G20 BRASIL 2024

IRENA
International Renewable Energy Agency

A JUST AND INCLUSIVE ENERGY TRANSITION IN EMERGING MARKETS AND DEVELOPING ECONOMIES

ENERGY PLANNING, FINANCING, SUSTAINABLE FUELS AND SOCIAL DIMENSIONS

ISBN: 978-92-9260-620-6

Citation: IRENA (2024), *A just and inclusive energy transition in emerging markets and developing economies: Energy planning, financing, sustainable fuels and social dimensions*, International Renewable Energy Agency, Abu Dhabi.

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.

Acknowledgements

This report was prepared by IRENA in collaboration with the Ministry of Mines and Energy of Brazil for The Group of Twenty (G20) under the Brazil Presidency (December 1, 2023 – November 30, 2024).

IRENA is grateful for the support, guidance and constructive engagements received from the Ministry of Mines and Energy, and the Ministry of Foreign Affairs of Brazil.

The report was developed under the guidance of Roland Roesch (Director, IRENA Innovation and Technology Centre) for Chapters 1-4; and Raul Alfaro-Pelico (Director, IRENA Knowledge, Policy and Finance Centre) for Chapter 5; and the co-leadership of Ricardo Gorini and Ute Collier. The report was co-ordinated by Yong Chen, with contributions from: Roland Roesch, Yong Chen, Ricardo Gorini (Chapter 1); Diala Hawila, Faran Rana, Erick Ruiz Araya, Job Mutyaba, Tarig Ahmed, Hannah Sofia Guinto (IRENA) and Michael Taylor (ex-IRENA), (Chapter 2); Asami Miketa, Daniel Russo, Juan Jose Garcia Mendez, Nadeem Goussous (Chapter 3); Chun Sheng Goh, Jinlei Feng, James Walker and Gondia Sokhna Seck (Chapter 4); and Raul Alfaro-Pelico and Giedre Viskantaite (IRENA) (Chapter 5).

IRENA also would like to express sincere appreciation to the following technical experts who reviewed the report and provided insightful feedback, specific comments and valuable inputs: Claire Nicolas (The World Bank), Suani Coelho (University of Sao Paulo), Constance Miller (FAO), Daniel Duma (SEI), Luiz A Horta Nogueira (UNIFEI), Pablo Carvajal (EY), Paul Komor (IRENA Technical Reviewer), Vivien Foster (The Centre for Environmental Policy, Imperial College London); IRENA colleagues, Ute Collier, Arno van den Bos, Binu Parthan, Michael Renner, Mirjam Reiner, Francisco Gafaro, Juan Pablo Jimenez Navarro, Deborah Machado Ayres, Iris van der Lugt, Mengzhu, Xiao, Jarred McCarthy, Samah Elsayed, Ilina Radoslavova Stefanova and Jose Toron; as well as Xavier Casals (consultant) and Nicholas Wagner (ex-IRENA).

Publication and editorial support was provided by Francis Field and Stephanie Clarke. The report was edited by Steven Kennedy, with design by Phoenix Design Aid.

Disclaimer

CONTENTS

FIGURES

TABLES

BOXES

ACRONYMS AND ABBREVIATIONS

ADFD	Abu Dhabi Fund for Development
ANEEL	National Electric Energy Agency
BEN	National Energy Balance
BNDES	The Brazilian Development Bank
CCS	carbon capture and storage
COP28	The 28th Conference of the Parties
D2D	data-to-deal
DFIs	development finance institutions
ECI	Etihad Credit Insurance
EMDEs	emerging markets and developing economies
EPE	Energy Research Office
ETAF	Energy Transition Accelerator Financing platform
EU	European Union
EU-RED	European Renewable Energy Directive
FiTs	feed-in tariffs
G20	The Group of Twenty
GDP	gross domestic product
GHG	greenhouse gas
IFC	International Finance Corporation
INECP	Integrated National Energy and Climate Plan
IPPs	independent power producers
IRENA	International Renewable Energy Agency
JA	jurisdictional approach
LDCs	least-developed countries
LPT	Light for All
LTES	long-term energy scenarios
LT-LEDS	long-term low-emission development strategies
MDBs	multilateral development banks
MIGA	Multilateral Investment Guarantee Agency
MME	Ministry of Mines and Energy
PDE	Energy Expansion Plan
PEP	Philippine Energy Plan
PET	Transmission Expansion Program
PNE	National Energy Plan
PPA	power purchase agreement
PV	photovoltaic
RenovaBio	Brazilian National Biofuel Policy
RFNBOs	renewable fuels of non-biological origin
SDGs	Sustainable Development Goals
SIDs	small island developing states
SOEs	state-owned enterprises
SOFIs	state-owned financial institutions
SrGBs	sovereign green bonds
TFEC	total final energy consumption
UNFCCC	UN Framework Convention on Climate Change
USD	United States dollar
WACC	weighted-average cost of capital

EXECUTIVE SUMMARY

Emerging markets and developing economies (EMDEs) are home to around 85% of the world's population. They collectively accounted for two-thirds of the world's energy-related carbon dioxide (CO_2) emissions and for 95% of the increase in emissions over the 2011-2018 period – a trend that is expected to continue unless EMDEs can meet their growing energy demand from renewable or low-carbon energy sources. Accelerating the energy transition in EMDEs is a critical step towards limiting the temperature increase to 1.5°C above pre-industrial levels by the end of this century. This will also improve the welfare of local communities through a fair distribution of benefits – making the transition just and inclusive – if due consideration is given to social equity in delivering the energy transition.

Scaling up renewable energy investments is of paramount importance for accelerating the global energy transition – in EMDEs as elsewhere. To propel a just and inclusive energy transition in EMDEs, it will be necessary to address existing disparities in investments.

Global energy transition-related investments exceeded USD 2 trillion for the first time in 2023. However, current patterns of investment are skewed, with the vast majority of financing going to advanced economies and a handful of large EMDEs such as China, India and Brazil. These countries represent relatively lucrative contexts for private investment owing to their well-established power and financial markets, as well as their capacity to incentivise investments through subsidies and tax measures. Putting these countries aside, the rest of the world received just 10% of global energy transition investments in 2023. Sub-Saharan Africa, home to 571 million people lacking access to electricity and more than 923 million people lacking access to clean cooking, received just USD 12 per capita in transition-related investments in 2023, 40 times less than the world average.

EMDEs presents attractive investment opportunities, when investment risks can be properly identified, allocated and mitigated. To capture them, risk mitigation instruments and strong leveraging of public resources will be needed.

For private investors and developers, investment risks in EMDEs have an immense impact on the cost of capital and project bankability. Yet the nature and level of those risks vary widely within the diverse EMDE pool. For that reason, investment risks must be analysed within specific country contexts so as to devise appropriate measures and instruments for implementation by EMDE governments and their partners – including G20 countries, multilateral and national development banks, development finance institutions, export credit agencies and insurance organisations, plus a host of joint initiatives. Within these implementation solutions, new instruments and business models, such as blended finance and green bonds, are playing a growing role.

Stronger public support will still be needed in some EMDEs than in others. In this regard, international collaboration has a pivotal role to play, not only in terms of providing concessional loans and grants, but also in technical support, technology and knowledge transfer, policy advice, capacity building, and, particularly, robust energy planning.

Effective integrated energy planning can provide the foundation for a healthy investment ecosystem.

A comprehensive integrated energy planning process enables the alignment of energy policies and investment strategies with broader socio-economic goals, notably a just and inclusive transition. The planning process – institutionally backed, regular and transparent – comprises the development and use of quantitative scenarios with harmonised objectives and decision making initiatives across all relevant stakeholders and sectors. This includes the alignment of short-term activities such as establishing policy, regulation, risk management, and financing with long-term objectives such as climate mitigation and adaptation. Properly conceived and executed, the result will present a clear view of investment needs; uncertainties will be minimised; and ad hoc decisions will be avoided. All of these results can boost investors' confidence while addressing development and climate goals.

Developing effective long-term energy plans and conceiving short- and mid-term actions require robust planning governance structure, strong institutional capacity, and comprehensive energy scenarios addressing both development and climate goals. This highlights the importance of engaging more than just energy planners in the planning process. Toward this end, enhancing co-ordination and objectives alignment between financial and energy ministries has proved particularly crucial in facilitating the financial support needed for the energy transition. The G20 can play a critical role in this respect.

The G20 can provide a powerful platform for expanding investment and improving planning in EMDEs through the proposed Global Coalition for Energy Planning, the goal of which is to support decision-making on financing and investment and to highlight the effectiveness of energy planning as a foundation for energy-transition investments in EMDEs.

The coalition can be built on existing efforts like the IRENA Global LTES Network and provide support on:

- Exchange of knowledge and best practices among energy planning institutions, primarily to support national policy making;
- Capacity building to strengthen institutional ownership of the planning process; and
- Enhancing partnerships and co-ordination for effective technical or financial assistance programmes.

The G20 can advance these goals by continuing to provide direct bilateral funding, as well as indirect funding through capitalisation of multilateral development banks, development finance institutions and other sources of concessional and grant-based financing.

Sustainable fuels are essential to the success of a just and inclusive energy transition, not only for their role in decarbonising hard-to-abate end-use sectors, but also for their socio-economic and environmental contributions. Sustainable biofuels, in particular, will play a key role in the energy transition of EMDEs.

Sustainable biofuels have long been part of the response to fossil fuels and rural energy challenges, especially in developing countries. Yet their unique role in decarbonising end-use sectors such as aviation, shipping, cement, and iron and steel, which are difficult to decarbonise through direct electrification, has recently grown. For example, biojet fuels, biomethanol and e-methanol have been identified as the most viable and promising options for decarbonising aviation and shipping; for cement and iron and steel, sustainable fuels used as both heat sources and reactants can reduce emissions from fuel combustion and industrial processes.[1]

Applications of sustainable fuels can be combined with localised supply chains in the circular bioeconomy, leveraging incentives offered for carbon and environmental management and maximising socio-economic benefits for local communities. This integration contributes to the achievement of several of the Sustainable Development Goals. For instance, under IRENA's 1.5°C scenario, employment related to all forms of bioenergy is expected to triple from its 2021 level to exceed 10 million by 2050, representing more than a quarter of all renewable energy jobs.

Good governance is vital in the large-scale development of sustainable biofuels, which must be aligned with broader bio-based and nature-based economies and integrated into environmental frameworks across regions.

Biofuel production, as part of the circular bioeconomy, has implications for land use, ecological conversation, food security, and local economic and social development. If not well managed, impacts can be negative. Proper management, by contrast, can bring powerful synergies. Creating and exploiting those synergies depends on situating biofuels within the broader context of land-based sectors.

In practice, harmonising the governance of disconnected sustainability systems offers an opportunity for integrated land-use management. Biofuel certification schemes are a powerful tool to induce adherence to social and environmental sustainability standards. Moving beyond conventional certification towards an integrated model for sustainability governance, one centred on inclusivity and transparency, has emerged as a promising path forward.

Integral to this paradigm shift in sustainability governance is the optimisation of land-use systems through various innovations to enhance optimisation and efficiency; these promise to bolster the supply of sustainable fuels while delivering benefits across sectors and stakeholders. Large-scale biorefineries, meanwhile, offer significant advantages by distributing feedstock risks and diversifying revenue streams. Processing multiple feedstocks to produce a variety of outputs has the benefit of accessing multiple markets and income sources. Integrating sustainable fuel production into larger bio-based value chains through biorefineries exploits the possibility of large-scale production of outputs that otherwise would not be economically viable.

[1] *For more on e-fuels, see: (IRENA, 2021b, 2023l and 2024g).*

A global energy transition presents opportunities for addressing basic deficits in access to electricity and clean cooking technologies through cost-effective renewable energy solutions, thus contributing to poverty reduction, improving livelihoods, and benefiting from a just and inclusive transition.

To capitalise on these opportunities, country-specific policies and financial measures must be devised to address justice and inclusion gaps in the energy transition. Implementation of those measures needs to be contextualised with consideration of local social, economic and cultural dynamics and needs for modern energy services. More specifically, efforts in the implementation need to be made to ensure that everyone – irrespective of gender, ethnicity or status, but particularly those historically disadvantaged regions and communities – has equitable access to social protection, education, mentorship, professional networks, credit and entrepreneurship opportunities. In this respect, capacity building through formal education, vocational training, upskilling and reskilling, and empowering local communities to engage in the decision-making processes for resource use, ownership structures and distribution of benefits that would be generated from the energy transition at the local levels. For example, community-owned energy systems can often offer an effective venue to create local value, enable economic development and build public support for renewables, enhancing social cohesion.

Financial support to ensure a just and inclusive energy transition process is key.

Donor funds from philanthropies, development finance institutions – domestic, bilateral and multilateral – and funds replenished through carbon and other taxes provide multiple sources of the needed financial resources to fund energy transition projects in EMDEs that contribute to greater social equality. Domestic instruments would then be needed to channel funds into projects, infrastructure and the enabling environment to mobilise private capital. It is worth noting, however, the funding should also be allocated to the intervention schemes that would deliver social inclusion in a long run, such as education, training and (re-)skilling, social assistance, infrastructure development, and the implementation of inclusionary business models such as community energy schemes.

1. INTRODUCTION

The fight against climate change is a race against time. With temperatures, storms, floods and wildfires setting new records, the world is in uncharted territory (COP28, IRENA and GRA, 2023; UNFCCC, 2023a; WMO, 2024).

At the 28th Conference of the Parties (COP28) to the UN Framework Convention on Climate Change (UNFCCC) in Dubai in December 2023, more than 130 countries made historic pledges to transition away from fossil fuels, to triple the globe's renewable power generation capacity by 2030 and to double the rate of improvement in energy efficiency by the same year. Those pledges showed a strong political will to mitigate global carbon emissions—but, more importantly, they provided the critical targets and measures to keep the climate goals of the Paris Agreement alive.[2] The COP28 pledges also reinforced the global consensus that nations should strengthen co-operation between the developed economies (the Global North) and the emerging markets and developing economies (EMDEs).[3]

How EMDEs participate in the global energy transition has become a critical condition for putting the world on a pathway towards net-zero emissions by mid-century. Why? Because this diverse group of countries, which represent 85% of the world's population, contributed most (95%) of the increase in in greenhouse gas (GHG) emissions over the period 2011-2018 (IMF, 2024; PBL, 2019). The group's contribution may rise to 100% of future emissions growth if it cannot meet its future energy needs with low-carbon energy and decarbonise its current energy systems, which already emit two-thirds of the globe's energy-related CO_2 emissions (IEA, 2023).[4]

A global energy transition means more than merely switching from fossil fuels to renewable energy and other low-carbon energy sources. Not only will it transform how energy systems are developed, operated and governed, it will also affect the technology supply chains and manufacturing capabilities, as well as social and economic development. The changes could also mean development opportunities for EMDCs by unlocking their resources and potential –important elements for a just and inclusive global energy transition. But to bring this about the transition process must be planned and governed through collaborative international efforts so as to ensure a fair and inclusive distribution of benefits as well as risks – a distribution that leaves no one behind (IRENA, 2024a; IRENA Coalition for Action, 2023; UNDP, 2023; WEF, 2024).

This report explores ways to identify and mitigate investment risks in the EMDEs, pointing out 1) that better energy planning can attract greater investment in renewable energy, 2) that sustainable fuels will play an important role in delivering the energy transition, and 3) that the social dimensions of the transition must be addressed in the transition.

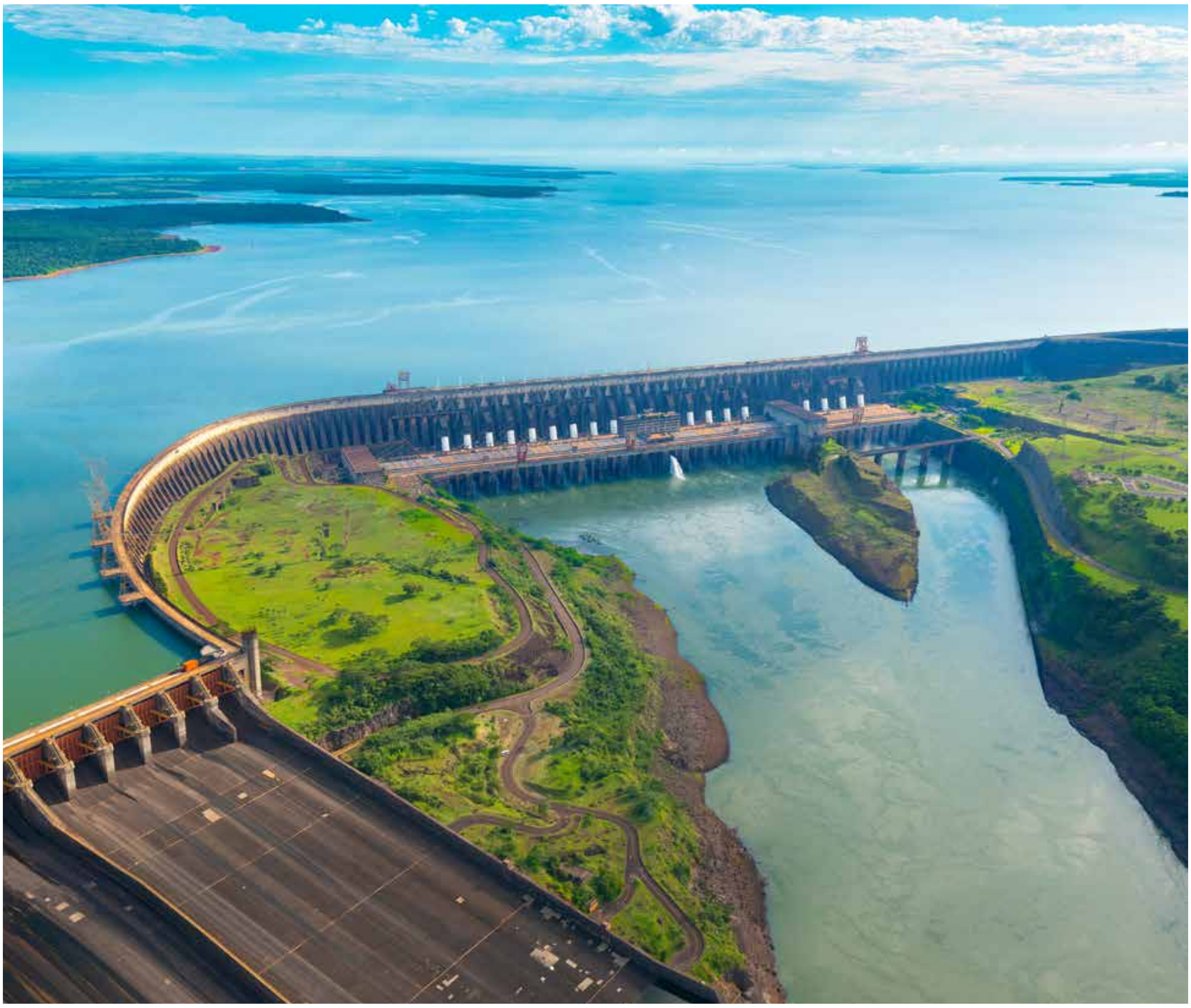
A paradigm change in energy investment is urgently needed. Accelerating the global energy transition requires scaling up investments across regions and countries to decarbonise current energy systems while meeting growing energy demand with renewable and other low-carbon solutions. This will not be possible without international and domestic capital from public and private sources – at affordable costs.

---

[2] *The central climate goals of the Paris Agreement are to keep the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. https://unfccc.int/process-and-meetings/the-paris-agreement*

[3] *The group of EMDEs consists of 155 countries, according to the International Monetary Fund (IMF, 2023a).*

[4] *The rise in the emissions contribution of EMDEs is ascribable to declining emissions from advanced economies. In 2023, the advanced economies showed a 4.5% decrease in emissions against a 1.7% increase in gross domestic product (GDP), according to the International Energy Agency (IEA, 2023).*



© Jose Luis Stephens/Shutterstock.com

Investment in the energy transition has to date been concentrated in a handful of countries and regions, notably the United States, the European Union, China, India and Brazil. Commitment, vision and policy support in the form of public funds and enabling frameworks have been the key drivers in those investments. The same cannot be said for many EMDEs – especially least-developed countries (LDCs) struggling to develop key infrastructure and attract financing for delivering modern energy services such as renewable power, electrification and clean cooking.

The lag is the result of higher real and perceived investment risks – among them political instability, grid integration problems, regulatory barriers, unreliable off-taker arrangements, foreign currency volatility and a shortage of skilled workers. Such risks drive up the cost of capital and limit the flow of finance. This in turn hampers socio-economic development.

