essential in structuring PPAs and respective finance guarantees for PROINFA, helping with project de-risking, and facilitating project finance. The PROINFA marked the start of the use of project finance for new renewable energy projects on a larger scale in Brazil. It paved the way for the implementation of the power auction mechanism established in the country at that time. In addition, BNDES also served as a significant long-term credit provider.

Although PROINFA had significant challenges that resulted in lower-than-expected contracted power volumes, it played a key part in creating a new dynamic for wind energy in Brazil (Losekann and Hallack, 2018).

[31] *Besides wind energy, PROINFA focused on biomass thermal power plants and small hydropower plants. In the case of biomass thermal power plants, BNDES adopted the boiler pressure increase as an eligibility criterion for offering more attractive interest rates.*

When the government eventually transitioned to power auctions, first with a wind energy auction in 2009 and thereafter in the regular power auctions, BNDES was instrumental in providing anticipated and publicly communicated long-term financial conditions in domestic currency. Its financial policy offered predictability for investors regarding the debt structure of projects, which led to reduced premium risks, heightened competition and, ultimately, lower costs for consumers. Most importantly, BNDES also provided improved financial terms for new renewable energy technologies, spurring innovation, the local supply chain and further growth in the sector.

For the first solar energy auction in 2014, BNDES took a pioneering financial initiative by providing a blended finance structure using funds from the Brazilian Climate Fund (see Box 4). BNDES set a limit on the proportion of debt that could be financed by the Climate Fund for each project. This amount was then combined with BNDES's regular funds.[32]

Box 4
The Climate Fund

The Climate Fund was established in 2009 as a key component of the Brazilian National Policy on Climate Change. It is an accounting fund linked to the Ministry of the Environment, designed to provide financial support for the implementation of projects, the acquisition of machinery and equipment, and technological development aimed at reducing GHG emissions and adaption mechanisms and offers direct financing with reduced rates and terms of up to 25 years. Areas of focus include renewable energy projects, efficient equipment and climate-related innovation.

The Climate Fund is managed by BNDES and the Ministry of the Environment, with the former handling the reimbursable resources and the latter managing the non-reimbursable funds. The resources come primarily from the federal government, donations, interest, and amortization of financing.

The Climate Fund allows BNDES to finance projects at lower interest rates than its regular funds. However, the original annual budget of the Climate Fund was limited, and BNDES received around BRL 300 million (approximately USD 60 million) annually from 2011 to 2023 on average.

In 2023, the Climate Fund's Yearly Resources Application Plan considered new funds from the issuance of sustainable bonds by the Brazilian Treasury, totaling USD 2 billion, which closed in September that year. That financial amount will be directed to the uses indicated by the fund's governance body, described in the Yearly Resources Application Plan.

However, although the budget has increased for 2024, the level of concessionality in the cost of funds has decreased. The original funds of the Climate Fund come from the government's participation of oil revenues and have interest rates of 1% a.a. The new funds from the sustainable bonds issuance have two levels of interest for energy transition purposes: 8% a.a. for wind and solar power generation and 6.15% a.a. for uses such as renewable hydrogen, energy storage, energy efficiency and sustainable fuels.

[32] *Within the limit of 80% of the capital expenditure, a project could receive financing of up to 15% from the Climate Fund and a minimum of 65% from BNDES's regular funds.*

In addition, BNDES has promoted the financing of renewable energy projects by issuing debentures. This support takes the form of (i) acquiring a sizeable portion of these debentures, (ii) facilitating their certification as green bonds by the Climate Bonds Initiative, and (iii) managing the Sustainable Energy Fund, which is tasked with investing in energy project debentures that comply with Climate Bonds Initiative standards.

BNDES also helped new renewables in Brazil by financing transmission expansion. Several transmission line projects have successfully raised funds by issuing incentivised debentures. Current financial conditions are related to the creditworthiness of the borrower and the project.

4.3 IMPORTANCE OF RENEWABLES IN THE BNDES STRATEGY

To prepare for its ambition to lead the transition to a carbon-neutral and socially equitable economy, BNDES has strengthened its funding policies for ESG-oriented initiatives, including the Climate Fund, the Amazon Fund, the Brazilian Agricultural Policy for Climate Adaptation and Low Carbon Emission, and BNDES Finame Low Carbon.[33]

More importantly, the bank has declared its primary role in supporting more sustainable business practices and acknowledging GHG emission reduction, the development of the bioeconomy, biodiversity protection, nature-based solutions, and ecological restoration (BNDES, 2023b).

In alignment with its strategy and with the Brazilian nationally determined contribution, BNDES announced its commitment to continuously align with the Paris Agreement, to limit the increase in global temperature to 1.5°C, to contribute to Brazil's neutrality in 2050 and to enhance investments for a just climate transition in the country (BNDES, 2023a).

BNDES's strategy to advance the green economy and lower GHG emissions depends heavily on renewable energy initiatives. In 2022, renewable energy projects accounted for 41% of its total disbursements and represented almost 90% of the GHG emission reductions facilitated by BNDES-supported initiatives (BNDES, 2022b).

4.4 BNDES PERFORMANCE IN THE DEVELOPMENT OF GREEN FINANCE

Green financing at BNDES has undergone significant changes since 2010. During this time, the landscape of financed energy sources shifted from hydropower plants to new renewables (wind, solar and biomass sources).

BNDES has played a pioneering role in financing wind power generation, funding over 18.9 GW of projects. The bank's portfolio equals 64% of the current 29.5 GW of installed wind power capacity. BNDES has also financed 3.9 GW of solar power generation projects, which equals 32% of the current centralised installed solar power capacity in Brazil (12.3 GW).