Breaking the vicious circle will require more public finance – including through multilateral and bilateral support – and redoubled efforts to de-risk investments. The ultimate goal is to lower the cost of capital while increase the flow. One way to do this is to raise capital from investors with a higher risk tolerance. Another way is through innovative de-risking instruments and financing schemes, accompanied by institutional reforms and collaboration. Help from credible independent energy institutions can be explored to expand project pipelines in the interest of attracting still more public and private capital, internationally as well as domestically.

Chapter 2 goes deeper in exploring the challenges and risks hampering investments in the energy transition in EMDEs. Chapter 3 focuses on the role that effective long-term energy planning could play in this context.

Chapter 4 is devoted to the unique role of sustainable fuels in decarbonisation. Despite the progress made in decarbonising the power sector over the past decade, reaching net-zero emissions by mid-century will be challenging without the use of biofuels, sustainable aviation fuels, and green hydrogen and its derivatives (IRENA, 2023a). These and other sustainable fuels will be essential in decarbonising hard-to-abate sectors where electrification is difficult – such as transportation, iron and steel, and chemicals, as well as in industries where a chemical feedstock is required.

Scaling up the deployment of sustainable fuels will require wider availability of sustainable feedstocks, expanded local and regional markets, certification of sustainable fuels in support of commodity trading, and harmonisation of legal and regulatory frameworks underpinning integrated international markets for sustainable fuels.

The need for fair distribution of the socio-economic benefits of the global energy transition is the subject of Chapter 5. Greater effort will be needed on redistributive policies, technology transfer, re-allocation of the technology supply chain, re-skilling of workforces, reduction of energy poverty, and assurance that the value created by the global energy transition improves the welfare of local communities (IRENA, 2023a).

"Enabling more people to benefit from the energy transition, especially those without electricity and clean energy for cooking in remote rural areas, is crucial to achieving the UN Sustainable Development Goals (SDGs), particularly SDG 7 to "ensure access to affordable, reliable, sustainable, and modern energy for all by 2030". With continued reductions in their cost and growing modularity in sizing, renewable energy technologies offer great options for delivering on SDG 7. Solar photovoltaic power, biogas, and run-of-river micro- and pico-hydropower are among the most prominent examples of this trend.

Chapter 5 explores the challenges associated with delivering a just and inclusive energy transition. It highlights the opportunities that the energy transition can bring for those in need of access to modern energy services and clean cooking, as well as their broader associated benefits in terms of poverty reduction and improving livelihoods, and the key policy enablers required to achieve a secure energy future for all.

2. AFFORDABLE FINANCING FOR THE ENERGY TRANSITION IN EMERGING MARKETS AND DEVELOPING ECONOMIES

KEY MESSAGES

The energy transition is essential for meeting global climate goals, enhancing energy security and promoting socio-economic development. But realising the transition requires investment – a great deal of it – in renewable energy, grid infrastructure, energy efficiency, and the electrification of heating, transport and other end uses.

Global investments in the energy transition exceeded USD 2 trillion for the first time in 2023 (BNEF, 2024a), but this sum is less than half of what is required (IRENA, 2023a). Moreover, investments are concentrated in renewable power and electric vehicles, while crucial investments for other end uses, grid transmission and distribution, and energy storage lag far behind – creating a bottleneck in the energy transition.

Going forward, an 'all hands-on deck' approach will be needed. This will involve more from the private sector, more from national governments, and more from financial institutions, not only to increase overall capital flows but also to promote holistic and inclusive investments.

Current investment patterns are skewed, going mainly to advanced economies and a handful of large EMDEs, notably China, India and Brazil.[5] These countries offer relatively lucrative contexts for private investment owing to their well-established power and financial markets and their ability to incentivise investments through subsidies and tax provisions. Excluding these countries, the rest of the developing world received just 10% of global energy transition investments in 2023. Sub-Saharan Africa, home to 571 million people without access to electricity and more than 923 million people without access to clean cooking (IEA *et al.*, 2024a), received just USD 12 per capita in energy transition–related investments in 2023 (BNEF, 2024a), 40 times less than the world average.

International collaboration with G20 economies, particularly in the form of public financing, can play a crucial role in derisking energy-transition investments in EMDEs. But the role of public funds will vary depending on each EMDE's needs, level of maturity of technology and infrastructure, maturity of capital and financial markets, and macroeconomic conditions. In contexts where private capital already flows readily and there is an established pipeline of bankable projects, public funds should continue to be used to ensure project bankability – with private capital doing most of the heavy lifting.

[5] *The advanced economies are comprised of 38 countries (IMF, 2023a). Together, they make up 14% of the world's population and 40% of global GDP.*

But in contexts where bankability proves difficult to achieve, even after introducing risk mitigation and allocation measures, public support must be scaled up, particularly in the form of concessional loans and grants. Additional support through technology and knowledge transfer and technical assistance will also be important in building an attractive portfolio of projects.

The G20 can play a key role in enlarging the scale and scope of investments, particularly through their own direct bilateral funding and their capital contributions to multilateral development banks (MDBs), development finance institutions (DFIs), and other sources of concessional and grant-based sources. This is particularly important, as many EMDE governments grapple with constrained fiscal budgets and high debt burdens. In addition, G20 can aid in the development of local capital and financial markets by supporting national regulators and other relevant authorities. This could include wider use of financial products such as green bonds, blended finance and project bundling.

Given the urgency of the energy transition, the G20 must help drive investment decisions based on considerations that transcend bankability and profit seeking, focusing instead on impact potential and the power to achieve multiple SDGs, notably those related to poverty (SDG 1), universal access to energy (SDG 7), and climate (SDG 13).

2.1 INVESTMENT TRENDS

EMDEs face large gaps in financing for their energy transitions. The gaps are formed by the terms and conditions of the financing available to EMDEs, which can make capital-intensive energy transition technologies unaffordable to them. Shrinking the gap depends on securing financing on better terms by reducing country risks (real and perceived) and increasing the availability of concessional finance, strengthening energy sector cashflows, and attracting public finance in the form of government spending and international grants (Foster *et al.*, 2023).

EMDEs are a diverse set of countries. They range from the world's second-largest economy, China, to a group of the least-developed nations that most of the people living in energy poverty. As such, the landscape for energy transition-related financing varies significantly within the group. This section examines the disparities in investments in EMDEs compared with advanced economies (section 2.1.1) and shows that investments that do go to EMDEs are concentrated in China, India and Brazil (section 2.1.2).

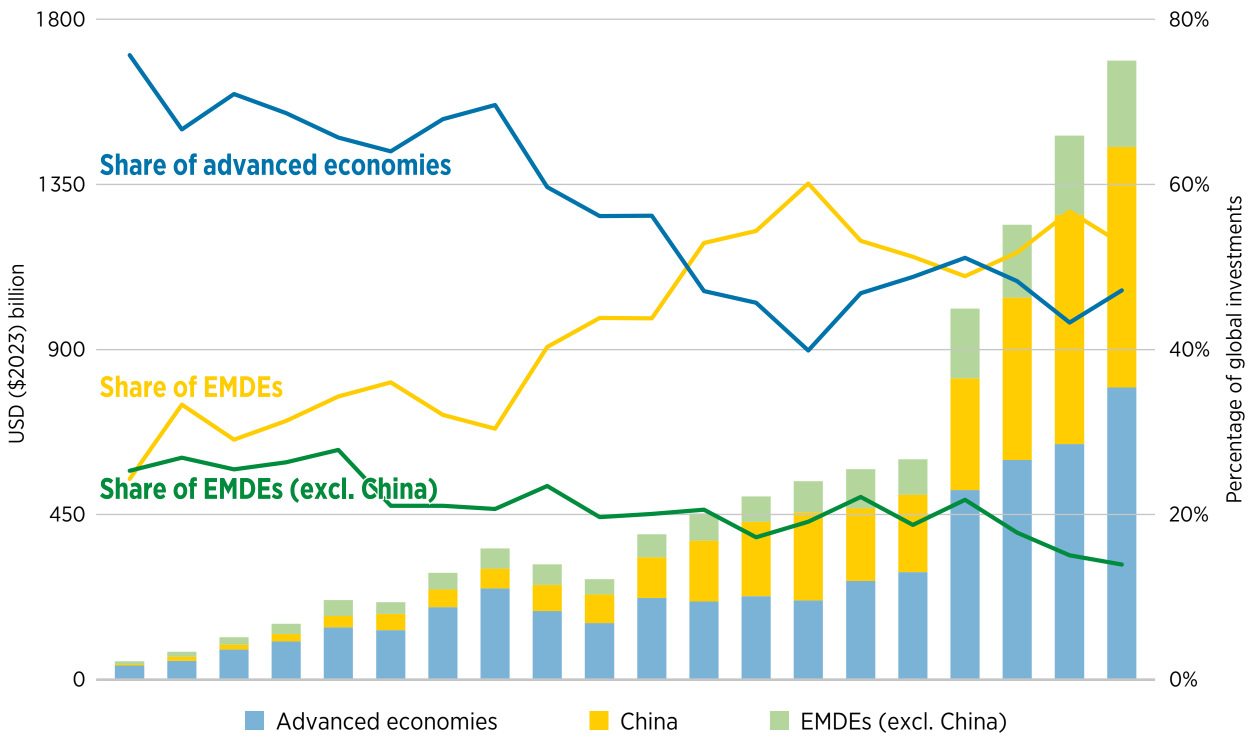
2.1.1 Disparities in investments between EMDEs and advanced economies

Global investments in energy transition-related technologies – including renewable energy, electricity grids, electrified heat, electrified transport (mainly electric vehicles, or EVs, and charging infrastructure), renewables-based hydrogen, carbon capture and storage (CCS) and energy storage – reached a record high of USD 1.7 trillion in 2023, of which EMDEs received 53% (a little less than USD 900 billion) (BNEF, 2024a).[6]

[6] *Transition-related investments (including energy efficiency) exceeded USD 2 trillion in 2023 as IRENA will show in the forthcoming 2024 edition of its annual World Energy Transition Outlook. However, energy efficiency data from (IEA, n.d.) is not disaggregated by country. Therefore, the rest of this section will focus on transition related investments excluding energy efficiency so they can be analysed in relation to the EMDEs.*

Advanced economies – 38 countries making up 14% of the world's population and representing 40% of global gross domestic product (GDP) – accounted for USD 800 billion in energy transition investments, 47% of the global total (Figure 2.1). Investments have been led by the United States and European Union, more recently bolstered by the expansionary fiscal stimulus for clean energy sectors created by the Inflation Reduction Act in the United States and the European Union's Green Deal. These policies are expected to continue driving energy transition investments in the coming years.

Figure 2.1 Energy transition-related investments in advanced economies and EMDEs



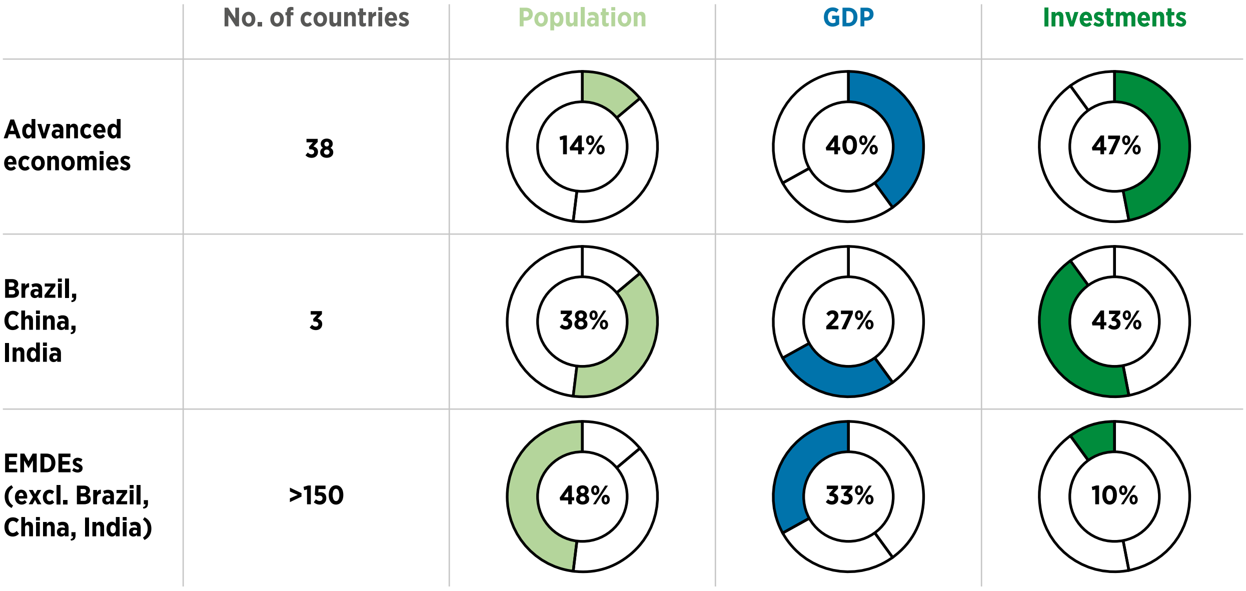
Based on: (BNEF, 2024a).
Note: EMDE = emerging markets and developing economies.

Almost 43% of global investments went to China, India and Brazil, which make up 38% of the world's population, and 27% of GDP (Figure 2.2). The focus of investments in these three countries is discussed in section 2.1.2.

Meanwhile, half of the world's population – living in more than 150 economies outside Brazil, China and India, and representing one-third of global GDP – received just 10% of the world's energy transition investments (Figure 2.2). Even this small share of investments is concentrated in major EMDE markets including Viet Nam, Poland, Mexico, Chile, Indonesia, United Arab Emirates, Thailand, Philippines, the Russian Federation, Malaysia, Hungary, and Peru. The remaining 140 EMDEs received less than 7% of global investments.

These disparities in investments have been increasing. Advanced economies attracted 18 times more investment per capita over 2020-2023 than the 154 EMDEs (excl. China), up from 14 times between 2016-2019 (Table 2.1).

Figure 2.2 Proportion of energy transition related investments in 2023 compared to population and GDP, by country groupings



Based on: (BNEF, 2024a; IMF, n.d.; World Bank, 2024).

Notes: GDP = gross domestic product; EMDEs = emerging markets and developing economies; Data based on latest year available. Annual investment figures are from 2023, while GDP and population data are from 2022. Country classification is based on IMF's World Economic Outlook.

Table 2.1 Energy transition investment per capita by country and country group

COUNTRY GROUP	CUMULATIVE INVESTMENT PER CAPITA (USD/PERSON) (2016-2019)	CUMULATIVE INVESTMENT PER CAPITA (USD/PERSON) (2020-2023)
World	242	501
Advanced economies	805	1 726
EMDEs	154	315
(excl. China)	58	95
(excl. China and India)	66	114
(excl. Brazil, China, India)	63	99
(excl. G20)	98	163
COUNTRIES/REGIONS		
Brazil	109	385
China	506	1 146
India	38	40
Sub-Saharan Africa	7	12

Based on: (BNEF, 2024a).

Notes: All figures in this table are based on nominal values. As BNEF coverage of grid transmission and distribution investment begins in 2020, these figures were excluded from the per capita investment calculations. The table considers the following sectors: renewable energy, electrified heat, electrified transport, hydrogen, and carbon capture and storage.

2.1.2 Concentration of investments

China is the global leader in energy transition-related investments. Since 2013, it has accounted for an average of 70% of investments in EMDEs each year, mainly driven by the government's commitment to renewable energy development and deployment in five-year plans. Excluding China, EMDEs received just USD 236 billion in investment in 2023, just 14% of the global total. In fact, as shown in Figure 2.1, although EMDEs' share of global investments has more than doubled between 2013-2023, the share has remained largely stagnant when excluding China.

Within the EMDE block, India and Brazil are the two other major investment markets, accounting respectively for 4% and 3.7% of EMDE-specific investments over 2013-2023. In Brazil, renewable energy investments quadrupled in 2020-2023 over the 2016-2019 pre-pandemic period, as more than 10 gigawatts (GW) of solar and wind energy projects reached financial closure (BNEF, 2024b). In India, electric vehicle investments are growing rapidly, while renewable energy investments have recovered to pre-pandemic levels after experiencing a slight decline in 2019 and 2020, likely due to economic slowdown from the COVID-19 pandemic and subsequent geopolitical crisis. Investments in both countries have been driven by a range of factors: large resource potential; strong government support in the form of ambitious targets and dedicated government programmes (the National Solar Mission in India, and the Auctions for Renewable Energy Support programme in Brazil); growing energy demand; and increased market liberalisation to attract more foreign direct investment.

The role of public financing varies. In Brazil, it accounted for almost a third of overall renewable investments during 2017-2020 (IRENA and CPI, 2023). The Brazilian Development Bank (BNDES) has been instrumental, investing around USD 100 billion in renewable energy projects and new power capacity and transmission lines from 2000 to 2023 while offering supportive financing conditions and risk mitigation strategies to stimulate private investments (IRENA and BNDES, 2024). In India, private investments are more prominent. Led by corporations and commercial financial institutions, private investments made up 78% of renewable energy investment over 2017-2020 (IRENA and CPI, 2023). The bulk of the investment in India was driven by attractive tariffs for renewable power as well as subsidies for EVs, sales which increased almost five-fold between 2020 (around USD 250 million) and 2023 (USD 1.2 billion) (IISD, 2024). In line with this trend, investments in electrified transport (mainly EVs) also increased five-fold after 2020, although they still make up a relatively small portion of India's overall energy transition investments (8%), which is dominated by renewable energy projects and grid investments.

Around 7% of EMDE-specific investments in 2023 were made in Viet Nam, Poland, Mexico, Chile, Indonesia, United Arab Emirates, Thailand, Philippines, the Russian Federation, Malaysia, Hungary, and Peru, in order of magnitude. Some of these countries have experienced rapid investment growth in the past, but further investment has been hindered by various infrastructural, market and regulatory issues. In Viet Nam for instance, attractive feed-in tariffs (FiTs) drove record-high investments in solar and wind technologies between 2018 and 2021, but grid constraints, curtailment, and pricing uncertainty has since deterred further investment (Le, 2022). The remaining 130+ economies in the EMDE accounted for just 15% of EMDE-specific investments in 2023 (less than 7% of the global total, as previously noted).

Despite its vast renewable energy potential, Sub-Saharan Africa is the region that receives the least investment, although it is home to 567 million people who still lacked access to electricity in 2021, with access rates in 23 African countries mired below 50% and more than 923 million people still without access to clean cooking fuels in 2022 (IEA *et al.*, 2024a). The region received just USD 12 per capita in energy transition–related investments during 2020-2023, about 40 times less than the world average and negligible in comparison with the advanced economies.

LDCs and small island developing states (SIDS) continue to attract very little renewable energy investment, even though they have set ambitious targets for renewable energy deployment and other energy-transition

© Jose Luis Stephens/Shutterstock.com

technologies. During 2013-2020, LDCs received a mere USD 30 billion, while SIDS received around USD 3 billion[7] (BNEF, 2024a), equivalent to less than 1% of the global total, a share that has likely dropped further since the pandemic. Going forward, a minimum of USD 100 billion will be needed in LDCs and SIDS to double their renewable energy capacity to 110 GW over 2023-2030 – a target they have set in their energy plans (IRENA, 2023b).

This imbalance highlights the unique challenges and competing priorities that many EMDEs face, making it difficult for them to match the scale and pace of investment seen in more advanced economies. Many EMDEs face several challenges at once. Some pressing issues include constrained fiscal space, political and regulatory instability, and the need to prioritise immediate social and economic concerns such as poverty reduction, healthcare, education, and safety. Additionally, smaller market sizes and less-mature financial markets can limit access to affordable capital. As a result, investments in the energy transition are even more skewed than GDP distribution.

[7] *This excludes USD 0.3 billion for SIDS that are also classified as LDCs. This figure is already accounted for in the USD 30 billion. Together, LDCs and SIDS make up USD 33 billion in investment over 2013-2020.*

2.2 INVESTMENT RISKS

A variety of investment risks pose a substantial barrier to renewable energy financing and deployment. These can include currency risks (*e.g.* unexpected volatility in exchange rates), political risks (*e.g.* war), and supply chain risks (*e.g.* delays in receiving equipment). Details on investment risks are presented in section 2.3.2.

When renewable energy projects are financed, particularly by the private sector, risk has a considerable impact on the cost of capital for a project and its financial viability. Because risk premiums are higher in EMDEs than in advanced economies, the public sector must play a more active role in reducing risks and barriers to lower the cost of capital and improve the financial viability of renewable energy projects.

2.2.1 The impact of risks on the cost of capital for renewable power projects

The higher cost of capital in EMDEs has been exacerbated in recent years by an uptick in inflation and the associated 'risk free' rate of borrowing. Inflation began to climb as the world emerged from the first year of the COVID pandemic in 2021, with the gradual restoration of supply chains and the release of pent-up demand. The conflict in Ukraine, however, sent energy and commodity costs soaring, driving consumer price inflation to an annualised rate of 9% in the United States (June 2022) and 10.9% in the European Union (September 2022), far higher than target values for inflation that typically platform at annualised rates of around 2% in most advanced economies. Many central banks reacted by raising policy rates in order to stifle inflation.

This has raised the cost of capital for all economic actors, including renewable power project developers. The yields on 10-year US Treasury Bonds, often used as a benchmark for the 'risk-free' rate of capital, more than doubled in 2022 to 2.95% from an average of 1.44% in 2021 (OECD, 2024). With inflation still running high, increases continued in 2023, with yields on US 10-year bonds peaking at 4.8% in October 2023 before finally starting to ease towards the end of 2023. Overall, however, the benchmark rate of risk-free capital had increased by a factor of 2.7. The situation was exacerbated by the macroeconomic damage of high energy prices and consumer inflation, which drove country risk premiums up in many markets, especially EMDEs, as their fiscal and macroeconomic situations deteriorated (IRENA, 2024b).

The uptick in base rates has had a particularly large effect on the energy transition, given that, except for bioenergy for power generation, renewable power technologies have no fuel costs, enlarging the role of the cost of capital. For a representative solar photovoltaic (PV) or onshore wind project, for example, the levelised cost of electricity increases by around 80% if the cost of capital is 10% rather than 2%, according to IRENA's analysis (IRENA, 2024b).

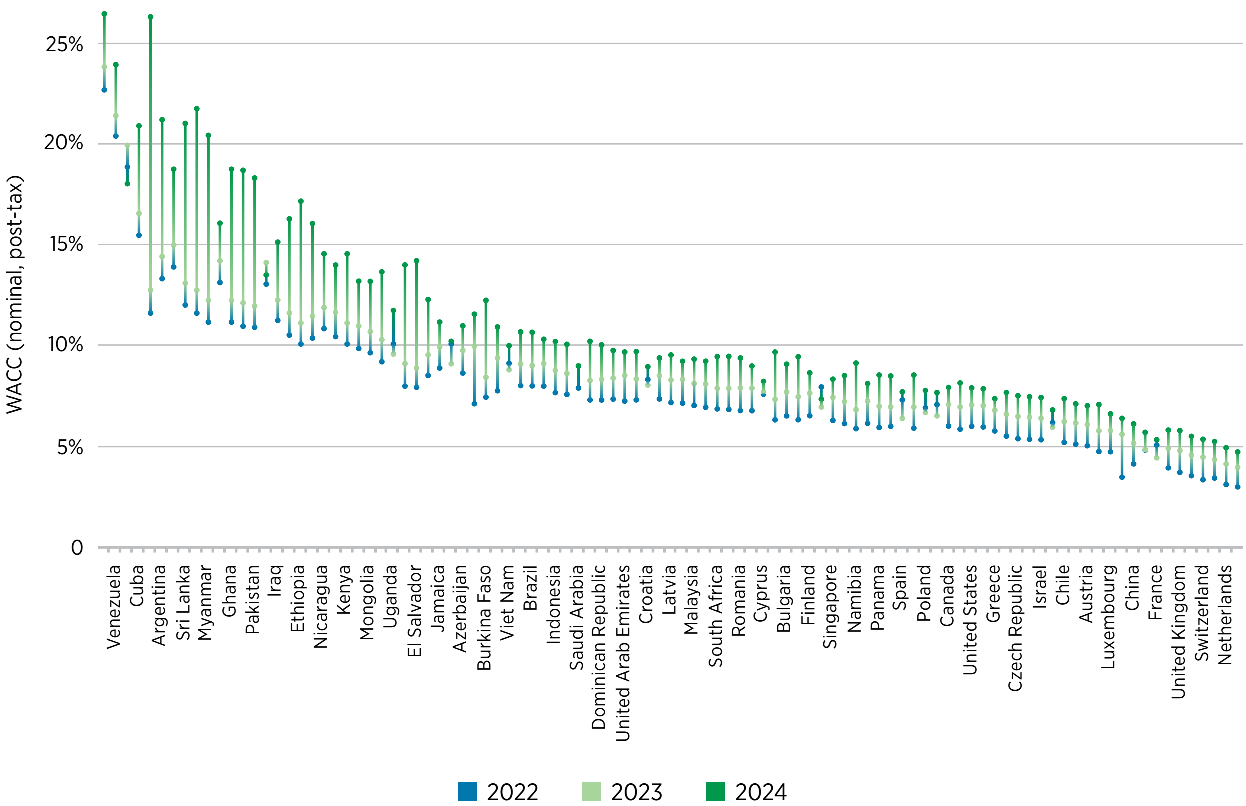
Figures 2.3 and 2.4 present the weighted-average cost of capital (WACC) for solar PV and onshore wind in 100 countries, based on the survey results of IRENA, ETH Zurich and IEA Wind (IRENA, 2023c) for onshore wind and in more detail for solar PV, with the benchmark model calibrated from the survey results where data gaps exist.[8]

Figure 2.3 highlights the changes in the WACC over time. The increase for utility-scale solar PV between 2022 and 2024 is readily apparent. In advanced economies, this increase has been relatively uniform, but the same cannot be said for many EMDEs. Disproportionate increases have appeared as lingering supply chain issues, highly inflationary environments, deteriorating macroeconomic and fiscal conditions have caused increases in the WACC in excess of 7% in the space of two years.

[8] *WACC assumptions are technology- and country-specific benchmark values for 100 countries from IRENA's WACC benchmark tool. The tool has been calibrated to the results of the IRENA, IEA Wind Task 26 and ETH Zurich cost of finance survey (IRENA, 2023c).*

The impact on projects commissioned in 2023 was significant, with an increase of 1 to 1.2 percentage points in Europe and 1 to 1.6 percentage points in Africa. However, the real impact will be felt in 2024, with a further increase in Europe's WACC of as much as 3.3 percentage points, though for most markets the increase will be in the range of 0.8 to 1.2 percentage points. In Africa, the situation is much more serious. The WACC of projects commissioned in 2024 could be as much as 6.5 percentage points higher than 2022, though in countries with more stable macroeconomic and fiscal outlooks the increase may be as little as 1.5 percentage points over 2023.

Figure 2.3 Nominal, post-tax-weighted average cost of capital for utility-scale solar PV projects by country, 2022-2024

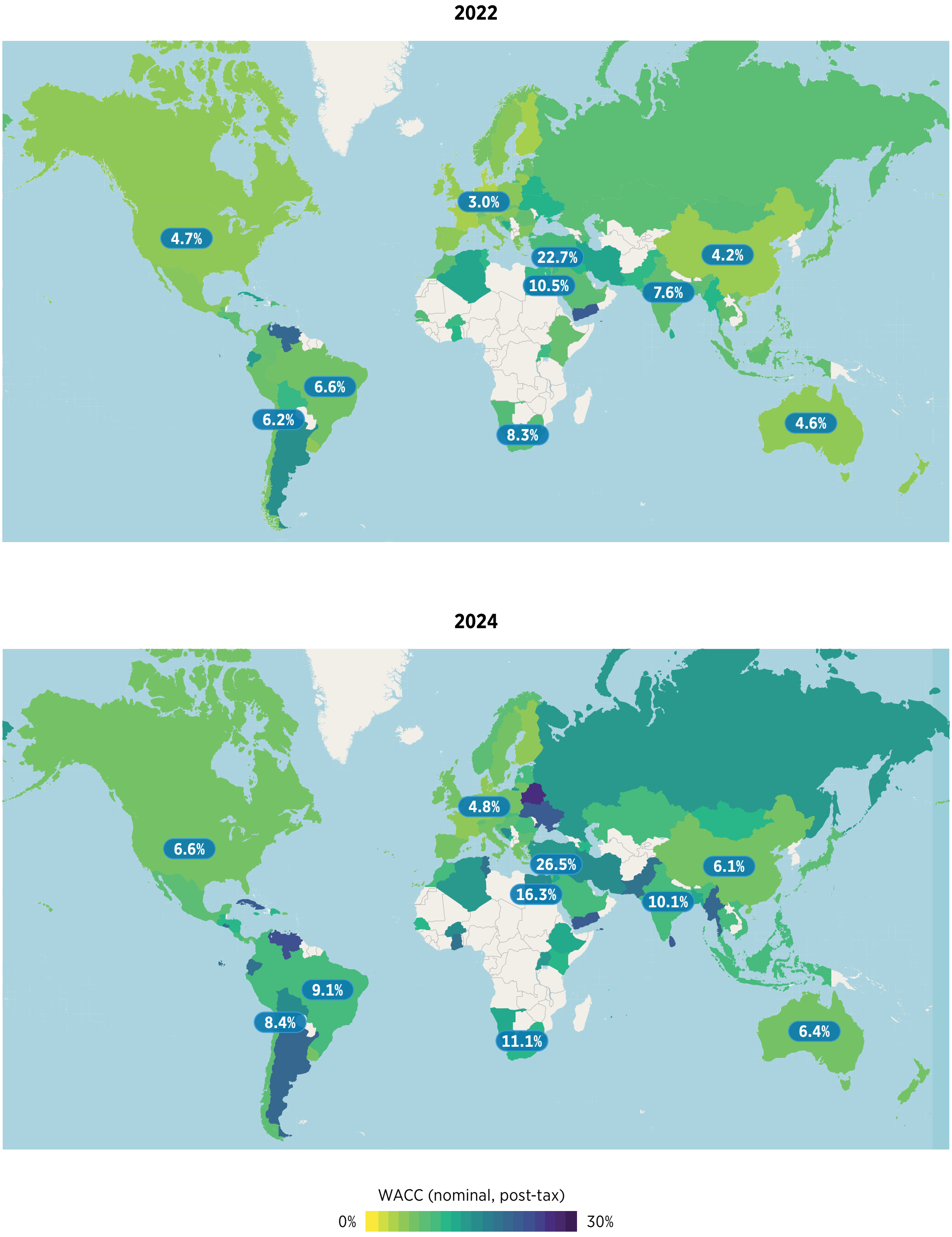


Source: (IRENA, 2024b).

Note: WACC values for a given year are calculated in the previous year.

In many markets, risk premiums for solar PV are lower than for onshore wind, although the difference varies depending on the level of maturity of the local market for each technology. For instance, there is virtually no difference in the cost of capital for solar PV and onshore wind in Germany, whereas in Finland onshore wind can attract a significantly lower cost of capital than solar PV. However, the overall trend toward an increase in the cost of capital is clear over the two years across all markets. The average cost of capital for onshore wind projects in 2022 and 2024 is presented in Figure 2.4.

Figure 2.4 Nominal, post-tax-weighted average cost of capital for onshore wind projects by country, 2022 and 2024



Source: (IRENA, 2024b).

Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

2.2.2 The level of risk and its impact on project bankability

EMDEs are very diverse countries with very different levels of risks. For example, some countries have well-developed power markets with honoured power purchase agreements (PPAs) – a key driver to attract private investment – as well as strong governance and ample availability of local currency financing (*e.g.* Brazil and India). Others struggle with issues such as utility credit worthiness and currency exchange risks (*e.g.* most countries in Sub-Saharan Africa). Even in countries that have well-established solar PV and/or onshore wind sectors, investments in other transition technologies can be perceived as posing high risks.

It is important, therefore, to evaluate investments in context to understand how EMDEs' unique characteristics and circumstances shape different types of risks, the resultant cost of financing and the actions needed to enable investments. Context-specific analysis can reveal whether tailored policy solutions can mobilise affordable financing or whether higher degrees of public intervention are needed, including public finance.

For purposes of energy-transition investments, EMDEs fall into three broad contexts (ESMAP, 2023).

- **Context A.** Jurisdictions with a developed renewable energy sector with large deployments of certain technologies (generally solar PV and onshore wind) and well-established power markets. Examples include China, India and Brazil. In this context, some renewable energy markets have gathered steam, and the private sector is engaged. Projects are generally bankable in the presence of an adequate policy environment.
- **Context B.** Jurisdictions that successfully mobilised large amounts of private capital in certain technologies (mostly solar PV and onshore wind or biogas) but are now hitting a ceiling due to technical challenges (*e.g.* risk of curtailment) or bankability risks (*e.g.* off-taker risk) such as Viet Nam and South Africa. Such contexts may be further characterised by high dependency on (and availability of) cheap coal reserves that hinder investments in renewable energy despite the risk of stranded assets. In this context, some policy adaptation and risk mitigation are needed to retain project bankability and private investors' engagement. This can also be the case for investments in less-mature technologies even in jurisdictions where some technologies such as solar PV and/or onshore wind do not need any support, as in Context A.
- **Context C.** Jurisdictions that have not been able to attract investments owing to constrained macroeconomic conditions or political conflicts that increase risks to the point where they cannot be mitigated through conventional policy instruments. Projects may not become bankable in the near-term, but investments in renewable energy are urgently needed for energy access and socio-economic development. Even if some projects have been successfully completed, generally with considerable support from MDBs, investments have not moved to the next phase of scaling up renewable energy deployment (*e.g.* investments in solar PV in Zambia and Mali). As these projects have been completed, other issues have emerged with regard to system integration, transmission constraints, utility creditworthiness and overcapacity. In such contexts, the role of concessional loans and grants is crucial. In Chad for example, such support is helping develop the country's first commercial solar plant of 60 megawatt (MW) (InfraCo Africa, n.d.). These forms of support can come either at the national level – through allocation of risks to stakeholders other than the private sector (*e.g.* government or public utilities) – or with the support of international players (*e.g.* MDBs or other players, such as the International Finance Corporation (IFC) and its Scaling Solar Programme, as seen in section 2.3.2). In this context, public financing and policy must shift the focus from 'bankability' to 'impact potential'. Investment decisions must be based on factors that go beyond realising financial profits for private investors to encompass climate, environmental, socioeconomic and development goals (see section 2.5). Box 2.1 showcases an analysis of bankability versus impact of projects submitted to IRENA's Energy Transition Accelerator Financing (ETAF) platform.

Box 2.1
Bankability versus impact potential and analysis of ETAF pipeline of projects

An analysis of 86 projects submitted to IRENA's ETAF platform between December 2022 and February 2024 shows that although many projects did not meet bankability criteria, they still ranked high in terms of impact potential.

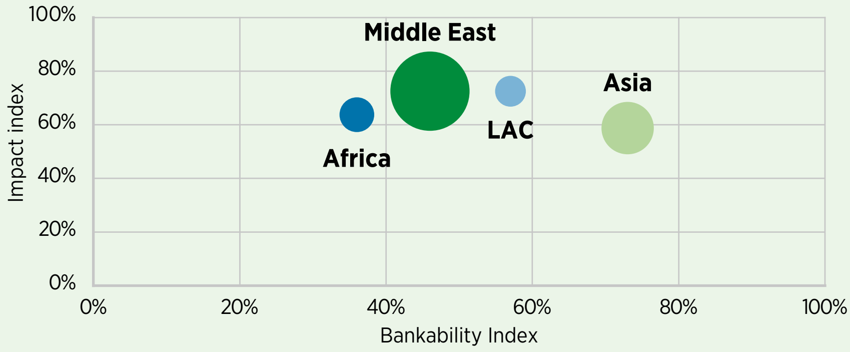
A bankability index was formulated by analysing the project's unit cost score, which is calculated from the ratio of the total cost of the project to its capacity; the equity share of the project's total cost; the status of the equity contribution (*i.e.* whether it is secured or not); and the ETAF secretariat's recommendation on the projects.

An index of impact potential was formulated by analysing the project's reported potential climate benefit (from emissions reduction) and number of people that would benefit from the project (in terms of energy access, affordability and jobs created). These values were drawn from the submitted information by the project developers.

Figure 2.5 shows where projects fall on the bankability versus impact-potential spectrums by region. These projects were all vetted by the ETAF secretariat and submitted to the funding partners. The size of the bubbles represents the total capacity of projects submitted. The figure shows that projects in Africa and the Middle East (chiefly Iraq), although falling a bit short on the bankability score, demonstrated high impact potential. Projects from Asia (excluding China and India) had the highest bankability, albeit with a slightly lower impact-potential index.

The results of the analysis show that many projects in some of the least-developed regions do not move forward because of their low bankability score regardless of the impact they might have on the communities and countries. This calls for a different approach in some contexts, notably a greater deployment of public and donor funds in socio-economic development. In countries with constrained government budgets, the international community must step in.

Figure 2.5 Bankability versus impact potential of projects submitted to ETAF funding partners



Note: LAC = Latin America and the Caribbean.

2.3 LOWERING THE IMPACT OF RISKS ON THE COST OF CAPITAL

In line with the specific context of EMDEs, especially contexts B and C, appropriate risk identification, allocation and mitigation can reduce the cost of capital for developers. By doing so, projects can achieve viable unit economics, allowing them to meet debt-service obligations and equity investors' expectations, while charging less for electricity. A considerable portion of risks to investors and private developers can be eliminated through risk mitigation measures or policy design (a good example is auctions). To date, risk mitigation measures have tended to allocate risks to utilities and governments. Innovative models are needed to spread the risks in a more equitable way, one that attracts private investors placing additional debt distress on governments. This section identifies the principal risks and discusses ways to mitigate or allocate them.

2.3.1 Risk identification

Identifying risks can help governments and DFIs implement the right policy mix or risk mitigation instruments to address them, or to turn to other solutions if risks are too high to be mitigated (as in Context C). Risks are present at the macro, energy sector, transactional and project levels, as described below and summarised in Table 2.2 (with corresponding allocation and mitigation measures).

At the *macro level*, chief among the risks that investors cite are political and geopolitical risks (such as political stability and the rule of law), governance and safety issues, and economic risks, including those linked to inflation and sharp currency depreciations.

At the *level of the power sector*, barriers present themselves in the form of policy-level support (or lack thereof) for the development of renewable energy, concerns about the power purchaser's creditworthiness (or consumer credit risk, particularly in the case of off-grid markets) and lack of sufficient investment in grid interconnection and transmission lines, among others. In addition, changes in legal or regulatory policies can erode investor trust. In the absence of structural policy and regulatory reforms, private power producers may fear loss of access to the transmission grid and worry that off-takers might not be creditworthy, operationally efficient and reliable. Finally, lack of government institutional capacity and synergy in the planning, procurement and contracting processes can lead to unsustainable project development outcomes (SEforAll, 2020).

At the *transactional level*, potential project developers may have doubts about the availability of appropriate financing instruments (in particular, affordable long-term debt) in local markets; matching funds and risk-mitigation tools; and know-how for structuring and financing transactions. They may also be concerned about accessibility to affordable finance due to relatively small transaction sizes.

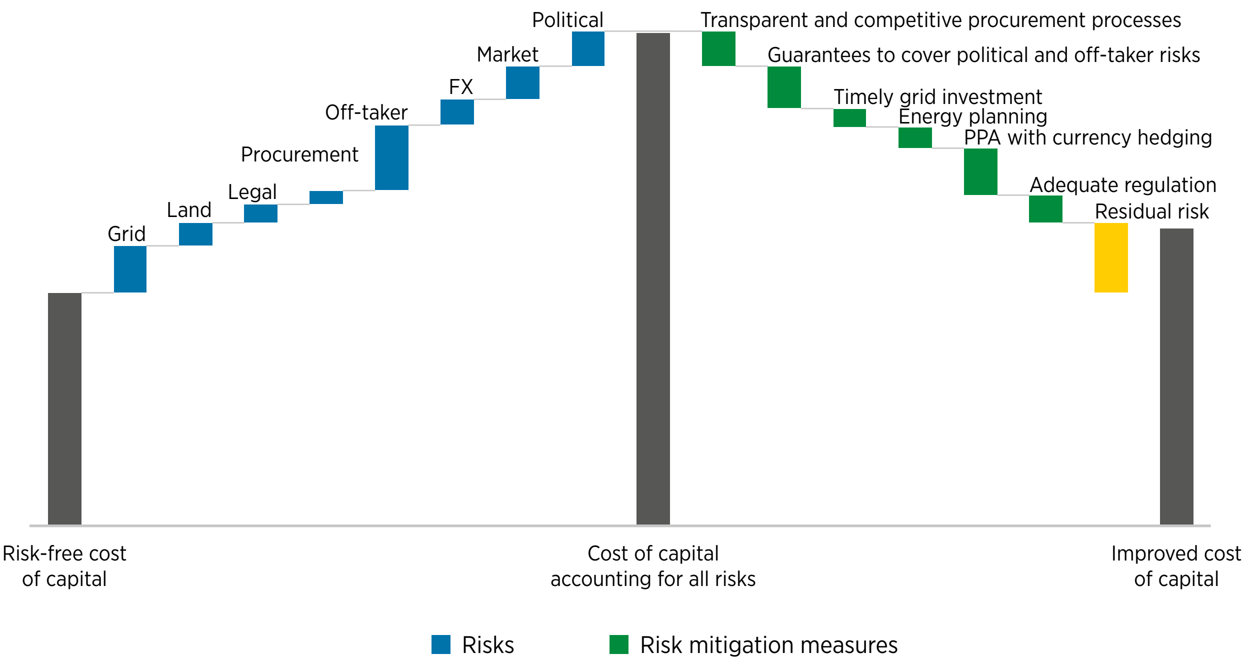
At the *project level*, developers face risks related to site provision and project preparation, supply chain disruptions, obtaining the permits needed on time including overcoming social and environmental risks, and during the operation of the project, risks related to natural disasters and arbitration and contract enforcement.