[33] *The Amazon Fund, initiated in 2008, is the world's largest REDD+ fund, receiving more than BRL 3 billion (approximately USD 600 million) in donations due to reduced deforestation in Brazil. The Brazilian Agricultural Policy for Climate Adaptation and Low Carbon Emission finances investments that mitigate the environmental impacts of agricultural activities. BNDES Finame Low Carbon supports the purchase of solar and wind energy systems; solar heaters; electric, hybrid or biofuel-powered buses and trucks; and machinery and equipment that enhance energy efficiency or reduce GHG emissions.*

In line with its leading position in green finance in the country, BNDES was the first Brazilian financial institution to issue a green bond on the international market, raising USD 1 billion in 2017 (BNDES, 2022b). The BNDES green bond, with a seven-year maturity, was used to finance eight wind projects with 1.3 GW of total installed capacity. The success of this issuance helped other Brazilian issuers access international markets and ushered in other initiatives by BNDES in the green finance realm.

BNDES was also the first Brazilian financial institution to issue green financial letters in the Brazilian market, raising BRL 1 billion (approximately USD 200 million) in 2020, directed to wind or solar generation projects (BNDES, 2022b).

At the end of 2020, BNDES announced a new product called BNDES sustainability and infrastructure bonds. The goal was to foster the issuing of sustainable, green and social bonds on the Brazilian capital market, helping to grant more liquidity to energy transition assets. By allowing lower interest rates for projects that show third-party certification or a second opinion assessing the bonds as green or social, BNDES became the first Brazilian long-term provider of credit to explicitly announce a lower interest rate for such bonds.

In 2021, BNDES launched the Sustainability Bond Framework (SBF), which supports the bank's issuing of green, social and sustainable bonds domestically and worldwide (BNDES, 2022b). The framework was developed with co-operation from the Inter-American Development Bank and includes a second-party opinion from Sustainalytics. The SBF encompasses a variety of renewable energies, potentially directing future funding to wind, solar, hydro, biomass, biofuels, and green hydrogen projects.

In addition to developing green finance, BNDES offers the country the advantage of enabling energy transfer funds via funding from multilateral organisations and government agencies. This funding is carried out with partner institutions such as the Inter-American Development Bank,[34] the New Development Bank, the Japan Bank for International Cooperation, Kreditanstalt für Wiederaufbau, the Nordic Investment Bank, the China Development Bank, Agence Française de Développement, the Swedish Export Credit Corporation and the Official Credit Institute.

BNDES's long-term relationships with international and multilateral financial institutions are instrumental in raising funds for the energy transition and channelling them to the projects approved by the bank. BNDES raised over USD 5 billion from 2009 to 2024 through fundraising operations involving green bonds and international finance institutions, with the proceeds specifically directed towards renewable energy projects.

This relational capital, combined with its accumulated technical expertise, positions BNDES as an important funding coordinator and catalyst of energy transition financing in Brazil.

4.5 BNDES'S PIONEERING ROLE IN FREE MARKET FINANCING

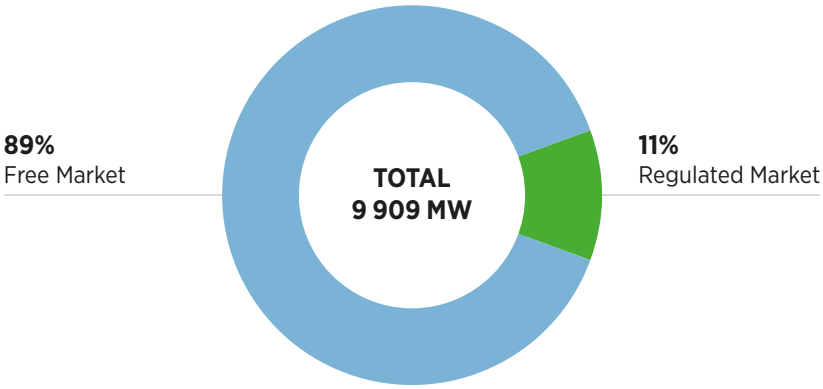
Regulated auctions, once the main driver for the expansion of power generation in Brazil, have diminished in importance in the last few years. Although still representing less than half (approximately 40%) of the country's total energy consumption, the free (unregulated) market has increasingly gained relevance in power generation expansion, mainly through wind and solar energy projects.

[34] *An example is the Inter-American Development Bank's Financing Program for Sustainable Energy, which was carried out in partnership with BNDES. This programme provided financing of USD 900 million for renewable energy generation projects, leveraging USD 700 million of private capital investment. As a result, 28 wind farms were deployed, adding an installed capacity of 779.98 megawatts of renewable energy generation to the Brazilian electricity grid (IDB, 2019).*

Those renewable sources, reflecting the significant levelised cost of electricity reduction in the last 15 years, have become very attractive for large consumers with ESG commitments and for investors seeking sustainable assets in the unregulated market. As a result, the financing landscape for generation projects has shifted markedly.

However, initially, the prevalence of short-term contracts and the reliance on a single off-taker were challenges for securing long-term project credit. To address the financial gap in the free market and facilitate project bankability, BNDES pioneered an innovative financing methodology through project finance and the support price mechanism in 2018. The support price mechanism serves as a benchmark for project evaluation during periods not covered by a PPA and allows for various commercial structures: merchant projects, projects dependent on pure unregulated PPAs, and a mix of regulated and unregulated PPA projects. By shortening PPAs, this approach has been effective, with BNDES funding more than 7 GW of wind and solar projects for the free market from 2019 to 2022. Moreover, projects that will predominantly attend the free market have become the primary recipients of BNDES loans for wind and solar power projects (Figure 13).