2.3.2 Risk mitigation and allocation

By lowering perceived and real investment risks, risk mitigation instruments are designed to mobilise capital from private investors, in contexts where this is feasible, and to ensure a more efficient use of public capital. Figure 2.6 shows how different measures can help lower the cost of capital.

A wide array of risk-mitigation instruments is available today. Providers include host governments; multilateral, regional and national development banks; DFIs; export credit agencies; insurance companies and a host of joint initiatives. The measures are typically provided on a project-by-project basis or as a bundled package for projects that are part of a structured procurement programme.

Figure 2.6 Illustrative impact on the total cost of capital (debt and equity) of risks and risk mitigation measures



Based on: (ESMAP, 2023).
Note: This example is illustrative. The exact magnitude of risks will vary across different contexts. FX = foreign exchange; PPA = power purchase agreement.

DFIs, in particular, have an important role to play in supporting investments in independent power producers (IPPs) in EMDEs by offering liquidity support and partial risk guarantees in lieu of sovereign guarantees and security packages, among other solutions. Such support is critical for the bankability of IPP projects in EMDEs, which may have few customers outside financially challenged power off-takers backed by fiscally constrained sovereign states. For investors – particularly lenders – to be comfortable with the risks involved, additional credit enhancement and risk mitigation cover is required.

Allocating or transferring risks to parties that are better positioned to handle them can help minimise transaction costs. This can be done through structured procurement mechanisms (or auction design), in addition to risk mitigation instruments. IRENA's extensive analysis of auction design has identified the options for allocating risk among the parties to an auction (IRENA, n.d.a).

The most common risks a renewable project may encounter in EMDEs are identified in Table 2.2, along with common instruments to minimise, hedge or transfer them. Examples of risk mitigation instruments in Africa can be found in Box 2.2; most are funded by advanced economies, including G20 members.

Some of these instruments may be difficult to access and sometimes expensive to buy (*e.g.* some currency hedges). Also, guarantees, for example, are increasingly hard to obtain, as they can be considered a contingent liability that is added to the national debt burden. These difficulties often hinder wider deployment of risk mitigation in markets such as Africa (IRENA, 2020a, 2020b).

It has been increasingly recognised that some risks – such as policy and regulatory risks, grid infrastructure related risks, and some segments of technology risks – can be more accurately assessed or mitigated if accompanied by energy planning and adequate capacity, skills and finance. In this respect, the notion of energy planning extends beyond the conventional purposes of ensuring enough supply to meet projected demand over a certain period of time. Planning can be extended to include long-term objectives aligned with climate targets, policy making, regulatory activity, and the socio-economic benefits of transitioning away from fossil fuels. Such planning could reduce uncertainty to some degree, provide greater transparency and boost the level of investors' confidence in risk assessment. In so doing, it could help lower financing costs for investors and developers, thereby making investment opportunities more appealing in EMDEs (IRENA and BNDES, 2024).

Planning will be further discussed in Chapter 3 and the report issued in partnership with the Brazilian Development Bank (IRENA and BNDES, 2024).

Table 2.2 Key investment risks and mitigation tools to address them

CURRENCY RISK

Risks associated with volatile foreign exchange rates adversely affecting investment value. Risks arise when there is a mismatch between revenues (often in local currency) and debt financing (often in hard currency).

Risk mitigation through financing instruments and policy (auction) design

1. Power purchase agreements (PPAs) denominated in local currency, with the public sector offering long-term funding in local currency (*e.g.*, through the national development bank).
2. PPAs denominated in hard currency or indexed to currency fluctuations (in which case currency risks are passed on to utility or government).
3. Currency hedge mechanisms (swaps, an emergency liquidity credit line for projects with predictable inflation-indexed future revenues, and insurance against extreme exchange-rate depreciation) from multilateral development banks or other public sources.
4. Government guarantees or partial credit guarantees.
5. Tax benefits offered for debentures issued in local capital markets to be used to finance renewable energy investments.
6. Issuance of green or sustainable bonds where the government bears the exchange rate risk.

Table 2.2 Key investment risks and mitigation tools to address them (continued)

Risk	Risk mitigation through financing instruments and policy (auction) design
NATURAL HAZARDS The risk that natural disasters will affect the ability of a counterparty to fulfil its obligations (produce power, make payments).	**1.** Property, casualty and specialty insurance. **2.** Contracts that remain valid if a natural disaster or force majeure affects contractual obligations, with the affected party released from liability for non-fulfilment during the event's duration (subject to government or regulator approval).
POLICY OR REGULATORY RISK Risks associated with changes in legal or regulatory policies that adversely affect project development or implementation (incentive programs, taxes, interconnection regulations, permitting processes).	**1.** PPAs containing a clause stating that if new taxes, sectoral charges, or legal modifications affecting any party are implemented during the contract's validity, the sale price may be adjusted accordingly (subject to government or regulator approval). **2.** Government guarantees, potentially backed by partial risk/credit guarantees, export credit guarantees and political risk insurance. **3.** In the long run, building a reputation for upholding contract terms.
MARKET RISK Risk of lower-than-anticipated demand.	**1.** Long-term PPAs (15-30 years) with take-or-pay provision. **2.** During extreme events (*e.g.* COVID-19 pandemic), government-structured loans to mitigate the impacts of reduced consumption and increased consumer defaults. Loan repayable through consumer tariffs.

Table 2.2 Key investment risks and mitigation tools to address them (continued)

CONSTRUCTION RISK

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

Risk mitigation through financing instruments and policy (auction) design

1. In auctions, technical qualification requirements that ensure the commitment and reliability of bidders.
2. Requirement that developers demonstrate technical and financial capability to build projects on schedule and deliver energy according to the auction requirements.
3. Requirement that power auction winners provide surety and performance bonds before contract signing.
4. Auctioneer oversight of project evolution.

RESOURCE RISK

Risks associated with uncertainties surrounding the availability of renewable energy resources.

Risk mitigation through financing instruments and policy (auction) design

1. Contract models for variable renewable energy (*e.g.* wind and solar PV generation) that allow for intertemporal compensation of production variation.
2. Policy design to incentivise generation at given hours of the day. For example, generation profiles through auction demand or incentivised payment when demand is low through auctioning of feed-in premiums to be paid on top of market rates (or other means).
3. Requirement that generators (*e.g.* for wind projects) carry out anemometric and climatological measurements over the contract period and that data thus obtained is periodically sent to the energy planning authority to better understand resource availability and support planning.

TECHNOLOGY RISK

Risks associated with the use of nascent technology or inexperienced labour.

Risk mitigation through financing instruments and policy (auction) design

1. Public sector-led capacity building and training.
2. Public sector-led pilot projects.
3. Administrative mechanisms that do not depend on competition (*e.g.* feed-in tariff).
4. Technology-specific auctions.
5. Specialised insurance products.

Table 2.2 Key investment risks and mitigation tools to address them (continued)

GRID AND TRANSMISSION RISK

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

Risk mitigation through financing instruments and policy (auction) design

1. Public sector-led studies and investments in infrastructure to reduce grid and transmission risks on generators (*e.g.* expansion of interconnections and transmission corridors to facilitate the integration of renewable energy).
2. In auctions with a lead time of less than five years, introduction of a preliminary qualification phase to select projects with connection feasibility through competition among projects with the same connection point. Projects with planned installed capacity exceeding the connection capacity cannot bid in the auction.

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.

Risk mitigation through financing instruments and policy (auction) design

1. Government guarantees, political risk insurance, partial risk/credit guarantees, export credit guarantees, liquidity facility – in short, instruments to allocate risks to another party, usually the government.
2. When applicable according to power market design, generator enters into bilateral contracts with a pool of buyers (*e.g.* distribution companies), mitigating impact of single default.
3. Requirement that buyers (*e.g.* distribution companies or utility) assign their accounts receivable to the generator through a managing bank, and/or deposit a certain number of months of PPA payments in advance. The managing bank will ensure that energy purchase contracts are paid before the distribution companies can access the funds.
4. In the non-regulated market, bilateral negotiation of PPAs, with generator assuming off-taker risk. In this case, a bank guarantee, letter of credit, and insurance are usually required.
5. PPA to include a termination clause in case of default.

Table 2.2 Key investment risks and mitigation tools to address them (continued)

RE-FINANCING RISK

Risk that a borrower cannot re-finance the outstanding loan during the project's life owing to problematic loan terms (high cost of borrowing, mismatch between loan maturity and lifetime of the asset).

Risk mitigation through financing instruments and policy (auction) design

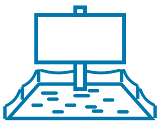
1. Development bank empowered to mitigate refinancing risk when credit markets are under stress.
2. Development banks permitted to participate in investor's capital market (*e.g.* debentures) subscriptions.
3. Tax benefits for debentures issued in domestic capital markets used to finance energy investments.

LIQUIDITY RISK

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

Risk mitigation through financing instruments and policy (auction) design

1. Government guarantees, letters of credit, fully funded escrow accounts, liquidity guarantees.
2. Government assurance that contractual obligations will be honoured.
3. Government-structured financial loan to mitigate buyers' liquidity risks. Loan to be paid back over a number of years through consumer tariff adjustments.
4. Establishment of a system to signal monthly expected electricity prices and to adjust tariffs accordingly, partially mitigating liquidity risks. If system is insufficient to cope with increase in electricity prices, government may structure a financial loan.



SITE PROVISION AND PREPARATION RISK

Risk that land ownership of the project site is unclear or that private land ownership is not allowed (*e.g.* in Ethiopia). It also refers to the risk that a government-provided site is poorly prepared or selected.

Risk mitigation through financing instruments and policy (auction) design

1. Sites provided by government, with limitations.
2. Developers required to demonstrate land use rights and preliminary environmental permits during the technical qualification process.

Table 2.2 Key investment risks and mitigation tools to address them (continued)

Risk	Risk mitigation through financing instruments and policy (auction) design
ARBITRATION AND CONTRACT ENFORCEMENT RISK Risk that the (international) project owners/funders are unlikely (or believe themselves unlikely) to get a fair or impartial hearing in local courts. Risk that contracts will not be enforced by the local judiciary.	1. International arbitration clauses in project documents.
PERMITTING RISKS Risk that permits required by the project (environmental authorisation, building permits, and generation licenses) are not provided on time – or at all.	1. Government or off-taker empowered to assume some permitting responsibilities and risks if the site is provided or if the country uses specific corridors or zones. 2. Preliminary environmental licensing required in the technical qualification process.
SUPPLY CHAIN RISKS Risk that projects will face delays in receiving equipment or that costs will increase during development.	1. Policies to localise value chains. Governments may play a role in attracting leading global manufacturers, encouraging local production of components and developing domestic supply chain through industrial policies and capacity building. 2. Measures to address inflation, rising costs and exchange rate risks associated with imported equipment (possibly through contract indexation).

Based on: (IRENA, 2016, 2020c; IRENA and AfDB, 2022; IRENA and BNDES, 2024).

Box 2.2
Risk mitigation instruments in Africa

The World Bank and its member institutions are the most prominent providers of credit enhancement and risk-mitigation cover in emerging markets and developing economies. In Africa, the African Development Bank and the International Development Finance Corporation (previously known as the Overseas Private Investment Corporation) are active providers of political risk insurance. Partial risk guarantees from the World Bank's International Development Association protect private lenders against debt-service defaults by host governments and against the failures of off-takers to meet certain obligations. The Bank's Multilateral Investment Guarantee Agency (MIGA) guarantees independent power producers against the risks of currency inconvertibility and transfer restrictions, expropriation, breach of contract, civil unrest and war. MIGA guarantees amounting to more than USD 100 million are protecting the long-term power purchase agreements of renewable energy projects in countries such as Djibouti, Kenya, Namibia, Senegal, and South Africa (Power Futures Lab, 2021).

Credit and political risks in Africa are also covered by joint initiatives such as the Regional Liquidity Support Facility launched in 2017 by the German development bank KfW and the African Trade Insurance Agency, a pan-African multilateral insurer providing credit insurance products to support investments in Africa (ATI (African Trade Insurance Agency), 2018). Similarly, the Africa Energy Guarantee Facility has been put in place by the European Union, KfW, the European Investment Bank, Munich Re and the ATI to provide insurance and reinsurance products for sustainable energy projects in Sub-Saharan Africa (European Commission, 2019).

GuarantCo, which forms part of the Private Infrastructure Development Group and is funded by the governments of Australia, Germany, the Netherlands, Sweden, Switzerland and the United Kingdom, as well as the International Finance Corporation, provides local currency liquidity support to independent power producers. It is providing a USD 2.92 million loan guarantee to the Akuo Kita 50 MW solar PV Project in Mali, as well as a USD 9.3 million guarantee to the Ambatolampy 20 MW solar PV project in Madagascar (Power Futures Lab, 2021). The TCX Currency Fund also provides hedging tools for currency risks.

The U.S. International Development Finance Corporation provides similar liquidity cover, including for the 30 MW Ten Merina solar PV project in Senegal, as does France's DFI Proparco, which enabled the extension of a loan term for a 37 MW solar PV project in Namibia by providing loan cover to a local commercial bank (Kruger *et al.*, 2019; Power Futures Lab, 2021).

2.4 EMERGING APPROACHES TO FINANCING RENEWABLE ENERGY PROJECTS

The past decade has seen the emergence of a host of new investment instruments and business models to mobilise capital towards the energy transition in some of EMDEs. Among these are blended finance, green bonds, result-based financing, contract standardisation and project bundling. Each of these is discussed in this section.

2.4.1 Blended finance

Often coupled with risk-mitigation instruments, blended finance encourages the sharing of risks and know-how among transacting parties through the pooling of public and private capital. It can often attract private financiers to transactions which on their own might have difficulty obtaining commercial financing without the participation of the public financier (IRENA, 2016, 2020c, 2023d). Blended finance covers an array of solutions – among them co-financing of projects among multiple parties; on-lending transactions, whereby a DFI on-lends its low-cost capital to local institutions; and the use of subordinated debt and convertible loans or grants provided by other public or philanthropic sources.

To make blended finance more efficient and widely deployable, financial markets in the target countries must be strengthened. This can be done by building the capacity of local financial institutions (*e.g.* through the launch in 2021 of the Leveraging Energy Access Finance Framework by the Green Climate Fund and the African Development Bank); mobilising local investors, including national development banks (IRENA and BNDES, 2024); promoting greater use of local currency; and engaging local stakeholders to identify opportunities to meet local needs. Improved collaboration among market participants, sharing of know-how and transparent reporting of results would also help increase the number of blended transactions as well as their effectiveness in mobilising the market. Finally, blended finance packages may work best when part of a portfolio approach and incorporated into national sustainable development plans (OECD, 2020).

In some cases, like the Alliance for Green Infrastructure in Africa, blended finance can be provided as part of a mix of other instruments (Box 2.3).

Box 2.3
A USD 4.5 billion finance initiative to unlock Africa's clean energy potential

Africa's combined energy access and transition challenges demand co-ordinated support from strong partnerships of multilateral agencies, donors and advanced economies. The United Arab Emirates has stepped in to provide a blended finance initiative at scale, co-ordinated with existing African initiatives.

During the African Climate Summit in Nairobi in September 2023, the COP28 president announced an initiative by the UAE to deploy USD 4.5 billion in blended finance to unlock Africa's clean energy potential under the umbrella of Etihad 7, a development platform aimed at providing clean electricity to 100 million people across the African continent by 2035.

The UAE initiative will bring together public, private and development capital from UAE institutions, among them the Abu Dhabi Fund for Development (ADFD), Etihad Credit Insurance (ECI), Masdar (a clean energy company, active in 22 countries in Africa), and AMEA Power in collaboration with Africa 50, an investment platform established by African governments and the African Development Bank. Meanwhile, Africa 50 is leading a complementary initiative, the Alliance for Green Infrastructure in Africa, which is designed to support the initiation, development and preparedness of bankable projects and subsequently to spur private investments in green infrastructure.

ADFD and ECI are kickstarting the combined initiative by funding the initial investment intended to catalyse private sector action. ADFD is providing financial assistance to address basic infrastructure needs, offer innovative finance solutions and mobilise private investments. ECI provides credit insurance to de-risk private capital. Masdar is committing additional equity and project finance through its Infinity Power platform. AMEA Power aims to build 5 GW of renewable energy capacity on the continent by 2030. The partners' commitments are summarised in Table 2.3.

Table 2.3 Commitments made at COP28 to support energy transitions in Africa

UAE ENTITY	INSTITUTION TYPE	COP28 COMMITMENT (USD MILLION)	AFRICA'S CLEAN ENERGY SUPPORT
ADFD	Financial	1000	funding the initial investment intended to catalyse private sector action
ECI	Insurance	500	credit insurance to de-risk and unlock private capital
Masdar	Technical: clean energy	2000 in equity 8000 in project finance	Targeting 10 GW of clean energy capacity by 2030
AMEA Power	Technical: renewable energy	1000 in equity 4000 in project finance	Targeting 5 GW of renewable energy capacity by 2030

Source: (WAM, 2023).
Note: GW = gigawatts.

With an enhanced clean energy landscape in the continent, lower costs made possible by regional energy integration, and enabling policies that facilitate and encourage investments, there will be more room for a sustainable investment ecosystem to pour more resources from the private sector.

Source: (AfDB, 2023).

2.4.2 Green bonds

Green bonds, like conventional bonds, help the bond issuer raise funds for specific projects in return for a fixed periodic interest payment and a full repayment of the principal at maturity. The green label tells investors that the funds raised will be used to finance environmentally beneficial projects.[9] Green bonds help governments raise finance for projects to meet climate targets while enabling investors to achieve their sustainability objectives (IRENA, 2020a).

Green bonds have proven to be a particularly successful capital market instrument, with an average annual growth rate of 60% over the 2015-2020 period. Total global issuances reached USD 270 billion in 2020 from USD 100 billion in 2015 (Climate Bonds Initiative, 2021). Cumulative issues topped USD 1 trillion in December 2020. The potential for further growth is still very large, as the global bond market stood at USD 120 trillion at the end of 2020 (Climate Bonds Initiative, 2021; SIFMA, 2021). Green bonds are a particularly effective tool for mobilising capital from institutional investors who prefer to invest large amounts indirectly via bonds or funds rather than directly into renewable energy projects (IRENA, 2020a).

A recent example on this front was the launch of Brazil's Sovereign Sustainable Bond Framework in September 2023. The framework covers three types of bonds: green bond, social bond, and sustainability bond (Sovereign Sustainable Finance, 2023). The first issuance raised USD 2 billion, with demand far outstripping supply. Proceeds will be allocated to Brazil's climate fund, managed by the BNDES, to support the government's strong commitment to environmental and social sustainability (Reuters, 2023). Another example is India's 2022 adoption of a Sovereign Green Bond Framework, described in Box 2.4.

Viewed globally by volume, about half of green bond issues had renewable energy as one of their use categories, while 16% were earmarked solely for renewable energy assets (IRENA, 2020d). To encourage further growth of this promising investment instrument, policy makers and regulators can work together with DFIs and green bond organisations such as the Climate Bonds Initiative to develop and adopt green taxonomies and bond issuance and rating rules; to raise awareness; to develop pertinent skills in local capital markets; and to provide seed capital and targeted grants to lower transaction costs, among other undertakings (IRENA, 2020a).

Box 2.4
Local currency sovereign green bonds in India

The Indian G20 presidency played a leading role in securing a commitment by the G20 countries to collectively triple their renewable power generation capacity by 2030. More than USD 15 trillion in investments, including in modernising grid infrastructure increasing grid flexibility, are required to achieve the tripling target (COP28 Presidency *et al.*, 2023). Sovereign Green Bonds (SGrBs) could become one of the most effective avenues for sourcing financing to achieve the target. In November 2022, India defined its Sovereign Green Bond Framework (Government of India, 2022), sending a strong signal to develop a domestic green bond market and attract investments to meet the country's climate and clean energy targets. The green bond issuances are expected to facilitate the adoption of proven renewable energy technologies (solar power, wind, small hydro) and drive research into emerging technologies like tidal energy.

[9] *"Green Bonds are any type of self-labelled fixed income instruments where the proceeds will be exclusively directed to finance or re-finance, in part or in full, new and/or existing green projects. It is regarded as a climate mitigation and adaptation tool" (IMF, 2023b).*

India joined the SGrB bandwagon in 2023, when the national government issued USD 1.9 billion in rupee bonds in two tranches (Reserve Bank of India, 2023). With five- and ten-year tenures, the bonds were largely subscribed by local banks and insurance companies, with limited participation from foreign banks. Investors did offer a moderate premium, called a 'greenium', in the range of 1-6 basis points. The proceeds are directed towards financing public projects aimed at reducing carbon emissions across nine sectors: renewable energy, climate change, sustainable water and waste management, clean transportation and pollution control, sustainable management of living natural resources and land use, and terrestrial and aquatic biodiversity conservation. India intends to raise an additional USD 2 billion in 2025 through SGrB issuances. The next tranche will have a 30-year tenure.

The limited interest from international investors can be attributed to the exchange rate risk and the risk of currency depreciation. Aiming to diversify and expand foreign exchange funding, the Reserve bank of India in November 2023 announced a 'fully accessible route' for SrGB investments designated as specific securities.

Additionally, in 2023, India classified investments in green bonds as infrastructure investments. Through this move, the government is expecting increased participation from pension funds and insurance companies looking for long term investments, since insurance companies in India need to invest at least 15% of their investment in infrastructure. The State Bank of India (India's largest public sector bank) has started working on a risk matrix for the borrowers; special credits will be given to those embarking on green initiatives.

The Indian SrGBs are scheduled to be incorporated in the global bond index (JPMorgan's Government Bond Index–Emerging Markets and its index suite) in June 2024, which could lead to incremental inflows of around USD 23 billion (Reuters, 2024). This could attract more foreign investors to Indian green bonds and potentially increase demand, spurring a rise in bond premiums.

2.4.3 Contract standardisation and project bundling

Renewable energy projects, like other infrastructure projects, entail significant transaction costs stemming from the complex technical, legal and financial work required to close a transaction. If several projects can be bundled together, per-project transaction costs can be greatly reduced for all parties, leading to faster and smoother closing – and often better pricing. Bundled projects can also help attract institutional investors.

An example of a bundled renewable energy transaction is the 102 MW Seven Sisters solar PV project in Jordan, which was led by the IFC. Combining seven relatively small (10-50 MW) projects developed by seven different developers, the project reached financial close in 2014. Being the lead arranger and lender of record, the IFC acted as an intermediary with other lenders and service providers. All transactions were combined into one financing platform, and legal documentation was based on a common template. Transaction costs were further reduced as bulk discounts were obtained from service providers, including legal, technical and insurance advisors (IFC, 2018). Given the success of the approach in Jordan, the IFC replicated it with the Nubian Suns project in Egypt, which reached financial close in 2017. Nubian Suns is a USD 653 million, 752 MW aggregation of 13 solar PV plants near the city of Aswan; the aggregation is part of the larger Benban Solar Park, which eventually will comprise 32 plants. The 11 financiers also included DFIs and international banks, while the Multilateral Investment Guarantee Agency provided political risk insurance for 12 of the projects (IFC, 2018).

As is evident from Seven Sisters and Nubian Suns, standardisation of legal documentation is an important enabler of project bundling and the resulting economies of scale. In addition to project documentation (*e.g.* PPA and operations and maintenance agreement), standardisation can also encompass risk mitigation instruments provided by DFIs. Documentation used for renewable energy projects is often based on documents originally developed for conventional power projects, which tend to be larger and more complex. In contrast, renewable power projects are often simpler, smaller and more rapidly implementable. Contracts designed for fossil fuel power often do not fit well with renewable energy and may increase transaction time and costs unnecessarily.

2.5 MAKING FINANCING MORE AFFORDABLE THROUGH PUBLIC FINANCING FROM THE G20

Public policy and financing will have to play a crucial role in EMDEs.[10] Given that most EMDE countries are fiscally constrained, international collaboration, including through the transfer of public funds, will play a crucial role (section 2.5.1). However, international flows of public funds remain low (section 2.5.2). The members of the G20 can spearhead international collaboration efforts and have a big role to play in supporting EMDEs if the world is aiming for just and inclusive energy transitions that leave no one behind.

2.5.1 How international flow of public funds can support EMDEs

In contexts where private capital has been flowing but needs to be scaled up, the focus of public funds can be on de-risking investments through policies and instruments that make projects bankable for private investors, as shown in section 2.3. In such cases, public funds can flow into designing and implementing conducive deployment policies (*e.g.* competitive procurement), and unlocking more affordable financing through risk mitigation or through investments in infrastructure to mitigate risks related to off-take.

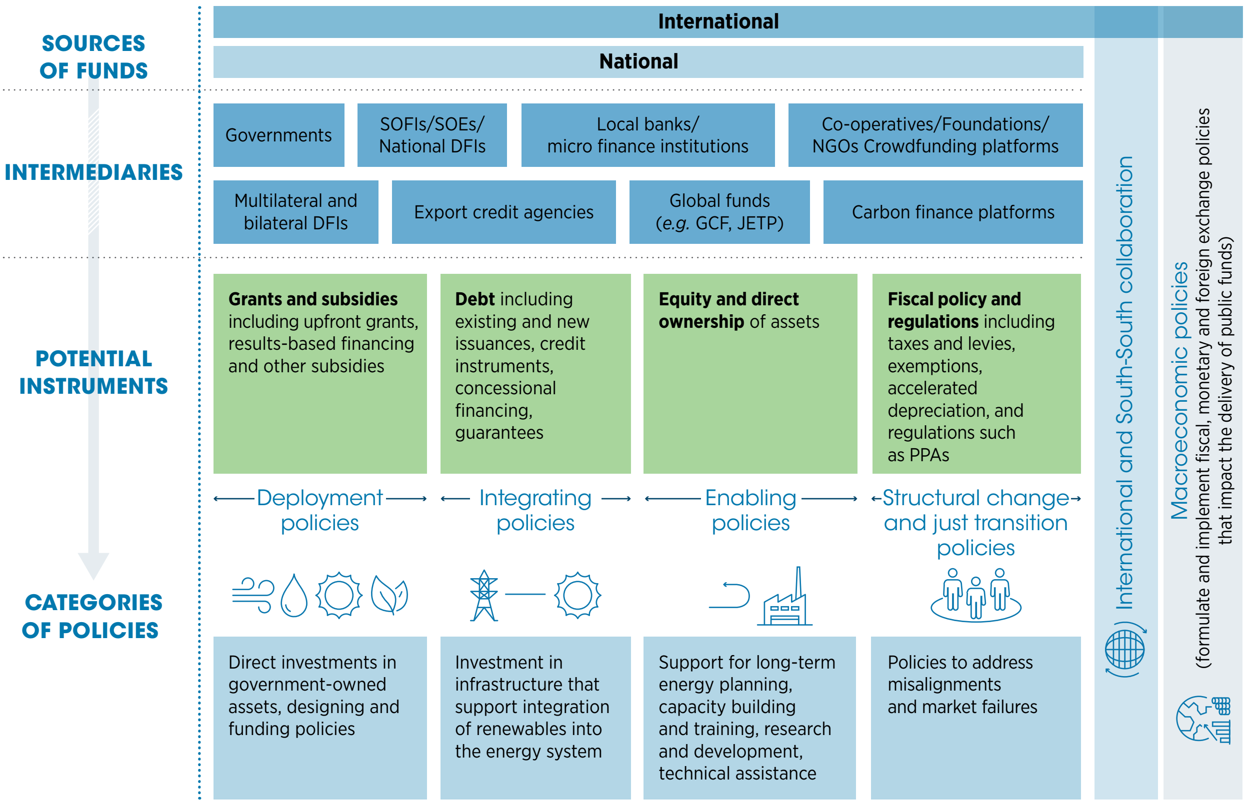
However, such measures may be insufficient in certain contexts (*e.g.* Context C described in section 2.2.2), where projects may not become bankable in the near term. In such contexts, public financing and policy must be co-ordinated to shift the focus from bankability to impact potential. Investment decisions will have to be made based on factors other than realising financial profits for private investors, factors that encompass short- and longer-term climate, environmental, socio-economic and development goals, in addition to the project's potential to kickstart a renewable energy sector. IRENA is currently working on an expanded framework to measure impact potential so that projects that promise to have the most impact on community welfare can obtain financing even if they are not bankable by conventional measures. Welfare in the new framework will embrace energy access and affordability; socio-economic development in terms of productive uses, jobs and income; and market potential in terms of serving as first-mover pilots.

[10] *Central banks and financial regulators can play a considerable role in unlocking climate-related financial flows in EMDEs. That role lies outside the scope of this analysis but is discussed in (Caiado Couto, 2023).*

In order to finance projects with high impact potential, funds will have to be disbursed as direct investments, grants, rebates and subsidies. Figure 2.7 illustrates the flow of funds, identifying the intermediaries through which they flow into the different categories of policy instruments. For instance, grants can be used to set up funds that can be leveraged to provide risk mitigation instruments without further stressing the budgets of already indebted countries.

For EMDEs with excessive deficits, particularly LDCs whose growing debt burdens and shrinking fiscal space hampers their ability to realise their development priorities, international flows of public finance, mainly from G20 members, are essential (UNCTAD, 2023). To this end, international financial institutions, including MDBs and climate and development funds, have an important role to play in ensuring universal access to energy, alleviating poverty, and achieving sustainable development and climate goals. This approach is crucial for countries in Context C, where impact potential must be embedded in the way projects are evaluated and funded. G20 members can lead the way in embracing and supporting the implementation of such methods to assess projects that receive financing.

Figure 2.7 The role of public finance in achieving energy transitions in EMDEs



Based on: (IRENA and CPI, 2023).

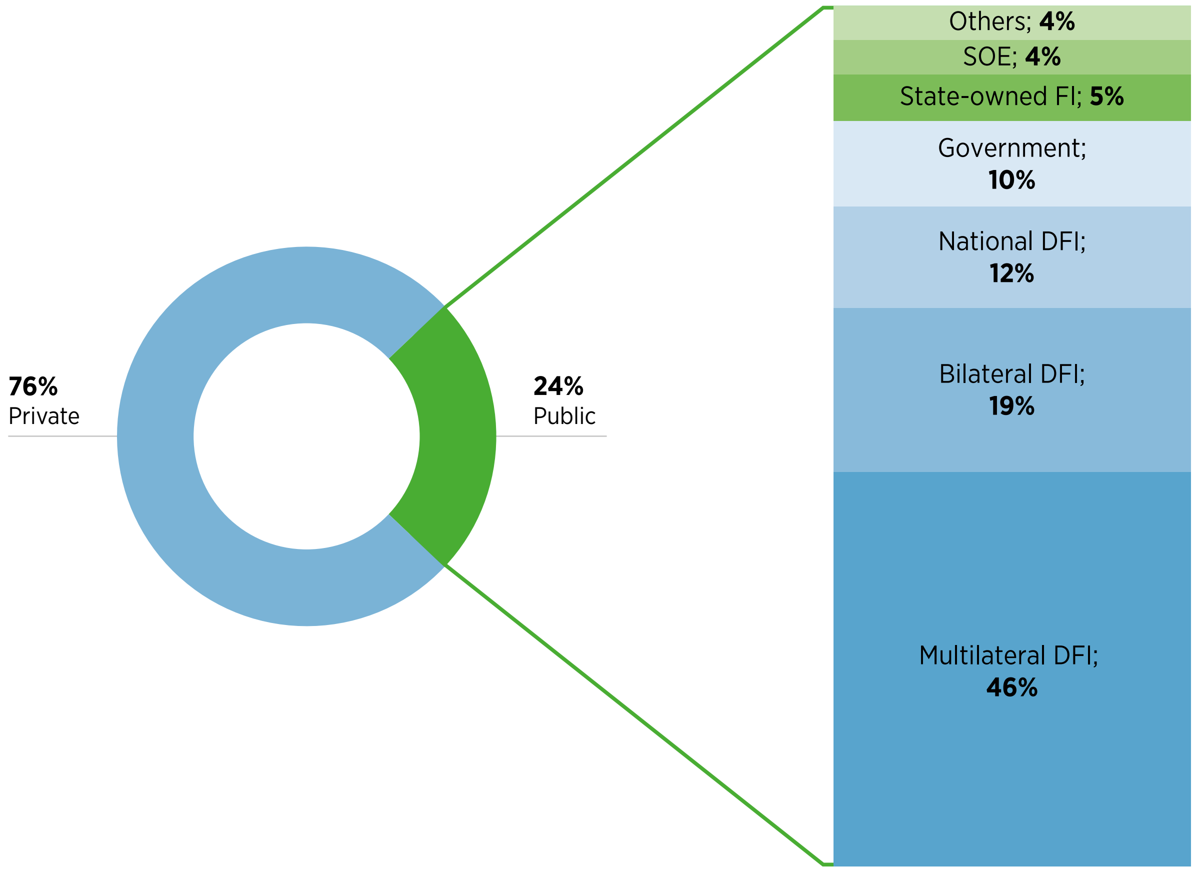
Note: SOFI = state-owned financial institution; SOE = state-owned enterprise; NGO = nongovernmental organisation; DFI = development finance institution; GCF = Green Climate Fund; JETP = Just Energy Transition Partnership.

2.5.2 The current status of public financing for renewable energy

In 2021-2022, the public sector provided 24% of renewable energy investment in EMDEs (excluding China). In other words, for every USD 1 of public funds spent on projects, an additional USD 3 came from the private sector. Governments, state-owned financial institutions (SOFIs), and national DFIs and SOEs, provided 31%

of public investments, mostly in the form of domestic flows. Multilateral and bilateral DFIs together provided 65% (Figure 2.8) although the portion of concessional loans and grants remains low.

Figure 2.8 Renewable energy investments in 2021-2022, by sources of financing and type of public investor, in EMDEs (excluding China)



Source: (CPI, 2024).
Note: FI = financial institution; DFI = development finance institution; SOE = state-owned enterprise.

Support from multilateral and bilateral DFIs typically is tracked and published each year (IEA *et al.*, 2024a). According to the latest figures, international flows of public money for renewable energy in developing countries has been in decline since 2018. Despite a slight rebound in 2022, it is still less than half of the flows in 2016 (IEA *et al.*, 2024b). This trend calls on multilateral and bilateral DFIs, as well as other development funders such as philanthropies to step up support.

SOFIs, DFIs and SOEs have played a considerable role in emerging economies and are expected to continue to do so. Brazil's BNDES is a case in point (IRENA and BNDES, 2024). In contexts where MDBs are not able to take on high-risk investments (especially in the absence of sovereign guarantees), SOFIs, DFIs and SOEs can fill some of the financing gaps.

Going forward, international public financing will have to carry a higher responsibility for funding energy transition infrastructure and building local capacities, while continuing to perform its function of de-risking investments to attract private capital. COP28 has already brought positive outcomes for financing the energy transitions in EMDEs (Box 2.5).

Box 2.5
COP28's climate finance outcomes

COP28 advanced climate outcomes through the adoption of the UAE Consensus – the new point of reference for global climate ambition and sustainable development. The UAE Consensus included a historic set of climate initiatives and measures such as the landmark agreement to transition away from fossil fuels in a just, orderly and equitable manner, an agreement to reverse and half deforestation by 2030, and the COP28 Presidency's Action Agenda, which included unprecedented financing commitments on energy, food, water, health, nature and inclusion.

COP28 saw the launch of the UAE Declaration of Leaders on a Global Climate Finance Framework. Endorsed by 13 world leaders, the framework offers a set of defining principles to make climate finance more available, accessible and affordable.

In terms of financial commitments, COP28 mobilised more than USD 85 billion in climate finance and commitments, including USD 3.5 billion to replenish the Green Climate Fund (raising the second replenishment to a historic USD 12.8 billion total) and almost USD 188 million toward the Adaptation Fund.

A host of innovative financing mechanisms were announced to support countries with high burdens of debt, particularly through pledges to the IMF Resilience and Sustainability Trust, commitments to channel Special Drawing Rights to the African Development Bank, and wide adoption of climate-resilient debt clauses that suspend a country's debt repayments when the country is hit by a natural disaster.

Multilateral development banks announced more than USD 180 billion in additional climate finance commitments through multi-year programs. They also committed to continue to develop a common approach to reporting climate impact, to launch a long-term facility to support countries with strategies for decarbonisation and climate resilience, and to embrace common principles for tracking nature-positive finance.

To deliver on shared prosperity for all, African leaders came together for the launch of the Africa Green Industrialisation Initiative. Projects valued at more than USD 4 billion were announced to harness Africa's vast and high-quality resources and expand clean energy access and economic growth through country-owned strategies. This initiative builds on the successes of the UAE-led Africa Green Investment Initiative, launched at the Africa Climate Summit with a value of USD 4.5 billion.

More such efforts are needed to scale up climate financing from its base of USD 1.3 trillion in 2021-2022 to the USD 9 trillion needed annually through 2030, and the USD 10.8 trillion needed each year from 2031 to 2050 (Climate Policy Initiative, 2023).

Source: (COP28 Presidency *et al.*, 2023).

3. USING ENERGY PLANNING TO DRIVE INVESTMENT

KEY MESSAGES

A sustainable energy transition requires long-term energy planning to frame short-term actions. Long-term energy planning, when implemented properly, can provide the foundation for a more efficient and effective investment ecosystem by presenting a clearer view of investment needs and reducing uncertainties. Avoiding ad hoc decisions can boost investors' confidence while contributing to the achievement of long-term development goals.

To develop comprehensive long-term energy plans and subsidiary short- and mid-term actions, countries need stronger planning capacity. Energy planning should cast a wide net, involving more than just energy planners, particularly financial institutions. Finance ministries and the broader financial sector must be involved in order to ensure financial support for the energy transition. The G20 can play a critical role in this respect, marshalling international collaboration in support of better energy planning.

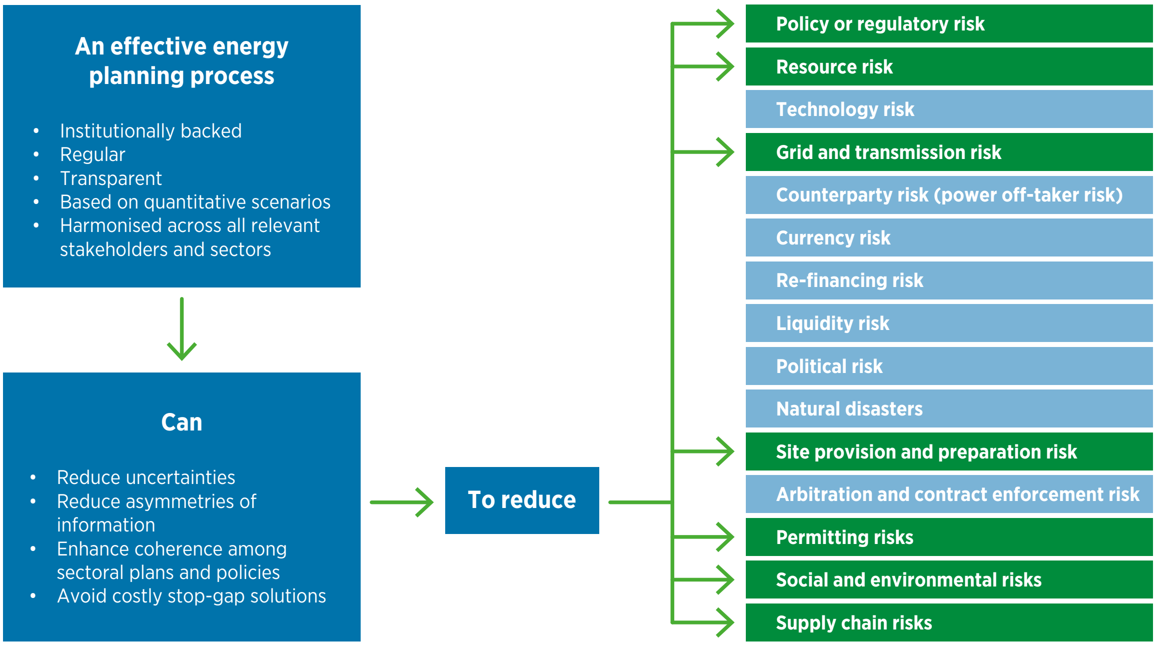
Dedicated efforts, such as the Global Coalition for Energy Planning, can build on ongoing efforts like IRENA's Global Long-term Energy Scenarios Network (Global LTES Network) to promote:

- Knowledge and exchange among energy planning institutions to support national policy making;
- Capacity building to strengthen institutional ownership of the planning process; and
- Enhanced partnerships and co-ordination for effective technical or financial assistance programmes.

This chapter highlights the importance of an effective energy planning process, which can reduce many of the risks evoked in the previous chapter (summarised in Figure 3.1) and induce investors to develop bankable projects for the energy transition. While energy planning naturally cannot address all risks – for example, natural disasters – it can mitigate many of them by providing a solid foundation for forward-looking policy and regulation, influencing how investors perceive stability and projected returns on investments. It can also ensure that projects align with net-zero or carbon-reduction commitments, based on the long-term energy transition strategies or planning framework adopted to deliver on those commitments. This, too, can provide a sense of security for investors. By contrast, policy uncertainty and the absence of an official long-term vision can increase the perception of risk, for both public and private investments.