Figure 13 BNDES support to wind and solar power, 2019 – August/2024



Source: BNDES unpublished data.

4.6 BNDES'S IMPACT ON RELATED SUPPLY CHAIN

BNDES has traditionally promoted the growth of the country's renewable energy industry by leveraging financial support that encourages the development of a domestic wind energy supply chain. As a result, many leading global wind turbine manufacturers have been attracted to Brazil.

BNDES's financial support for the new renewable energy sources in Brazil reflected policy decisions primarily aimed at increasing capacity and ensuring resource adequacy in the power market. Consequently, its financial strategies took an adaptive approach, evolving to reinforce domestic production and technical expertise while considering the economic imperatives of renewable energy producers. The bank's financial solutions comprise credit, guarantees, services, non-refundables and equity (BNDES, 2022b).

According to (BNDES, 2022b), establishing a domestic wind energy supply chain has enhanced investment security by enabling the industry to cater to domestic projects and allowing parts and components to be exported to international markets. Moreover, it has significantly impacted social dynamics by creating qualified job opportunities throughout the production chain, bolstering Brazil's renewable energy sector.

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4.6.1 The impact on the wind energy industrial chain

Brazil's first wind energy projects can be traced back to the early 2000s as the outcome of the feed-in-tariff mechanism, PROINFA. Despite facing some challenges, PROINFA played a key role in bringing a new push to wind energy in Brazil (Losekann *et al.*, 2018).

The country's wind power development only regained momentum after the 2008 international financial crisis (ABDI, 2014), which affected wind energy demand in established markets. This situation prompted wind operators and suppliers to explore new markets. Motivated by the favorable financial conditions offered by BNDES, international turbine producers established a presence in Brazil, increasing the number of international producers and further boosting the country's wind energy sector.

Three fundamental mechanisms have contributed to the development of Brazil's wind energy supply industry: a pipeline of wind power projects to attend to the expected load growth, the availability of public finance (through BNDES) at better conditions for new renewable technologies, and the BNDES accreditation policy to access its long-term funding.

According to Abeeolica, the Brazilian association of wind energy and new technologies, Brazil has become one of the top ten countries in installed wind generation capacity and was the third-largest market in new installed capacity in 2022, adding 3.8 GW. 2023 was a record year for wind farm installation, with 4.8 GW and 123 wind farms added. Reflecting wind power's increased competitiveness, and due to investments totalling USD 42.5 billion (or more than half of all renewable investments) over the last ten years, wind power installed capacity increased by twelve times, from 2.5 GW in 2012 to 30.45 GW in 2023.

The rapid expansion of wind power in the Brazilian power system during this period paved the way for the emergence of an intricate wind energy supply industry. Ferraz *et al.* (2022) estimated that the size of the Brazilian market for wind energy suppliers amounted to USD 28.5 billion from 2006 to 2019 (Ferraz *et al.*, 2022).

BNDES offers competitive long-term financing options for renewable energy projects, including extended repayment periods. To access BNDES's favorable financing package, however, developers of wind farms must obtain their wind turbines from suppliers that have adhered to the bank's accreditation policy. The main objective of the bank's accreditation policy has been to enable higher levels of innovation and product density (Ferraz *et al.*, 2022).

Obtaining BNDES financing by adhering to its accreditation policy is not mandatory when participating in power auctions. In other words, the BNDES financing policy allows the market to signal to companies – both manufacturers and wind farm developers – whether it is beneficial to engage with the bank.

For wind turbine manufacturers, the decision to comply with the BNDES accreditation policy conditions depends on various factors, such as the feasibility of meeting the bank's requirements and the potential market gains from increased demand triggered by the policy (Ferreira, 2017). For wind farm developers, on the other hand, the decision to seek financing from BNDES hinges on factors like the competitiveness of the financing terms and the list of manufacturers registered under the BNDES accreditation policy.

Over the last 15 years, wind farm developers have mainly relied on BNDES financing. This preference has created, in turn, an incentive for an increasing number of turbine manufacturers to align with the BNDES accreditation policy. According to Losekann and Hallack (2018), the goal of building a local supply chain has been achieved: domestic suppliers (national or international firms operating in Brazil) provide 18 out of 32 components currently listed in the BNDES accreditation policy (Losekann and Hallack, 2018). While São Paulo remains the primary hub for the metal-mechanical base, companies producing significant components like blades and towers have expanded to the Northeast and South Regions, closer to the wind farms (Ferraz *et al.*, 2022).

More importantly, BNDES' financing strategies have evolved gradually to meet the changing demands of the wind energy market, focusing on strengthening local production and technical capabilities. Thus far, the BNDES accreditation policy impacting wind energy suppliers has undergone three modifications.[35]

Before 2009, BNDES applied a unique accreditation policy to all sectors based on a weight-based index and a value-based index, calculated as the ratio of component costs to the sale price. These indexes were required to be at least 60%, regardless of the type or complexity of the equipment.

Between 2009 and 2012, while wind power was gaining increasing attractiveness, BNDES introduced a new approach to the wind turbine accreditation process at the level of individual firms. The approach used progressive accreditation plans, targeting the arrival of new wind turbine manufacturers in the country. BNDES prioritised certain production stages and set specific targets for each supplier to gradually increase local production of all wind turbine parts (De Araújo and Willcox, 2018). The main objective of this accreditation policy was to attract international firms to produce domestically. The progressive accreditation plans were relatively successful: 11 turbine producers started their operations in the country.