Additionally, this chapter also shed light on the urgent need to strengthen energy planning capacity in EMDEs. In this respect, existing platforms such as IRENA's Global LTES network will be presented to showcase how the exchange of experiences among national and international institutions in energy planning can enhance energy planning capacity and energy governance.

Figure 3.1 The link between energy planning and key investment risks



Based on: (IRENA, 2016, 2020c; IRENA and AfDB, 2022; IRENA and BNDES, 2024).

3.1 LONG-TERM ENERGY PLANNING AS A FOUNDATION FOR INVESTMENT

An overarching goal of long-term energy planning is to support energy policies and investment strategies and ensure they broader climate goals, including a just and inclusive transition. Starting with a robust and quantitative analysis of the energy sector and stakeholder engagement, the energy plan underpins the formulation of policy and regulations and guides institutional co-ordination and the design of market frameworks.

More specifically, energy planning is the analytical backbone that makes it possible to formulate national targets, sub-sectoral policies and investment strategies from a thorough quantitative analysis of possible energy sector developments. The process, often aided by modelling of energy systems, sets the direction for a country's energy policy. Long-term energy planning is also a foundation for guiding short-term actions and developing mid-term milestones, including, for example, key infrastructure and workforce development needs, and supply chain enhancement.

A comprehensive long-term energy planning process – *i.e.* a regular, transparent, and institutionally backed process to develop quantitative scenarios – is often the foundation of a conducive environment for investment, including activities to establish policy, regulation, risk management and financing. Such planning is already

© Tukio/Shutterstock.com

a central component of many energy policy-making processes around the world, and the official plans that result from the process are critical to guide decisions on when, where and how to invest in the energy sector.[11]

If done properly, energy planning can:

- Reduce uncertainties that typically surround investments in the energy sector by providing clarity about the government's direction;
- Reduce information asymmetries among key stakeholders on investment needs to meet short-, medium- and long-term targets;
- Help to avoid costly stop-gap solutions or investment mistakes that prevent the development of long-term infrastructure;
- Enhance the coherence of different sub-sector plans, thus making the resulting plan more credible.

Each of these outcomes can serve to accelerate investment and reduce transaction costs, ultimately leading to lower overall system costs.

However, many countries and regions still lack robust energy planning practices, even as the clean energy transition is increasing the need to expand both the scope and scale of long-term energy planning, which will be critical to accelerate the major investments needed around the world, especially in EMDEs. The following will be necessary to redress these deficiencies:

[11] *For an overview of existing energy planning processes, see the IRENA Energy Transition Planning Dashboard (IRENA, n.d.b).*

- Better governance to ensure more integration and co-ordination at the national and trans-national levels, across sectors and across stakeholders – for example, energy and climate;
- Stronger institutional planning capacity, especially in developing countries, LDCs and emerging economies;
- Widening the scope of strategic energy planning instruments, like long-term energy scenarios (LTES), to address comprehensive development needs and climate goals.

The next section will offer case studies of how good planning can mobilise financial resources for the energy transition. Succeeding sections will survey the three critical components of good planning listed above.

3.2 FIVE CASE STUDIES OF EFFECTIVE ENERGY PLANNING

Effective energy planning can create a safer environment for investments in clean energy deployment and infrastructure. This has been demonstrated in many cases where a process characterised by strong governance and close inter-institutional collaboration has mobilised financial resources from a range of different sources.

Costa Rica
Putting in place a long-term energy planning framework to attract international finance

The Costa Rican Ministry of Environment and Energy has built energy planning into the process of developing the country's National Decarbonisation Plan. That process is institutionally backed by all relevant ministries and planning institutions; it is transparent to all stakeholders; and it is based on quantitative scenarios. This means, for example, that scenarios for the National Decarbonisation Plan also informed the preparation of Costa Rica's Nationally Determined Contribution. There is also a strong emphasis on citizen engagement in the official planning process, such as regional forums and dialogue with lawmakers, so as to better integrate social and political issues (IRENA, 2022a).

This comprehensive approach, which aligns energy planning with broader national goals, has enabled Costa Rica to secure high-level political support for the strategy from the outset, thus conferring legitimacy. Recently, Costa Rica has built on this foundation to mobilise financing through the implementation of a so-called "Data-to-Deal (D2D)" framework (Jaramillo *et al.*, 2023). The D2D framework emphasises the involvement of the Finance Ministry at an early stage and leverages transparent open data and modelling to create credible plans that the government can finance nationally and use to attract international funding. As a result, Costa Rica's 2019 energy plan based on the D2D framework had mobilised over USD 2.4 billion from international concessional sources by the end of 2022. The country will be able to replicate this work in a regular process, as it has also built institutional capacity within national universities.

Brazil
Co-ordination between the National Development Bank and the Ministry of Mines and Energy/EPE-Energy Research Office to boost renewable energy investments

In Brazil, the collaboration between the Ministry of Mines and Energy (MME)/Energy Research Office (EPE) and BNDES illustrates the positive impact of establishing strong inter-institutional co-ordination in energy planning and highlights the importance of local institutional capacities in energy and financial planning (IRENA and BNDES, 2024).

In Brazil, integrated energy planning is centralised through the MME/EPE to support cost-effective and sustainable energy deployment. The planning process integrates stakeholders and data from across the national energy spectrum through the use of databases, strategic investment plans and transmission expansion studies.

BNDES is officially involved in the planning process. It plays a critical role in the implementation of plans and studies by facilitating favourable financing conditions in local currency and developing risk mitigation strategies to make renewable energy projects more attractive to private investors. Between 2004 and 2023, this approach resulted in the addition of over 100 GW of installed capacity, primarily from renewable resources, and the construction of more than 75 000 kilometres of new transmission lines. BNDES financed approximately USD 100 billion of these projects. The fact that BNDES is well integrated into the planning process has been a key factor in Brazil's expansion of its renewable infrastructure and its ability to attract investments in wind, solar and bioenergy projects, including wind turbine manufacturers and local job creation.

Done properly, energy planning can guide private investment at a more granular, national level. Targets based on short-, medium- and long-term energy scenarios, for example, can point to the capacity that must be deployed in the near future. In co-ordination with regulatory authorities to ensure fair and bankable project conditions and tariffs, such targets can form the basis for auctions or tenders to elicit investments.

The Philippines
Alignment of energy plans and renewable energy auctions

In the Philippines, the Department of Energy leads the development of the Philippine Energy Plan (PEP), which serves as the country's blueprint for transitioning to clean energy. The Department of Energy co-ordinates with various agencies throughout the planning process, with extensive stakeholder consultations conducted at each stage to achieve consensus among industry, non-governmental organisations and environmental groups. Feedback from these consultations is used to revise the PEP before it moves to approval, implementation, monitoring and evaluation.

Based on the foundation of strong co-ordination in the development of the PEP, the Department of Energy is able to use the document as a foundation for its Green Energy Auction Program, an initiative to auction renewable energy capacity in line with the targets stated in the PEP documents. In 2022, 2 GW of renewable energy was successfully auctioned to investors. After lower-than-expected participation in the 2023 auction, the regular and transparent nature of the planning process enabled the Department of Energy to carry out new stakeholder consultations and introduce policy amendments to increase investment in the next auction round (IRENA, n.d.a).

El Salvador
Long-term energy planning as the basis for sectoral co-ordination and auctions to guide investment

El Salvador's long-term energy planning has played a crucial role in shaping public policy instruments and regulatory reforms to mitigate investor risks and stimulate public and private investment through well-structured auctions. One notable example of leveraging long-term energy planning to attract investment is the utilisation of the country's power sector expansion plans to schedule bidding processes to procure power capacity. Winners of these bids enter into long-term PPAs with the off-taker, a distribution company. The bidding processes are aligned with the country's energy goals, ensuring that all awarded projects support the country's development objectives. Through these mechanisms, the energy sector has attracted more than USD 1.5 billion in investment with significant participation of the private sector and foreign investors. The investments are projected to reach USD 2.152 billion by 2026, spanning 26 projects in the power sector (Rendón *et al.*, 2020).

Effective energy planning frameworks can also ensure that public budget allocations reflect ongoing deliberation between the institutions responsible for energy planning and those responsible for funding (*i.e.* finance ministries). Inclusive consultation of stakeholders ensures that plans provide investment signals to a broader range of stakeholders than traditional power sector plans by involving technology developers and investors that can help accelerate the transition.

Italy
Co-ordinated planning to allocate public funding and provide investment signals

The Italian government's focus on research and innovation has been incorporated into long-term energy scenarios within the country's Integrated National Energy and Climate Plan (INECP). The Ministry of Economic Development has set up entities at two levels to support the development and implementation of innovative technologies for the energy transition. The first, consisting of a task force of multiple ministries, aims to double public funds, while the second, made up of major public research organisations, serves as an operational task force to explore how various technologies may fit within INECP scenarios, and to use that information to allocate funding. For example, the effort has explored new ways to integrate renewables and energy storage and to use electric vehicles in transportation (IRENA, 2020a). By committing resources towards these objectives, the Italian government also provides clear signals to technology developers and investors, encouraging investment into the technologies and promoting their adoption in the long term.

3.3 COMPONENTS OF EFFECTIVE ENERGY PLANNING

Since 2018, IRENA has run the Global LTES Network with nearly 30 country members, including nine G20 countries and 13 technical partners. The LTES Network is built on the "Long-Term Energy Scenarios for the Clean Energy Transition Initiative", a time-bound initiative that IRENA has run since 2018 under the umbrella of the Clean Energy Ministerial. One of the main goals of the programme has been to gather best practices for how countries can address new clean energy challenges with evidence-based planning. As mentioned earlier, effective planning is a process that is institutionally backed, regular and transparent, in which quantitative scenarios are harmonised across all relevant stakeholders and sectors. The sections below discuss three key elements that countries can focus on to establish more comprehensive planning: strong governance frameworks, government capacity and comprehensive scenarios.

3.3.1 Strong governance frameworks: Aligning energy planning across sectors and stakeholders

The process of energy planning varies widely across different countries and contexts. In some governments specific steps and outputs are described in national law; in other countries planning processes are less formal. The same variations can be seen in the scope of stakeholder involvement and consultation.

While diverse approaches are acknowledged, some common elements of effective long-term energy planning have been identified (IRENA, 2020d). One such element is that the clean energy transition demands more stringent co-ordination across sectors and engagement of a broader set of stakeholders. This is illustrated by the case presented in Box 3.1.

Box 3.1
Access to energy: Brazil's Light for All Program

Brazil's National Programme for Universal Access and Use of Electric Energy, popularly known as Light for All (or LPT), is a sustained initiative aimed at delivering the benefits of electricity to rural and remote communities. Since its inception in November 2003, LPT has been extended several times, yielding impressive results for more than 17.3 million people in rural Brazil. In its latest phase, LPT has set a new target of benefiting half a million households by 2026 through expansion of the power grid extension and deployment of solar PV systems.

Co-ordinated by the MME, LPT was launched on a solid legislative foundation (Decree no. 4.873 under Law 10.438 of 2002). Co-ordination has made implementation more far-reaching: Not only has LPT provided access to electricity, but also it has made it *affordable* and has encouraged productive uses of electricity to improve livelihoods. At the end of 2023, investments planned for the LPT totalled BRL 32.36 billion (USD 6 billion).

LPT's success is attributable to many factors, including co-operation across governmental agencies and strong stakeholder engagement throughout the process. Resources for the programme come from the federal government as a subsidy, through the Energy Development Account administered by the Electric Energy Trading Chamber, and from executing entities. In the past, financing also came from the Global Reversion Reserve and from state governments.

The programme is currently operated by Eletrobras, with the executing entities being concessionaires, providers of public electricity distribution services, and rural electrification co-operatives.

The operational structure of the LPT, its procedures, and its technical, financial and work prioritisation criteria are defined by the MME. The National Electric Energy Agency (ANEEL) is also responsible for monitoring the plans of executing entities and supervising compliance with the programme's goals and deadlines.

By bringing electricity to a population that does not yet have access to this fundamental public service, the LPT improves the quality of life of communities and facilitates access to other public services, such as health and education. The latter benefit underscores the significance of continued co-ordination among governmental agencies and relevant stakeholders in the post-electrification phase to ensure the sustainability of social benefits in the long run.

Based on: (MME n.d.).

The electrification of new sectors, the need for enhanced grid infrastructure, and the unique geographic and production patterns of renewable energy require better co-ordination among government institutions whose planning spans different sectors, time periods and spatial boundaries (*e.g.* from short to long term, generation to distribution, or local to national). Given that the clean energy transition is inextricably linked with climate and economic policies, better co-ordination is also required across energy, climate and economic planning, which often fall under different institutional jurisdictions. The examples of Ghana and Chile are presented in Box 3.2 and Box 3.3. Inconsistencies or contradictions in the planning process can delay or prevent investments from being realised. For example, investors may not proceed with an investment if they receive different signals from different planning institutions.

Furthermore, the energy transition may affect sectors and stakeholders beyond the traditional scope of energy planning, which tends to have a stronger focus on supply-side planning. For example, the emergence of distributed energy sources and smart grid technologies can turn energy consumers into more active participants in the energy system, making co-ordination with local distribution utilities critical. It is imperative to identify *all* of the stakeholders affected by long-term energy planning, and to establish a transparent process in which planning can accommodate different objectives and levels of influence. Transparency is critical in building a plan's legitimacy, acceptance and effectiveness. Without a transparent process of participation of different stakeholders, investments can be delayed and blocked at many points.

Effective energy planning processes should therefore establish robust cross-government co-ordination and active stakeholder participation. Specifically, energy planning approaches should:

- Integrate co-ordination and participation as core components;
- Have a clearly defined schedule aligned with energy and climate policy goals; and
- Assign clear responsibilities to the stakeholders participating in the process.

These elements improve the legitimacy of the planning process and create a more stable environment that reduces uncertainties and asymmetry of information, thus raising the confidence of investors.

Box 3.2

Ghana: Bottom-up collaborative process and stakeholder engagement for power planning

Ghana's energy planning showcases the importance of strong governance and broad stakeholder engagement in advancing the clean energy transition. The government leads a highly collaborative process, involving key personnel from various sectors at both technical and executive levels to ensure sustainability.

Under the planning framework, the Energy Commission leads the development of the Integrated Power Sector Master Plan, which was launched in 2018 and updated in 2019. The governance structure for power planning in Ghana is chaired by the Ministry of Energy and the Energy Commission. These institutions oversee a steering committee and power planning technical committee, both of which are composed of key personnel from different sectors, including the grid operator, the economic regulator, and independent private producers, among others. This governance structure ensures sustainability in power planning and engages sector leaders throughout the planning process.

Meetings to share scenario results are intended for representatives from academia, civil society organisations, research institutions and development partners. This allows the government to engage with stakeholders at an early stage and builds trust and consensus around the planning process.

Ghana's planning process is continuous, evolving based on variations in the supply and demand of electricity. The cycle starts by assembling the planning team, which determines the scope of the scenarios and planning. Next, the data are collected, verified and analysed and a draft report prepared. This report is subjected to a double consultation process with stakeholders. Once the report is accepted, the plan is adopted and published, and the cycle starts again. The continuous process results in consecutively shorter timelines, as all stakeholders improve their capacity to participate in and execute the planning stages.

Source: (IRENA, 2023e).

Box 3.3
Chile: Institutionalised long-term energy planning for ambitious quantitative targets and subnational development planning

Chile has institutionalised long-term energy planning as a public regulatory instrument under the Electricity Services Act, which establishes five-year energy planning processes and annual updates. The process starts with the development of long-term energy scenarios drawing on the outcomes of citizen engagement and input from regional activities. Other inputs are the National Energy Policy, the Framework Law on Climate Change and Chile's commitment to achieve carbon neutrality by 2050, in addition to various policies, strategies, initiatives and commitments at the national, regional, provincial and district levels. The Electricity Services Act requires energy projections to be updated annually. The process concludes with the identification of development opportunities for the energy sector and infrastructure requirements.

The energy planning process in Chile is also designed to promote citizen engagement and regional development. To ensure the legitimacy of the energy planning process, individuals and legal entities can register to take part. Over 700 people are registered to participate in the second five-year process (2023-2027). To ensure that the vision is not overly centralised, regional participation is promoted and regional development criteria are taken into account. For example, Chile has established a process in which various institutions are responsible for preparing an annual transmission expansion plan. Environmental and territorial variables are taken into account in the routing study that will determine where the power lines are to run.

Source: (IRENA, 2022a).

3.3.2 Ensuring government capacity for energy planning

A government's capacity to perform energy planning also depends on its ability to apply technical planning resources such as modelling tools, energy scenarios and quantitative analyses. Various levels of insourcing and outsourcing have been successful in different contexts. Some governments build in-house scenario development capacities to elaborate possible trajectories of energy sector development. Such capacity is often built directly within energy ministries, energy agencies or other government institutions. Independent energy agencies or technical institutions can be a middle-of-the-road option to allocate planning and scenario-building capacity and boost in-house capacity (Box 3.4). Governments can also choose to outsource all or part of their scenario development work to one or several research/technical institutions or consultancies. Figure 3.2 displays a list of advantages and challenges at both ends of the spectrum.

Figure 3.2 Advantages and challenges for insourcing and outsourcing of energy planning scenario development

INSOURCING: LTES capacity within ministries or energy agencies		**OUTSOURCING:** LTES capacity out-sourced to research/ technical institutions or consultancies
Ensures closer and faster interaction with policy makers.	**GOVERNMENT INVOLVEMENT**	Can result in intermittent and shorter interactionswith policy makers.
Tends to have a limited number of scenarios, often reflecting more conservative viewpoints.	**SCENARIO DIVERSITY**	Tends to cover a broader range of scenarios, reflecting the client's views and agenda.
Depends on government technical capacity and access to tools and information.	**QUALITY OF RESULTS**	Allows procurement from different high-end commercial tools tailored for purpose.
Quick response to pressing government policy needs, subject to the capacity of the team.	**RESPONSE RATE**	May take time to procure scenarios but offers a range of execution timings as specified by government needs.
Ensures full transparency of inputs and outputs through closer interaction with an in-house modelling team.	**TRANSPARENCY**	Tends to be black box, and proprietary licences may potentially limit full access to the tools.
Can be cheaper byt requires significant efforts to build modelling capacity.	**COST**	Tends to be expensive to hire commercial consultancy firms.
• **Quality assurance (*e.g.* engaging with academia).** • **Team or agency dedicated to modelling and scenario building.** • **Setting an institutional process for regular updates of LTES.**	**KEYS FOR SUCCESS**	• **Absorptive capacity within a government to understand the modelling results.** • **Full disclosure of scenario data and modelling methodology.** • **Access to enough high-quality research institutions.**

Source: (IRENA, 2020d).
Note: LTES = long-term energy scenarios.

Regardless of the approach taken to develop planning scenarios, a government must have the in-house capacity to understand and use the scenarios to inform policy and investment. One of the key issues holding back good energy planning to enable investment – especially in EMDEs – is over-reliance on the parties (or typically a single private party, whether consultancy or utility) responsible for developing the scenarios, and a lack of government ownership and understanding.

Avoiding such situations requires institutions that are well funded and well staffed to lead the planning process, sustainably set within the government's planning framework. Meeting that requirement ensures that a basic level of government ownership can be established. While institutional funding and training will naturally be government driven, both international and local support (*i.e.* from academic institutions) can be marshalled to assist in the capacity-building process and can often be a key catalyst for organisations that are just starting to build capacity in this area (see section 3.5).

Box 3.4
Brazil's independent planning institution to ensure sustainable energy planning

In Brazil, the Energy Research Office (EPE) plays a key role in supporting the Ministry of Mines and Energy through the independent preparation of studies and research. Funded by the federal budget and owned by the federal government, EPE was established to fulfil the government's constitutional responsibility to promote sustainable development within Brazil's energy sector. EPE's active participation in national energy sector discussions underscores its significance in the planning process, which involves developing comprehensive scenario-based studies and policy research. Among EPE's contributions are documents like the Ten-Year Energy Expansion Plan (PDE), the National Energy Plan (PNE), the National Energy Balance (BEN) and the Transmission Expansion Program (PET).

To ensure the sustainability and continuity of EPE's contributions, in-house training courses have been held at EPE on the development and application of scenarios and on the use of analytical tools. Partnerships have created opportunities to inform and educate stakeholders and develop new scenarios. These plans, prepared by dedicated and permanent experts, have helped dispel uncertainty about the deployment of renewable energy and infrastructure in Brazil.

Source: (IRENA, 2020d).