However, BNDES concluded that this policy was not enough to promote the domestic production of more technology-intensive components in the wind power industry and significantly distorted the technology choice towards less-advanced components (Losekann and Hallack, 2018). In 2012, the progressive accreditation plans evolved into a sectoral accreditation methodology, where the accreditation changed its focus from the firm level to the industry level. The sectoral accreditation methodology considered the industrial capacity and the sophistication level of the components produced in the country, with minimum efficient scales of production and potential backward links (Ferraz *et al.*, 2022). This marked the first time BNDES used a sectoral approach in its financing procedures.

The sectoral accreditation methodology was successfully implemented. The major global wind turbine manufacturers adhered to the accreditation process and developed their own industrial capacity and a relevant supply chain to serve them. The BNDES accreditation team mapped over 53 new investments throughout the implementation period, totalling more than BRL 1.3 billion (approximately USD 300 million).

[35] *The first and second modifications were explicitly designed for wind energy suppliers; the last was valid for purchasing capital goods in all sectors.*

In 2016, the year the BNDES methodology was fully implemented, the supply chain included six wind turbine manufacturers, over 100 component suppliers, and more than 3 000 sub-suppliers, highlighting the successful development of the wind energy industrial chain in Brazil.

The current BNDES accreditation policy values Brazil's insertion into global production chains by providing for a mix of domestic production and imported components. Even though local producers face higher costs compared to the international market, they have made substantial efforts to adapt to Brazil's specific production and value chain conditions, leading to significant improvements in operational efficiency. Efforts to adapt equipment to local conditions have resulted in some innovations. Nevertheless, innovation capabilities along the value chain are still limited (Ferraz *et al.*, 2022).

4.6.2 The impact on the solar energy industrial chain

Building on its experience with the wind power supply chain and considering the relative industry infancy in Brazil, BNDES's financial policy for the solar power supply chain also focused on local industry strengthening and technical capabilities.

Before 2014, Brazil did not have a well-established PV module manufacturing industry, which, according to its accreditation policy, prevented BNDES from supporting solar energy projects due to a lack of local suppliers (BNDES, 2017).

In 2014, BNDES adopted a specific methodology for accreditation of PV module manufacturing targeted to components deemed to have market viability for local production. Through this policy, BNDES financed PV projects in direct proportion to the technology components provided by local suppliers. Analogous to the wind power sector, BNDES's financial methodology incorporated a progressive requirement for specific components and processes over time, considering minimum efficient scales of production and potential backward links. The solar PV sectoral accreditation methodology coincided with the first government power auction for solar PV, followed by another two in 2015, providing a significant demand for PV panels, trackers, inverters and other equipment, with installed capacities of over 3 000 megawatts (BNDES, 2017).

BNDES updated the criteria for the accreditation of equipment in the PV sector in 2017 and 2020, adapting the requirements for using the supply chain to the levels adopted by the market and maintaining incentives for the established industry.

The results have been mixed so far. Even though Brazil has large silicon reserves, it lacks purified silicon producers up to the solar grade (Garlet *et al.*, 2022). The commercially dominant production of solar PV technology internationally is concentrated in China due to its strong economies of scale and low transportation costs. Competing solar technologies have not yet reached the required competitiveness to challenge this dominant position. Overall, the Brazilian industry is not as competitive as other international suppliers in PV module manufacturing.

As a result, companies have taken different approaches in Brazil: Enel, for example, relied on balance sheet financing for its first solar power investments and thus was not affected by BNDES's financing accreditation policy; Canadian Solar received BNDES's first energy financing in 2017.

System integrators, primarily small businesses, generate the most value in the Brazilian solar PV industry value chain. Greener (2024) estimated 26 150 PV system integrators by the end of 2023, most located in the country's Southeast Region.

5. LESSONS LEARNED FROM THE BRAZILIAN EXPERIENCE WITH THE DEPLOYMENT OF RENEWABLE POWER

KEY INSIGHTS:

1

Brazil's successful experience is based on the alignment of financial mechanisms and energy planning via BNDES, the EPE and the MME, scaling up renewable investments and improving the environment for these projects.

2

Brazil's experience with the EPE/MME shows the impact of strategic energy planning in promoting investment, renewable integration and environmental sustainability.

3

BNDES leads global renewable energy financing with low-cost loans in local currency, innovative financing strategies and risk mitigation instruments.

4

The synergy between BNDES, the EPE and the MME, long-term planning, and environmental targets drive renewable energy projects in Brazil, serving as inspiration for EMDEs.

5

The strategic design of auctions in Brazil promotes the growth of renewable energy by ensuring clear regulations, predictable processes and long-term PPAs.

The Brazilian experience suggests that countries can create a conducive environment for renewable energy projects by ensuring that financial mechanisms are aligned with long-term energy planning and environmental considerations. In the Brazilian case, this was implemented by domestic institutions with finance expertise (BNDES) and energy planning knowledge (the EPE and the MME) working in direct collaboration to provide investors and consumers with the right balance of risk-return allocation. This integrated approach has not only scaled up renewable investments but also developed and enhanced the respective supply chain in the country.

The Brazilian experience may inspire other countries that see similarities with the Brazilian context. However, for nations with different circumstances, concerted efforts of multiple stakeholders will be required to address the challenges and scale of ambition associated with the transition to a decarbonised power mix. MDBs and DFIs can play a crucial role by offering a comprehensive support package to governments, including concessional and blended financing, risk mitigation instruments for private investments, and technical assistance to advance policy and utility reforms (ESMAP, 2023).

5.1 THE CRUCIAL ROLE OF ENERGY PLANNING IN THE RENEWABLE POWER EXPANSION IN BRAZIL

As shown by the Brazilian experience, the MME, by creating a planning agency (the EPE), has significantly and confidently contributed to shaping the future of investments in the energy sector.

The EPE has played a pivotal role in the Brazilian experience by disseminating public information on anticipated load growth, current power projects, potential power expansion plans, and transmission line developments through its long-term energy plans. These detailed plans, developed through comprehensive long-term energy planning, facilitate informed decision making by offering a clear view of future energy scenarios (EPE, 2016a). This contributes to a transparent and predictable environment for stakeholders and mitigates information asymmetry within the market and institutional governance, including among energy authorities and environmental agencies (EPE, 2016b).[36] In addition, the EPE's efforts to directly engage with entrepreneurs further improve the planning process, aligning it more closely with viable business models. Furthermore, involving society in the planning process enhances the legitimacy and acceptance of the energy strategy. This inclusive approach ensures that the views and concerns of a broad spectrum of society are considered, leading to more equitable and effective energy policies.

The EPE has also showcased the importance of integrated generation and proactive transmission planning, especially when a significant renewable energy expansion is expected, to avoid excessive curtailments of renewable energy plants and reduce mismatches between generation and transmission projects.

The relevance of Brazil's grid system, which allows generation in one region and consumption in another geographically distant area, highlights the importance of grid integration. With its continental scale, the interconnected grid may serve as a prime example of the benefits of integration (*e.g.*, the effects of portfolio diversification) between countries to untap unevenly distributed renewable energy resource potential.

EMDEs that aim to expand renewable energy investments can benefit from establishing or strengthening their planning bodies to conduct detailed energy resource assessments, grid integration studies, and

[36] *Additionally, projects considered in the government's energy planning can be prioritised for environmental licensing or access to fiscal benefits.*

socio-environmental impact analyses. Such bodies can also play a crucial role in facilitating public and private sector dialogue and ensuring that the planning process is inclusive and considers the needs of all stakeholders.

The Brazilian experience demonstrates that an integrated planning framework can facilitate the transition towards a more sustainable energy power mix. It highlights the importance of collaboration, innovation, and strategic alignment in achieving both energy security and environmental sustainability.An effective government energy planning system can significantly improve credibility in countries with evolving regulatory and governance frameworks. In countries perceived as high risk due to regulatory uncertainties, establishing credible regulatory and governance institutions is a gradual process, requiring time and concerted effort. In the short term, MDBs and international financial institutions can address potential regulatory risks. However, effective government energy planning can provide a more comprehensive solution to regulatory and governance challenges, associating them with other public policies (*e.g.*, development policies) that also affect the energy industry. Well co-ordinated, long-term power system planning is crucial for developing a sustainable, reliable and efficient energy landscape.

5.2 COLLABORATION BETWEEN ENERGY PLANNING BODY AND NDB TO PROMOTE RENEWABLE ENERGY

As the Brazilian experience with BNDES, the EPE and the MME showcases, countries can create a conducive environment for renewable energy projects by ensuring that financial mechanisms are aligned with long-term energy planning and environmental considerations.

BNDES's approach demonstrates the critical role of financial institutions in reducing investment risks and uncertainties. By providing stable financial conditions and supporting the supply chain for equipment manufacturers and service providers, BNDES has facilitated investments in the renewable sector. Other countries can learn from this by establishing or empowering their DFIs (or by working with MDBs) to offer country-specific financial solutions and guarantees that lower the barrier to entry for renewable energy investments. International financial institutions can reduce the cost of financing through various mechanisms: concessional loans, longer tenures or co-financing (ESMAP, 2023).

The EPE and the MME have complemented these efforts by ensuring the efficient integration of renewables into the national grid through strategic planning and risk mitigation strategies. Their innovative wind and solar energy contracting models have notably integrated these sources into Brazil's power mix. The EPE's planning studies have also been crucial in outlining a long-term power expansion plan to deliver reliable and affordable power services to the country, identify potential socio-environmental conflicts, and facilitate transmission network expansion to ensure a robust infrastructure for renewable energy.

5.3 THE IMPORTANCE OF EFFECTIVE ENERGY AUCTIONS

Brazil's approach to auction design and implementation offers several lessons and recommendations. Effective auctions require a comprehensive regulatory framework with clearly defined roles for participating institutions and adequate funding and human resources. Recurrent, transparent and predictable auctions lower investment risk and encourage participation by ensuring stakeholders can engage effectively and incorporate adequate lead times and contract durations that reflect the capital intensity of the technology and the financing principles.

Brazil's experience also shows that auctions can serve multiple objectives, with variations in lead times, contract durations and obligations tailored to specific renewable sources or technology mixes. The rules and conditions of these auctions in Brazil have been adjusted to reflect the evolving market over the years, reflecting a deeper understanding of implementation risks, natural resource availability, technology advances, and other factors.

Brazil's systematic use of power auctions has been a significant factor in successfully expanding renewable energy, achieving security of supply and diversifying its energy portfolio at competitive prices.

The auction programme has played a crucial role in mobilising private investment. One crucial aspect of the electricity reform in Brazil in the early 2000s was the design of an appropriate PPA. The EPE, the MME and BNDES worked together on the PPA design to ensure adequate revenue security for investors, fostering competition in the power auctions. One notable example relates to PPAs for wind power projects during their early stages of development in Brazil: the EPE and the MME collaborated with BNDES and other institutions to formulate a mechanism to accommodate generation uncertainty, enhancing the viability of the projects and thereby boosting investors' confidence.