3.3.3 Expanding the scope and content of long-term energy scenarios

Energy planning is a multifaceted process that must navigate the complexities of energy systems, policy landscapes and market dynamics. For effective, evidence-based energy planning, LTES will play a central role in framing viable energy pathways, supported by an array of strategic instruments, such as energy statistics and data, energy modelling software, stakeholder engagement platforms, policy analysis methodologies and assessments of renewable energy potential. Collectively such tools make it possible for countries to craft and refine investment strategies.

Scenario-based planning is a framework, often informed by energy modelling tools, that outlines potential pathways for the sustainable development of energy systems, including specific subsectors, such as the power sector. LTES are developed to inform productive national and international policy debates, allowing governments to develop well-founded long-term visions and associated energy policies. LTES are also used to inform recommendations on where to direct investment, to ensure that projected demand can be met at the lowest cost. Many LTES are published in energy planning documents. These documents are typically updated at regular intervals to reflect evolving demand and supply projections and to ensure the security of supply in the energy system (IRENA, n.d.b).

As an outcome of the Paris Agreement, long-term climate strategies are now on the menu of planning documents a government can develop. In particular, LT-LEDS (long-term low-emission development strategies) aim to align climate action with national energy and economic development, and help to identify and prioritise mitigation actions by providing a comprehensive analysis of mitigation costs, potential synergies and the risks associated with trade-offs. In so doing, they can help attract climate finance (IRENA, 2023f).

As of May 2024, around 50 countries had developed an LTES as well as an LT-LEDS for the purpose of national energy or climate planning (IRENA, forthcoming-a). However, the relative novelty of the LT-LEDS has led to diverse approaches in their development. Some are based on detailed scenario analysis, while others rely on alternative strategic frameworks that do not utilise scenario-based planning.

For the results of energy planning to be seen as legitimate, the scope LTES should be expanded beyond purely technical aspects of the energy transition to embrace comprehensive development needs and climate goals. The widening of scenarios' scope will ensure that any technical and economic analysis provided in the LTES is aligned with technical and economic elements in the LT-LEDS, thereby providing a comprehensive vision of climate and economic planning that is harmonised with national energy planning, as discussed in section 3.4.1. Such improvements can send a unified and transparent message to decision makers and investors.

3.4 THE ROLE OF INTERNATIONAL COLLABORATION

International collaboration can support national and local efforts to attract investment by exchanging best practices, providing technical assistance and capacity building, and in some cases offering financial support.

IRENA has seen successful results in helping countries enhance their institutional capacities for energy planning through its Global LTES Network, which has served as a pivotal platform for the exchange of knowledge and best practices.

The Global LTES Network is dedicated to fostering the broader and more effective deployment of LTES by governments. It encompasses scenario users within government planning teams and policy-making bodies, as well as scenario developers from governmental modelling groups and technical entities that support governments in developing scenarios. The Network strives to enhance institutional capacity in three primary areas: 1) strengthening the development of scenarios; 2) improving the use of scenarios; and 3) fostering a national planning ecosystem capable of utilising scenarios to accelerate the clean energy transition.

The members of the network, including nine countries from the G20 group, engage in programmatic activities organised by IRENA. Workshops, events and regional and thematic webinars facilitate dialogue and mutual learning. The network's peer-to-peer platform promotes knowledge exchanges among EMDEs, among Global North countries, and bi-directionally, overcoming traditional North-to-South knowledge transfer structures. Members also have the opportunity to benchmark their own processes and practices against other participating countries, and foster more advanced planning ecosystems within their government institutions. The involvement of G20 countries not only highlights its significance but also enhances the potential for these dialogues and learnings to influence global energy policy and planning practices.

In addition to providing global platforms, IRENA – along with other international organisations, bilateral and multilateral donors, and development partners – has been a source of technical support for building energy planning capacity.[12] This is especially true in EMDEs, where short-term gaps in resources have required outside support, especially at the start of the process of building capacity for energy planning. Institutional platforms, training programmes and human resources funding from such actors has often been a catalyst for more sustained capacity building work. A short example from Eswatini is presented in Box 3.5.

[12] *Examples include the Optimus Community, which, with IRENA's participation, hosts events to build capacity in the use of the Energy Modelling Platform and promotes the U4RIA Principles of good governance for energy modelling (retrievability, reusability, repeatability, reconstructability, interoperability, auditability). Additionally, there are relevant programmes by IRENA, the International Energy Agency Energy (and its Technology Systems Analysis Programme), and Stockholm Environment Institute are among other support providers.*

At the same time, there are cases where support for planning activities lacks strong impact, due to fragmentation of the approaches of international actors. This may lead to overlapping programmes that sap rather than supplement the resources of the partner countries seeking to strengthen their planning capacity. Through its work in this field, IRENA has identified several areas that international collaboration could focus on to continue improving energy planning for investment, including the support of coherent and inclusive governance; national ownership and capacity building; and the use of technically robust, transparent and accessible tools.

Efforts to improve international collaboration should also encompass knowledge and best practice exchange on innovative energy planning methodologies, in particular a) guidance on inclusive governance frameworks, to develop a robust ecosystem for energy planning; b) identifying elements currently missing in scenarios (*i.e.* risk) that can be used to mobilise finance and de-risk investments; and c) mapping cutting-edge innovations, tools and methodologies for energy planning adaptable to the energy transition. Moreover, international collaboration should be focused on capacity-building programmes to strengthen institutional ownership and human resources in countries and creating opportunities for cross-sector stakeholder engagement and partnership building aimed at avoiding duplication of efforts and identifying synergies for technical or financial assistance.

Box 3.5
Eswatini: The role of international assistance in capacity building

Eswatini's capacity in scenario development has been enhanced through international assistance. The National Energy Master Plan of Eswatini, which extends up to 2034 and is being updated to 2050, was developed with input from both local and international partners. The Ministry of Natural Resources and Energy, which is responsible for the plan, collaborated with the Eswatini Energy Regulatory Authority, Central Statistics Office, the University of Eswatini and the Centre for Sustainable Energy Research, among others. A steering committee provided policy direction, supported by a working team that handled scenario modelling, data collection and analysis. This team maintained close contact with global organisations like the International Atomic Energy Agency, IRENA and the United Nations Development Programme for technical reviews, and with public and private investment institutions to ensure alignment with available funding and implementation resources. The updated plan will focus closely on renewable technologies and more accurate local data, aiming to guide investments towards a sustainable energy future.

Source: (IRENA, 2023e).

4. SUSTAINABLE FUELS FOR THE ENERGY TRANSITION (WITH A FOCUS ON BIOFUELS)

KEY MESSAGES

Sustainable fuels are essential for the energy transition, as they are critical for hard-to-abate sectors like aviation and shipping, which are difficult to decarbonise through direct electrification.

Since the availability of biomass feedstock is tied to regional factors, decarbonisation strategies vary by country. Diverse business models and supply chains underscore the regional complexities of bioenergy. International and trans-regional trade of sustainable fuels, supported by cross-border investments, is crucial for global decarbonisation.

Sustainability governance is vital for the large-scale development of sustainable fuels, to ensure that development plans align with broader bio-based and nature-based economies and are integrated into region-wide environmental frameworks. Biofuels are part of the circular bioeconomy, derived from bio-based feedstock within integrated land use systems that also produce food, feed, fibres and other materials. Efforts should focus on harmonising disconnected sustainability governance systems and promoting inclusive solutions, through innovative approaches such as a jurisdictional approach (JA).

Integral to this shift is to make land use more efficient through optimising related systems and to bolster the supply of sustainable fuels while delivering benefits to other sectors. Vast tracts of underutilised and degraded land may be repurposed for feedstock production, in turn mitigating loss of carbon stock and supporting local biodiversity, while creating new economic opportunities for smallholders, and incentivising improved resource governance and environmental management.

Biorefineries make it possible to distribute feedstock risks and diversify revenue streams. They process multiple feedstocks to produce various outputs, and thus help access different markets and income sources. Integrating the production of sustainable fuels into larger bio-based economy value chains through biorefineries makes the large-scale production of economically challenging products more feasible.

4.1 INTRODUCTION

Sustainable fuels are an essential solution to address energy demand in sectors that cannot readily be electrified directly. It is clear that a diverse mix of sustainable fuels, including biofuels and e-fuels,[13] should be developed and supported to suit different national and regional contexts, as well as the varying requirements of the end-use sectors that rely on fuel. This chapter largely focuses on biofuels, and their vital role in the global energy transition; e-fuels' implementation is also considered.

IRENA's 1.5°C Scenario outlines various forms of bioenergy that would account for 18% of total final energy consumption (TFEC) by 2050, including direct uses (16%) and to generate electricity (2.3%) (IRENA, 2023a). According to the 1.5°C Scenario, direct use of low-emission hydrogen (electrolytic "green" hydrogen, hydrogen produced from biomass, and so called blue hydrogen produced by reforming natural gas with carbon capture and storage) and hydrogen-derived e-fuels, including methanol and ammonia, is expected to account for a further 14% of TFEC by 2050. Sustainable fuels, in liquid, solid or gaseous state, emerge as key options across diverse sectors, especially those that are hard to decarbonise and require an energy-dense carrier. Aviation and shipping in particular require clean, sustainable transport fuels, including e-fuels, to phase out their current fuels.

Sustainability governance forms the foundation for the large-scale development of sustainable fuels, particularly biofuels. Ensuring feedstock sustainability becomes pivotal in determining the suitability and feasibility of sustainable fuels as decarbonisation solutions and in prioritising limited feedstock for a large variety of end uses. The governance of bioenergy sustainability has been a long-standing topic of discussion over the past decades, and now its scope extends to include e-fuels and bio-based feedstock. This imperative aligns with the broader frameworks of bio-based and nature-based economies (Box 4.1) and sectors (*e.g.* bioenergy, forestry, agriculture, waste management, *etc.*) and enables the seamless integration of sustainable fuels into overarching environmental considerations across diverse regional contexts.

Box 4.1
Bioenergy in the frameworks of bio-based and nature-based economies

A bio-based economy, also generally referred to as a bioeconomy, entails the production, utilisation, conservation and regeneration of biological resources. It also entails the knowledge, science, technology and innovation required to offer sustainable solutions (information, products, processes and services) within and across economic sectors and enable a transformation to a sustainable economy. A bioeconomy can harness bio-based science and technology to address challenges and provide multiple services and products for a growing population while preserving natural resources. These services and products include food, feed, wood (products and furniture), paper, bio-based textiles, biochemicals, bioplastics, biopharmaceuticals and bioenergy (FAO, 2023).

[13] *E-fuels are liquid and gaseous fuels produced using green hydrogen (from electrolysis, hence the term "e-fuels") and a source of carbon, for methanol, or nitrogen, for ammonia. "Synthetic fuels" include those produced using fossil-derived hydrogen.*

Bioenergy is part of a larger bioeconomy, which also includes agriculture, forestry and fisheries, and the production of food, paper, wood and agricultural fibre products, biomaterials, bio-based chemicals and medicines (IRENA, IEA Bioenergy and FAO, 2017). This broader bioeconomy accounts for about USD 2 trillion of annual trade and one-eighth of the overall global trade volume. Policies to promote the bioeconomy may include intensified efforts to map global soils; systematic monitoring of contributions to SDGs; the development of skills and knowledge for using bio-based materials in manufacturing and consumer products; biorefinery demonstration projects combining the production of energy and higher-value materials; and research on new food systems, sustainable aquaculture and artificial photosynthesis. They may also include specific renewable energy targets, mandates, loan guarantees and financial incentives.

Bioenergy can also be framed under a nature-based economy, an economic system that mitigates climate change and biodiversity loss by prioritising the protection and regeneration of nature while producing bio-based feedstocks for socio-economic benefits. This approach involves implementing nature-based solutions, which are inspired and supported by nature; cost-effective; provide environmental, social and economic benefits; and help build resilience by incorporating diverse natural features and processes into various landscapes through resource-efficient and locally adapted interventions (Chami *et al.*, 2022).

The significance of regional, national and local contexts for biomass feedstock production cannot be overstated. The availability of feedstock is intricately tied to geographical, biophysical and socio-economic factors, especially in land-based sectors. Varied feedstock options for diverse end uses present unique pathways in the energy transition, causing decarbonisation strategies to vary from one country to another. Also, the diversity of business models and supply chains from feedstock to bioenergy carriers, especially in EMDEs in Southeast Asia, Latin America and Sub-Saharan Africa, highlights the regional intricacies of bioenergy dynamics.

International, trans-regional trade of sustainable fuels, supported by robust cross-border investments, emerges as a necessity for global decarbonisation aligned with the Paris climate targets. Given differences in biophysical, economic and energy consumption realities, the trade of sustainable fuels is seen as a way for diverse regions to address their decarbonisation needs. Substantial volumes may traverse countries or even entire regions, for instance, from Latin America and Africa to Europe and Southeast Asia to East Asia. Recognising the complementary functions of sustainable fuels and understanding the dynamics of their trade across borders are imperative.

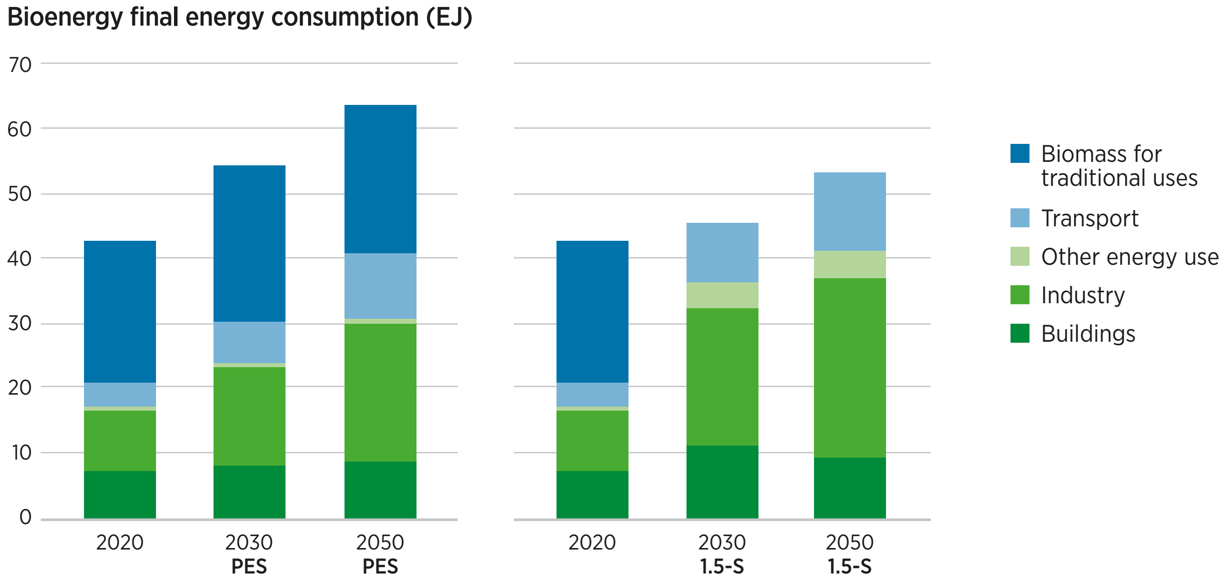
This chapter delves into the multi-faceted dimensions of sustainable fuels, highlighting their key role in the energy transition. It first outlines the unique contributions of sustainable fuels across sectors. It then discusses the strategic implications of their global trade. In conclusion, potential synergies of sustainability governance across energy, climate change and environmental management are explored.

4.2 SUSTAINABLE FUELS AND THE ENERGY TRANSITION

IRENA defines bioenergy use as falling into two broad categories: 'traditional' and 'modern'. 'Traditional' refers to the combustion of biomass such as wood, animal waste and charcoal. The latter, 'modern' refers to liquid biofuels from bagasse and other plants; bio-refineries; biogas produced through anaerobic digestion of residues; wood pellet heating systems; and other technologies (IRENA, n.d.e).

Achieving comprehensive decarbonisation requires a meticulous evaluation of all available options, accounting for various end uses and sector-specific settings and requirements. Such an evaluation is crucial for optimising resource utilisation while minimising unwanted socio-economic and environmental impacts. Sustainable fuels play a pivotal role in the energy transition. They help address hard-to-abate sectors, where direct electrification is challenging. To this end, IRENA's *World Energy Transitions Outlook* 2023 provides the estimated contributions of bioenergy in the four major sectors in two scenarios (Planned Energy Scenario and the 1.5°C Scenario, which are compatible with the climate goals of the Paris Agreement), as illustrated in Figure 4.1.

Figure 4.1 Final bioenergy consumption by sector in 2020, 2030 and 2050, under the Planned Energy and 1.5°C scenarios



Source: (IRENA, 2023a).
Note: 1.5-S = 1.5°C Scenario; EJ = exajoule; PES = Planned Energy Scenario.

Biojet fuels, biomethanol and e-methanol, and various other sustainable fuels emerge as potential substitutes for conventional fossil fuels. They currently stand as the most viable and promising options for decarbonising the aviation and shipping sectors, where larger-scale electrification is hardly possible. Sustainable aviation and shipping fuels have gained substantial attention in recent years. Sustainable aviation fuels could account for around 65% of the required sectoral effort to reach net zero in 2050, or up to 4% of the global reduction in anthropogenic emissions (IATA, n.d.; IRENA, 2021a, 2021b).

On the road, sustainable fuels offer a complementary solution to electric vehicles, especially in areas where geographical, climatic and socio-economic conditions may hinder the widespread adoption of electric vehicles. The degree of decarbonisation through sustainable fuels depends on multiple factors, including

technical suitability as well as feedstock availability, which must be assessed within regional and national contexts. Policy makers must consider how to best use biofuels (and the limited biomass feedstock behind them) to meet different energy demands – and also which decarbonisation technologies are optimal in each context (IRENA, 2022b; IRENA, IEA Bioenergy and FAO, 2017).

In the hard-to-abate industrial sectors, especially cement, and iron and steel, which present significant challenges for direct electrification, sustainable fuels may carve a distinct niche. Acting as both heat sources and reactants, they can help abate emissions from fuel combustion and industrial processes. Preliminary estimations suggest that substituting fossil fuels with sustainable fuels in both cement and steel industries may reduce global emissions by up to 5% (Kusuma *et al.*, 2022; Safarian, 2023). In the chemical industry, renewable methanol produced from biomass or synthesised from green hydrogen and carbon dioxide may provide an alternative means to achieve net-zero (IRENA and Methanol Institute, 2021).

In regions with cold seasons and limited gas grid connectivity, high-efficiency decentralised heating systems employing sustainable fuels, especially biomass in agriculturally and forest-rich areas, can be effective in achieving both energy security and decarbonisation (Goh *et al.*, 2020). In some cases, biogas and biomethane for residential and commercial use can be generated from biodegradable waste and residue-based feedstock (Coelho, 2024).

Micro-grids fuelled by biofuels present a viable option for electrification in rural areas without access to the main power grid but in close proximity to ample bio-based resources, including agricultural and forestry residues generated from local activities. Integrating biomass-based decentralised power generation systems with complementary renewables (*e.g.* micro-hydroelectricity, if accessible) can effectively meet the local electricity demand.

Similarly, in regions with limited access to clean cooking solutions, localised supply chains for modern bio-based cooking solutions and fuels can help address issues associated with unsustainable traditional biomass, which has substantial adverse health and environmental impacts. Advanced and modern bio-based cooking solutions – using biogas and bioethanol – and modern biomass cookstoves and fuels offer higher-efficiency, lower-emission and safer renewable solutions than traditional biomass (IRENA, 2024c).

In decentralised applications, modern biofuels not only reduce emissions but also offer incentives for environmental management and local economic development. Decentralised systems fuelled by locally sourced, well-managed feedstock replenish the local carbon stock. These systems may also help overcome the challenges associated with the long-distance transport of fuels.

In summary, sustainable fuels can play a unique role across various sectors and present either the best available or complementary options for decarbonisation. Notably, the application of sustainable fuels can utilise localised supply chains, leveraging incentives from carbon and environmental management and maximising socio-economic benefits to local communities. This integration offers comprehensive solutions for local socio-economic development and helps achieve multiple SDGs.

4.3 STRATEGIC IMPLICATIONS OF SUSTAINABLE BIOFUELS IN REGIONAL CONTEXTS

The strategic implications of sustainable biofuels are immense when examined within the specific regional contexts where their deployment plays a crucial role in generating diverse social, economic and environmental benefits. Sustainable management and utilisation of biomass resources are pivotal in fostering income opportunities across the agriculture, processing and energy production industries. For instance, under IRENA's 1.5°C Scenario, jobs related to all forms of bioenergy are expected to surge to over 10 million by 2050, from about 3.4 million in 2021 (IRENA and ILO, 2023); around 27% of these jobs are expected to be renewables based (Box 4.2). Asia will have 39% of the global bioenergy jobs by 2050, followed by the Americas (18%), Sub-Saharan Africa (17%) and Europe (16%). This growth underscores the multi-faceted role and significance of sustainable fuels for the EMDEs, which are rich in biomass resources but have limited capacity to reach ambitious decarbonisation goals.