The growth of variable renewable energy sources, such as wind and solar energy, reflects not only global reductions in equipment costs but also the strength of local investment capacity and the strategic design of the auction programme.

5.4 THE ROLE OF DFIs IN PROVIDING ACCESS TO LOW-COST FINANCING FOR RENEWABLES

BNDES's involvement in Brazil's renewable energy sector underscores the critical role of low-cost financing and the profound impact of strategic public investments in propelling sustainable energy solutions. By providing long-term funds in local currency, BNDES has successfully lowered financial barriers and fostered a supportive ecosystem for renewable energies. This approach is further enhanced through innovative financing mechanisms, risk mitigation strategies and international collaboration, setting a global benchmark for DFIs in supporting the transition towards a more sustainable and renewable energy future.

Its extensive experience in funding infrastructure projects positions BNDES as a global leader in renewable energy financing. The bank's extensive experience in funding infrastructure projects is supported by its highly qualified staff, demonstrating its capability to back complex, long-term projects.

For countries lacking energy planning and DFI experience, forming working groups with entities like the EPE and BNDES can offer invaluable insights and models for adequate renewable energy financing and development strategies. Creating regional initiatives or institutions for energy planning agencies and DFIs may help bridge knowledge gaps and foster international best practices in renewable energy expansion, with more tailored regional solutions.

5.5 THE IMPORTANCE OF DFIs IN PROVIDING INNOVATIVE FINANCIAL SOLUTIONS

BNDES is at the forefront of pioneering innovative financial instruments, including blended finance, green bonds and guarantee sharing, in the Brazilian financial market.

BNDES showcases the successful application of on-lending solutions to facilitate access to low-cost financing. On-lending mechanisms further improve the accessibility of affordable financing for renewable energy initiatives.

Additionally, BNDES has been pivotal in introducing novel financing mechanisms to the Brazilian financial markets, including debentures and customised initiatives for the non-regulated market, which is increasingly expanding the share of renewable energy in the power mix. These mechanisms include shorter-duration contracts and US dollar denominated loans specifically designed for renewable projects associated with export companies, demonstrating BNDES's readiness to embrace risk as the sector evolves.

5.6 DE-RISKING POWER CONTRACTS

Table 1 shows the main risks associated with long-term renewable energy projects and how Brazil addressed them.

Table 1 Key investment risks for renewable energy projects and how Brazil addressed them

CURRENCY RISK

Risks associated with changing or volatile foreign exchange rates adversely affecting investment values. Risks arise when there is a mismatch between assets (revenues) and liabilities (debt financing).

How Brazil addressed the risk

1. PPAs are denominated in BRL, but the public sector (through BNDES) offers long-term funding in local currency (BNDES project finance).
2. The government offers tax benefits for debentures, issued in Brazilian capital markets, that are used to finance energy investments.
3. More recently, USD-denominated PPAs were allowed for export companies in the free market.
4. In 2023, the Inter-American Development Bank announced USD 3.4 billion in currency hedge mechanisms (swap, emergency liquidity credit line for projects with predictable inflation-indexed future revenues, and insurance against extreme exchange rate depreciation risks).
5. Under its Sustainable Bond Framework, Brazil issued its first sustainable bond in 2023, totalling USD 2 billion. The federal government bears the exchange rate risk.

Table 1 Key investment risks for renewable energy projects and how Brazil addressed them (continued)

NATURAL DISASTER RISK

The risk that a natural disaster will affect the ability of a counterparty to fulfil its obligations (e.g., produce power, make payments).

How Brazil addressed the risk

1. Under Brazilian law, the contract remains valid if a natural disaster or force majeure impacts contractual obligations. However, the party affected by such events is not held liable for any failure to fulfill obligations during the period the event affects them. This exemption requires ANEEL's approval.

POLICY OR REGULATORY RISK

Risks associated with changes in legal or regulatory policies that have significant adverse impacts on project development or implementation (*e.g.*, incentive programmes, taxes, interconnection regulations, permitting processes).

How Brazil addressed the risk

1. PPAs generally contain a clause stating that if any new taxes, sectoral charges or legal modifications that affect any party are created during the contract's validity, the sale price may be adjusted accordingly. This adjustment will come into effect only after ANEEL's approval.
2. Elimination of the transmission and distribution tariff discount for wind and solar energy was not applied to existing power plants but is valid only for new investments.
3. Brazil has the practice of upholding the sanctity of existing contracts.

MARKET RISK

Risk of lower-than-anticipated demand.

How Brazil addressed the risk

1. Long-term (15- to 30-year) PPAs are indexed by the Consumer Price Index for new power projects.
2. Until 2017, auction contracts for renewable energy sources offered payment for effective generation (availability contracts).
3. During the height of the COVID-19 pandemic, the government structured a financial loan to mitigate the impacts of reduced consumption and increased consumer defaults. The programme involved paying back the loan over five years through consumer tariffs.
4. Distribution companies can pass up to 5% of excess PPAs to the regulated tariff. Additionally, involuntary excess of PPAs as defined in the law (*e.g.*, due to regulated consumers who opt to be free consumers) can be passed through, subject to ANEEL's approval.

Table 1 Key investment risks for renewable energy projects and how Brazil addressed them (continued)

CONSTRUCTION RISK

Risks associated with the project running behind schedule, facing cost overruns or failing to achieve commercial acceptance for technical reasons.

How Brazil addressed the risk

1. Technical qualification is required to bid in the auction to ensure the commitment and reliability of the bidders.
2. Developers are required to demonstrate technical and financial capability to build projects on schedule and deliver energy according to the power auction requirements.
3. Power auction winners are required to provide surety and performance bonds before contract signing.
4. ANEEL oversees the project evolution.

RESOURCE RISK

Risks associated with uncertainties around the availability, future price, and/or supply of renewable energy resources.

How Brazil addressed the risk

1. New contracting models were set up for wind and solar PV generation, which allowed for the intertemporal compensation of production variation.
2. Wind power generators must carry out anemometric and climatological measurements throughout the contract period. The data obtained are periodically sent to the EPE to gather the information needed to support electrical and energy studies. This information system has helped better understand the potential of wind energy resources in Brazil.
3. Hourly prices were introduced in 2021, and market-based prices are under development by regulators.

TECHNOLOGY RISK

Risks associated with the use of nascent technology or an inexperienced labour force deploying it.

How Brazil addressed the risk

1. Renewable energy sources were firstly encouraged through a feed-in tariff programme (PROINFA) and later with technology-specific auctions (*e.g.*, reserve energy auctions) recommended by EPE studies.
2. Generators (excluding wind, solar, biomass, small hydro, and qualified co-generation) and transmission and distribution companies are required to invest 1% of their annual net operational revenue in R&D and the energy efficiency programme conducted by ANEEL.

Table 1 Key investment risks for renewable energy projects and how Brazil addressed them (continued)

GRID AND TRANSMISSION RISK

Risks associated with limitations in interconnection, grid management, and transmission infrastructure (including curtailment risk).

How Brazil addressed the risk

1. In power auctions with a lead time shorter than five years, there is a preliminary phase to select the projects with connection feasibility through competition among projects with the same connection point. Projects that exceed the connection capacity cannot bid in the auction.
2. Proactive transmission planning has enhanced transparency and predictability regarding connection risks. This approach involves auctioning transmission grid infrastructure in advance, based on resource availability and a clustering methodology aligned with announced renewable power projects.
3. EPE conducts critical studies to mitigate grid and transmission risk for generators, such as the expansion of system interconnections (in particular, transmission project corridors to facilitate the integration of significant amounts of renewable energy from the Northeast Region) and the installation of substation hubs to integrate wind farms into the main grid.

COUNTERPARTY RISK (POWER OFF-TAKER RISK)

Credit and default risk by a counterparty in a financial transaction. For renewable energy investments, this category is related to the risk of default or non-payment by the power off-taker, typically the electric utility.

How Brazil addressed the risk

1. The generator signs bilateral contracts with a pool of distribution companies participating in the power auction, mitigating individual default impact. In the case of reserve auctions, the CCEE is the counterparty.
2. Distribution companies are required to assign their accounts receivable to a generator in a managing bank. In addition, they must deposit three months of payments for PPAs in advance. The managing bank will ensure that energy purchase contracts are paid before the distribution companies can access the funds.
3. Distribution companies are subject to strict regulations, with most having a low credit risk.
4. In the non-regulated market, PPAs are bilaterally negotiated, and the generator assumes the off-taker risk. In this case, a bank guarantee, letter of credit, and insurance are usually required.
5. The PPA includes a termination clause in default cases.
6. Price signal mechanisms, such as BNDES's support price, could fill the gap between PPA tenure and financing assumptions to model project financial structure.

Table 1 Key investment risks for renewable energy projects and how Brazil addressed them (continued)

FINANCING RISK

Risk of limited funding due to stress in credit markets.

How Brazil addressed the risk

1. BNDES can mitigate financing risk by providing funding when credit markets are under stress.
2. In addition to providing long-term funding, BNDES can also participate in subscribing to investors' capital market instruments, such as debentures.
3. The government offers tax benefits for debentures issued in the Brazilian capital markets that are used to finance energy investments.

LIQUIDITY RISK

Possibility of operational liquidity issues arising from revenue shortfalls or mismatches between the timing of cash receipts and payments.

How Brazil addressed the risk

1. The CCEE ensures that contractual obligations will be honoured.
2. Before 2015, distribution companies could only compensate for short-term price increases in the next annual tariff adjustment process, creating a potential liquidity crisis. In 2014, when short-term electricity prices rose sharply, and the distribution company's operating costs increased, the government structured a financial loan to mitigate the distribution company's liquidity risks. The loan was to be paid back over eight years through consumer tariff adjustments.
3. In 2015, ANEEL established the tariff flag system to signal monthly expected electricity prices and enable tariffs to be adjusted accordingly, partially mitigating liquidity risks.
4. When the tariff flag system was insufficient to cope with the increase in electricity prices, the government used the same strategy of structuring a financial loan as during the COVID-19 pandemic and the drought crisis of 2021.

SITE PROVISION AND PREPARATION RISK

Risk that land ownership of the project site is unclear or that private land ownership is not allowed. It also refers to the risk that a government-provided site is poorly prepared and/or selected.

How Brazil addressed the risk

1. Developers must provide land use rights and preliminary environmental permits during the technical qualification process carried out by the EPE.

Table 1 Key investment risks for renewable energy projects and how Brazil addressed them (continued)

ARBITRATION AND CONTRACT ENFORCEMENT RISK

Risk that the (international) project owners/funders are unlikely to get a fair or impartial hearing in local courts – or at least that this is their perception. It also refers to the risk that contracts will not be enforced by the local judiciary.

How Brazil addressed the risk

1. In Brazil, PPAs typically stipulate arbitration as the primary mechanism for resolving disputes. Arbitration is generally faster than resorting to judicial and administrative courts, and the arbitrators presiding over the case will be experts in the field.

PERMITTING RISKS

The risk that permits required by the project (*e.g.*, environmental authorisation, building permits, generation licences) are not provided at all or on time.

How Brazil addressed the risk

1. Preliminary environmental licensing is required in the technical qualification process. During construction and operation, any public authority involved in the licensing process may revise permits at any time. Alignment among the EPE, the MME and environmental authorities allows any potential questions and concerns related to environmental permits to be anticipated and addressed.

SUPPLY CHAIN RISKS

The risk that projects will face delays in receiving equipment or that costs will increase during development.

How Brazil addressed the risk

1. BNDES has played a pivotal role in attracting leading global wind turbine manufacturers to Brazil, encouraging local production of technology-intensive components, developing a robust domestic supply chain, enhancing timely project development, and reducing exchange rate risk associated with imported equipment.

Source: Adapted from IRENA (2016, 2020a, 2022).

Note: ANEEL = National Electricity Agency; BNDES = Brazilian Development Bank; BRL = Brazilian real; CCEE = Electric Energy Commercialization Chamber; EPE = Energy Research Office; PPA = power purchase agreement; PROINFA = Programme of Incentives for Alternative Electricity Sources; PV= photovoltaic; R&D = research and development; USD = US dollar.

5.7 THE CREATION OF A PIPELINE OF BANKABLE PROJECTS

In Brazil, the EPE is responsible for project accreditation, known as "technical qualification". This process evaluates proposals based on clear criteria from engineering, environmental, social and financial standpoints. This streamlined approach ensures that projects that will bid in the government power auctions meet the highest sustainability and feasibility standards through a clear and transparent qualification process. This helps prepare projects that are more likely to succeed and builds confidence among investors and financiers in the renewable energy sector.

The technical qualification process not only ensures project development under viable conditions but also mitigates construction and winner's curse[37] risks in power auctions.

The information from the technical qualification also allows regions with a high concentration of interest in renewable energy project deployment to be identified; these regions are then earmarked for potential transmission corridors. These insights are also critical for energy planning and should be fed back into the planning process through reports and technical information, including energy plans and resource availability studies.

5.8 THE PROMOTION OF SUPPLY CHAINS

In addition to its financing role, BNDES promotes the development of manufacturing installations and adherence to mandatory criteria, such as the accreditation requirements in the wind sector. Its global leadership in renewable energy financing is a testament to its comprehensive approach to supporting sustainable energy projects.

The BNDES approach in driving sector-specific growth by reducing risks and costs, co-ordinating financing programmes with renewable energy auctions, and carefully selecting sectors to support has fostered the development of a robust domestic supply chain in the wind power sector and ensured the sector's positive contribution to local communities by generating employment and income. Focusing on positive social impact and synergy with industrial and regional development is essential for achieving a more inclusive and sustainable transition to renewable energy.

However, the Brazilian experience in the solar industry shows that successful approaches in one industry might not be easily carried over to other industries. Although a financial ecosystem has been created in the solar industry, with several public financial institutions, the lack of comparative advantages has hindered the development of specific segments, such as solar panels, that have limited value creation within the country.

5.9 THE IMPORTANCE OF QUALIFIED STAFF IN ENERGY PLANNING AND NDB INSTITUTIONS

Ensuring the availability of skilled professionals in licensing and funding is crucial for developing sustainable renewable energy projects. The lack of qualified professionals can be a significant bottleneck in developing good renewable energy projects (Luscombe *et al.*, 2024). Therefore, investing in education, training and capacity building is essential to creating a pool of talent that can support the sector's growth.

[37] *The winner's curse refers to the phenomenon where the winning bid in an auction exceeds the item's intrinsic value or true worth. This discrepancy often arises from incomplete information, emotional influences, or other subjective factors affecting bidders' decisions (Hayes, 2024).*

This is true for all entities involved in institutional governance. The EPE, for example, exemplifies the role of a national organisation in fostering expertise in the renewable energy sector. The EPE's investment in its technical staff through in-house training programmes, partnerships with other entities and participation in international forums has enhanced the capabilities of the technical staff over time and, more importantly, facilitated the sharing of experiences and lessons learned on a global scale.

On the financial side, the BNDES workforce of highly skilled employees demonstrates their capabilities in providing solutions to the complexities of renewable energy projects, bringing a wealth of knowledge and experience in financial structuring, risk assessment and sustainable investment strategies. The quality of BNDES's staff plays a pivotal role in the institution's ability to provide tailored financial solutions that meet the specific needs of renewable energy projects. Their expertise not only facilitates the financing process but also ensures that projects are viable, sustainable and aligned with Brazil's energy and environmental goals.

5.10 INVESTMENTS IN RESEARCH, DEVELOPMENT AND INNOVATION

According to Brazil's long-term energy plan (National Energy Plan 2050), investments in research, development and innovation (R&D&I) are pivotal in overcoming the challenges of implementing an energy transition. These initiatives are expected to break through technological, economic, social and environmental barriers by fostering the creation and dissemination of new products, services and business models.

Given the significance of these investments and the unique aspects of Brazil's energy sector, R&D&I investment clauses have been integrated into the regulatory frameworks of the energy sector. However, creating conditions that enable technological advancements such as biofuels, synthetic fuels, energy efficiency and digitalisation of the economy to benefit all stakeholders is challenging.

As the sector undergoes a paradigm shift due to technological changes, there is a need for better prioritisation of R&D&I lines with the most promising potential. It is essential to align this prioritisation with the MME's long-term strategy and have extensive dialogue with society to define clear priorities for the sector.

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