As described in (RES4A *et al.*, 2022), a key component of the energy transition is to "align energy infrastructure development planning to socio-economic development agendas and priorities". For regions with extensive agriculture and forestry sectors, such as Southeast Asia and Latin America, creating synergies with existing economic activities can be a priority to achieve multiple SDGs while contributing to climate change mitigation. As these regions navigate the complexities of decarbonisation, a priority for them is to leverage bio-based resources from agriculture and forestry to replace fossil fuels (IRENA, 2022c, 2022d, 2023g, 2024d).

This perspective is notably pertinent for EMDEs, for which it is particularly urgent to address the trilemma of achieving equitable economic growth, sustainable land management and a just energy transition. The ongoing energy transition provides a compelling opportunity to transform conventional land-based economies from unsustainable land exploitation to the sustainable use of resources for food, fuel and materials. If crafted carefully, a new development model, often framed as a "bioeconomy" or "bio-based economy", has the potential to offer alternative paths and new income sources, especially benefiting local communities (Box 4.2) (Köppen *et al.*, 2022).

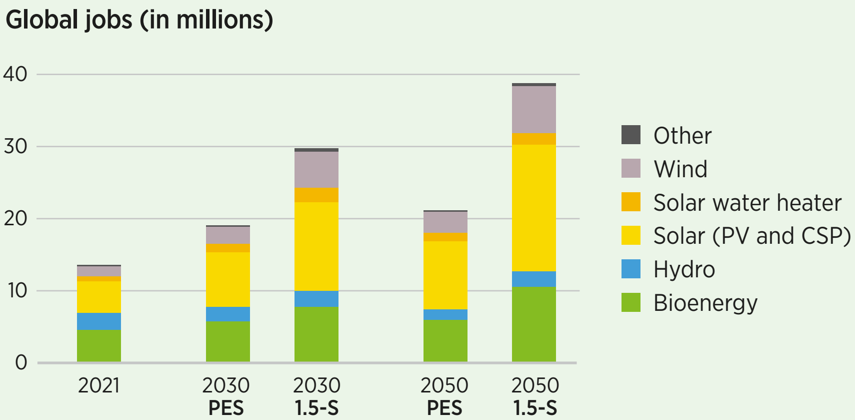
In Sub-Saharan Africa and other regions with similar contexts, a priority is to harness local bio-based solutions to provide clean cooking solutions (IRENA, 2024). This holds particular significance for meeting the SDGs given that some 2.3 billion people (more than a quarter of the global population), about 40% of whom live in Sub-Saharan Africa, still rely on polluting fuels and technologies to cook, posing threats to human health, livelihoods and the environment. Options such as combining bio-based pellets from forestry or agricultural residues with modern efficient stoves, bioethanol and biogas, for example, may provide new opportunities in alleviating energy poverty while simultaneously improving livelihoods. It entails establishing local supply chains grounded in sustainable land management practices, which also contributes to long-term carbon and environmental management, fostering the well-being of communities and local economies.

Given the inherent ties of the energy transition to regional and country-specific contexts, localised solutions such as sustainable fuels offer strategic benefits to the EMDEs. A tailored approach would boost sustainability by integrating advanced practices and innovative business models. Such an approach can effectively capitalise on existing regional expertise and infrastructure, especially when combined with incentives from carbon offset mechanisms and nature-based solutions. These factors highlight the necessity for collaborative, adaptable strategies that integrate the energy transition with economic development and environmental management.

Box 4.2
Biofuel jobs and incomes

In 2022, bioenergy jobs were predominantly in the liquid biofuels and biogas industries. According to IRENA's estimate, the biofuel sector has employed nearly 2.5 million people world-wide, mostly in feedstock operations. Latin America accounts for 42% of the global biofuel jobs, while Brazil remains the world's largest employer (about 856 000 jobs, despite a sugarcane mechanisation process introduced since 2002). Asia, chiefly Southeast Asia, is not far behind, with 37% of the global total. The more mechanised agricultural sectors of North America and Europe represent smaller shares (15% and 6%, respectively). Compared with liquid biofuels, the biogas industry is estimated to encompass just over 300 000 jobs (IRENA and ILO, 2023). Under IRENA's 1.5°C Scenario, presented in the *World Energy Transitions Outlook* 2023 (Figure 4.2), jobs in the bioenergy industry are expected to nearly triple from their 2021 levels, reaching over 10 million by 2050 (IRENA, 2023a).

Figure 4.2 Global renewable energy jobs under the PES and the 1.5°C Scenario, 2021-2050

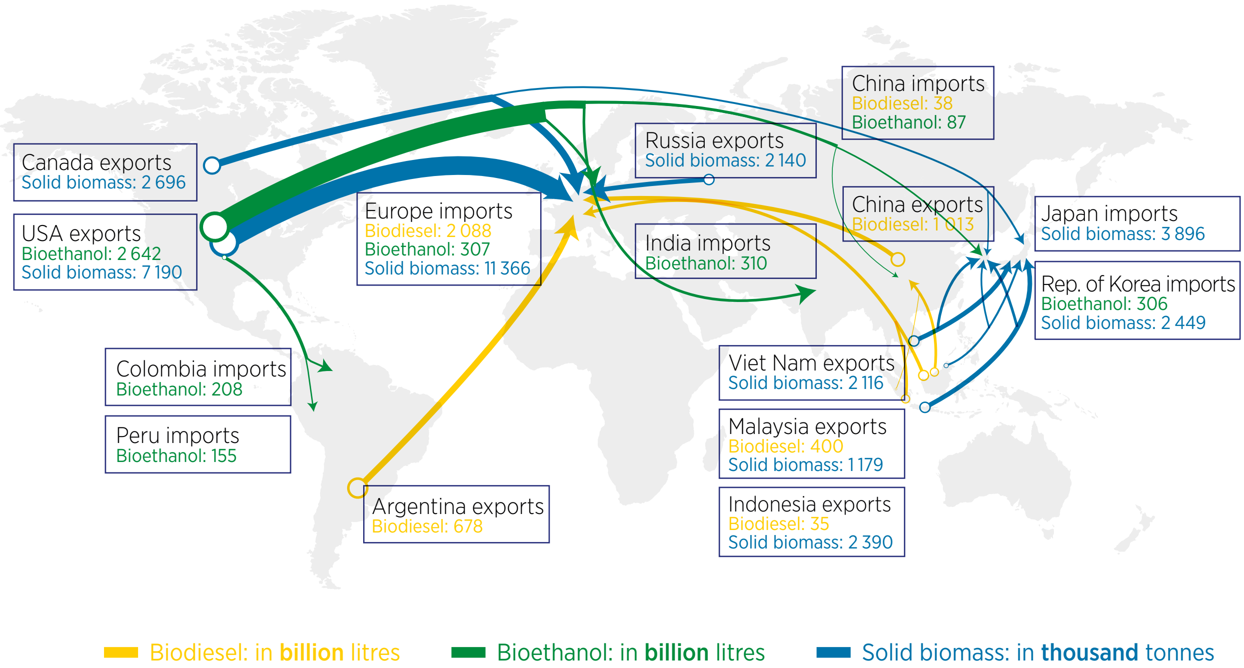


Source: (IRENA, 2023a).
Notes: "Other" includes geothermal and tidal/wave. CSP = concentrated solar power; PES = Planned Energy Scenario; PV = photovoltaic.

4.4 COMPLEMENTARY FUNCTIONS OF SUSTAINABLE FUELS IN INTERNATIONAL AND TRANS-REGIONAL TRADE

In recent decades, the global trade of sustainable fuels has surged, driven by the uneven distribution of feedstock and evolving demands. Key bioenergy commodities, including wood pellets, biodiesel and bioethanol, have gained prominence over the past decade (Junginger *et al.*, 2016). Notably, Europe and Northeast Asia emerge as the primary destinations for sustainable fuels, needed to facilitate the transition from fossil fuels to renewables. The fuels being imported include solid fuels for power and heating, and liquid fuels for transport. Meanwhile, Latin America, Southeast Asia and North America play pivotal roles as major exporters of sustainable fuels. Figure 4.3 provides an overview of global bioenergy trade in 2020 (IRENA, 2022e).

Figure 4.3 Global bioenergy trade in major markets in 2020



Source: (IRENA, 2022e).

Note: Owing to data limitations, not all international bioenergy trade is shown in the figure.

Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

International trade serves as a crucial mechanism enabling countries to complement one another and optimise the utilisation of resources. In the short term, biomass-rich regions can export bioenergy products, whereas resource-scarce regions can benefit from imports. Engaging in bioenergy trade allows countries to diversify their energy mix, especially in sectors that are hard to decarbonise. It is essential to recognise that sustainable fuel trade, especially in bioenergy, includes more than just energy commodities. Many widely traded products are integral components of larger chains embedded in the agriculture and forestry sectors. The global demand for sustainable biofuels provides incentives to optimise resource utilisation economically and environmentally.

In the long run, international trade can create economic opportunities to jumpstart sustainable fuel deployment in both exporting and importing countries. Also crucial are overseas investments in bioenergy, which are instrumental in accelerating sustainable fuels' deployment in EMDEs. Exporting nations can benefit from the commercialisation of their biomass resources, leading to economic growth, income generation, job creation and the subsequent development of a sustainable bioenergy sector catering to both domestic and international markets. Suitable business models and good governance can ensure that the income generated significantly benefits small farmers in EMDEs, who rely on land for their livelihood. On the other hand, importing countries can leverage this dynamic to develop domestic infrastructure and technologies that help local sustainable fuel production to grow. For instance, Japan's substantial biomass imports coincide with its efforts to revitalise forestry; here, the bioenergy market is boosted by policy schemes providing incentives for decarbonisation, such as feed-in tariffs (IRENA, 2022e). In the meantime, the global demand for advanced aviation biofuels and bio-based chemicals and materials that promise to further the decarbonisation of hard-to-abate sectors offers opportunities for developing countries to support biorefinery supply chains.

Given the current state and the foreseeable trends in the energy transition, as well as the requirements for achieving the 1.5°C Scenario, it is anticipated that trans-regional trade and investment in sustainable fuels will continue to take centre stage. The strategic focus is on fostering international co-operation, especially between developed regions and EMDEs. It is therefore crucial to implement policies and measures that specifically improve sustainability governance, a topic further discussed in the next section.

4.5 HARMONISING SUSTAINABILITY GOVERNANCE SYSTEMS FOR ENERGY, CARBON AND ENVIRONMENTAL MANAGEMENT

4.5.1 Certification schemes for biofuels

Over the past decades, there have been concerns about the sustainability of biofuels, given their potential impacts on the environment, societies and economies. To address these concerns, biofuel certifications have been developed to ensure that production methods adhere to social and environmental sustainability standards.

With the emergence of the European Union (EU) as the largest biofuel market, the European Renewable Energy Directive (EU-RED) established a regulatory framework for the promotion of the use of renewables-based energy. The framework mandates the sustainable production of the biomass used for biofuel or bioenergy and the independent verification of sustainability claims. This has prompted the design and introduction of multiple voluntary schemes for agriculture- and forestry-derived liquid and solid biofuels so that these fuels align with the EU-RED requirement. The schemes cover various feedstocks, geographies and scopes (EC, n.d.). Auditors are hired independently to verify supply chains world-wide and validate millions of tonnes of biofuels consumed in the European Union.

In practice, some certification schemes specifically for biofuels overlap with regulatory frameworks on feedstock production in producing countries. For instance, Indonesia has developed national schemes for palm oil, primarily based on compliance with existing laws and regulations. For feedstock from the forestry sector, existing certifications like the Programme for the Endorsement of Forest Certification and the Forest Stewardship Council, which have global coverage, have been employed as the basis for monitoring the sustainability of solid biofuels, such as wood pellets imported from different regions.

This situation clearly illustrates that the impacts of biofuels extend beyond the energy sector and are closely linked to agriculture and forestry. It should be recognised that sustainable biofuels are an integral part of the circular bioeconomy, derived from bio-based feedstock within multi-functional, integrated land use systems that also produce food, feed, fibres and other materials (see Box 4.1). Addressing sustainability challenges involves situating biofuels within the broader context of land-based sectors, with particular emphasis on recognising the complexity of intra- and extra-value chain governance extending across multiple end uses.

To address challenges related to biomass sustainability, focus can be on harmonising disconnected sustainability governance systems and tailoring constructive solutions for inclusivity rather than exclusion. Advancing beyond conventional certification towards an integrated sustainability governance model, centred on inclusivity and transparency, emerges as a promising path forward. Brazil's RenovaBio programme provides economic compensation based on the achievement of sustainability indicators that indicate a mitigation effect. The certification scheme has demonstrated good results in the past four years (Box 4.3).

Box 4.3
Brazil's RenovaBio programme

In 2017, the Brazilian National Biofuel Policy (RenovaBio) recognised the strategic role of biofuels (ethanol, biodiesel, biomethane and biokerosene for aviation and others) in the national energy matrix in terms of their contribution to energy security, the predictability of the market and the mitigation of greenhouse gas (GHG) emissions in the fuel sector. In this sense, RenovaBio is aligned with Brazil's Nationally Determined Contributions under the Paris Agreement. RenovaBio aspires to reduce the carbon intensity of the country's transportation matrix by expanding the use of biofuels and creating a carbon credit market to offset GHG emissions from fossil fuels.

RenovaBio consists of three strategic axes. First, annually, the government establishes national decarbonisation targets for ten years. The targets are expanded into mandatory individual targets for fuel distributors, proportional to their shares in the fossil fuel market. Second, biofuel producers voluntarily certify (through qualified certification agencies, using the RenovaCalc approach) their production and receive, for each plant, an energy-environmental efficiency score. These notes are multiplied by the volume of biofuel traded, resulting in a decarbonisation credit (CBIO, equivalent to 1 tonne of carbon dioxide equivalent [CO_2eq] not released into the atmosphere) that a producer can commercialise, which is the third axis. CBIOs are traded on the stock exchange. The calculator, "RenovaCalc", a tool based on life cycle analysis (freely available on the website of the Ministry of Mines and Energy), measures a biofuel's carbon intensity (in grams of CO_2eq per megajoule) and compares it to the carbon intensity of its fossil fuel equivalent. The "energy & environment efficiency score" is thus generated.

RenovaBio recognises that different biofuels contribute differently to GHG emission reduction, and those produced with lower carbon intensity (relative to liquid fossil fuels) will generate more CBIOs per volume unit. Therefore, the more efficient and sustainable the individual production, the more the CBIOs that can be issued and the greater the gains by the produced biofuel. RenovaBio still establishes that, to be eligible, the biomass processed in plants cannot come from areas where native vegetation has been suppressed. Biofuel producers must also demonstrate that biomass was produced in accordance with Brazilian environmental legislation, as demonstrated by regularity in the Rural Environmental Registry (CAR). According to the Brazilian National Agency of Petroleum, Natural Gas and Biofuels (ANP), which regulates and co-ordinates RenovaBio, this programme resulted in Brazil avoiding 117 million tonnes of CO_2eq over 2020-2023.

Source: (BMME, 2023).

4.5.2 The jurisdictional approach

Companies and stakeholders across diverse sectors, from food to materials, are increasingly turning to the jurisdictional approach (JA) as a strategic tool to safeguard their supply chains against risks, including from deforestation and social conflicts. The JA represents a unique form of integrated landscape management, with the following defining feature: the delineation of landscapes within policy-relevant boundaries, coupled with a comprehensive strategy highlighting substantial government involvement. The JA seeks to embed sustainable practices in governance systems that extend beyond an individual company's supply chain, aiming for a broader and more inclusive impact.

Both the JA and individual company strategies require the active and meaningful participation of various key stakeholders and vulnerable groups, with the common goal of aligning activities and inputs to define and achieve objectives collaboratively. The JA's overarching aim is to harmonise social, economic, climate and environmental goals through inclusive stakeholder participation, fostering alignment among governments, businesses, communities, smallholders and civil society organisations. By establishing a formal jurisdictional basis, this approach may tap the potential to contribute to territorial-scale spatial planning, effectively addressing multiple challenges in monitoring and improving biofuels' sustainability.

Crucially, when a jurisdiction attains certification, this signifies that all related products within its boundaries comply with the established standards. Consequently, the JA can improve environmental regulations and ease the certification cost burdens, especially for a massive population of smallholders relying on agriculture and forestry for livelihood.

Several jurisdictions, often at the provincial or state level, have embraced this approach to fortify market access for their land-based products. For example, the approach has been taken by organisations like the World Wildlife Fund in deforestation hotspots like Mato Grosso in Brazil, Sabah in Malaysia and East Kalimantan in Indonesia (WEF, n.d.; WWF, n.d.). Even at lower administrative levels, such as those of districts and municipalities, as seen in Indonesia's Siak and Seruyan districts, this approach is gaining traction (JCAF, 2021). Ecuador stands out as an exception, with the entire country striving to obtain jurisdictional certification under the Roundtable on Sustainable Palm Oil.

Given the pivotal role that biofuels can play in incentivising the transformation of existing land use systems, steering sustainability governance towards a more constructive direction becomes imperative. This has significant implications for countries heavily reliant on land for economic development, simultaneously holding crucial roles in global carbon storage.

4.5.3 Certification schemes for e-fuels

As with biofuels, regulatory frameworks and associated certification schemes have emerged for e-fuels. These schemes are deemed necessary for demonstrating the sustainability attributes of e-fuel value chains, to ensure that the e-fuels used are effectively contributing to the energy transition. There are technical challenges associated with developing e-fuel certification schemes to drive global market development, and as with biofuels, there are opportunities for emerging regimes to be harmonised. This is discussed in Box 4.4.

Box 4.4
Status of e-fuel certification

Because e-fuels have multi-functional roles in different value chains, like biofuels, their certification has associated challenges. Methanol and ammonia, which have vital roles as feedstocks for fertiliser and high-value chemicals production, respectively, are both traded commodities today. Fossil fuel–derived hydrocarbons are used as feedstocks and fuel in the production of almost all methanol and ammonia.

The multifunctional roles of green hydrogen and ammonia and methanol derivatives as e-fuels make them more important as tools for the energy transition but also increase the complexity associated with establishing rules for the associated commodity markets. The different technical requirements placed on e-fuels in their various prospective applications also mean that different approaches may be appropriate for setting limits on and measuring the greenhouse gas emissions associated with their production, distribution and use.

In the regulatory realm, the European Renewable Energy Directive (EU-RED) provides guidance on the sustainability attributes expected of the low-emission ammonia and methanol e-fuels produced for use in Europe and the criteria they are expected to fulfil (EC, n.d.). The EU-RED regulations refer to “renewable fuels of non-biological origin” (RFNBOs). RFNBOs captured in this regime include the e-fuels discussed here: hydrogen, ammonia and methanol. The EU-RED regulations propose acceptable emission thresholds for e-fuel production and require producers to demonstrate the attributes of the electricity used to produce hydrogen (and hydrogen-derivative RFNBOs, including ammonia and methanol). These regulations are intended to guarantee the sustainability and low-emission characteristics of the e-fuels produced. The implementation of EU-RED is to be supported by certification schemes, which will be accredited to provide the data architecture needed for producers to demonstrate their adherence to regulatory standards.

An unresolved challenge in certifying low-emission or green e-methanol is how to address the carbon stream essential to methanol production in standardisation and certification regimes (IRENA and Methanol Institute, 2021). Carbon is an essential component of methanol, and carbon is typically sourced from fossil fuels. In future low-emission methanol value chains, consumers and regulators will need to be assured as to the source of the carbon used in the production of the traded volumes of e-methanol. Current certification approaches rely on estimations of the emissions associated with the sourcing of carbon in the focus value chain. The approach to doing so is not yet standardised, and further transparency will be required to grow confidence.

4.6 INTEGRATED STRATEGIES FOR LARGE-SCALE DEPLOYMENT OF SUSTAINABLE FUELS

The energy transition involves more than just substituting one energy source for another; it entails a transformation in how countries produce, store, transport and utilise energy. Upstream, it is intricately linked with land use, whereas downstream, it intersects with the material utilisation of energy carriers.

4.6.1 Optimising land use with innovative approaches to sustainable biofuel production

Improving land use efficiency through sustainable land and forest management is a crucial strategy for bolstering the supply of sustainable fuels while generating additional benefits relevant to other sectors. This involves actively utilising under-utilised, low-carbon land for feedstock production, presenting an opportunity to prevent carbon stock loss due to forest conversion relative to business-as-usual scenarios. Additionally, proper land management can prevent further degradation and contribute to the replenishment of lost carbon stock (Brady *et al.*, 2024).

This approach has strategic implications for countries with substantial non-forested land currently not under agricultural use. In Southeast Asia alone, over 93 million hectares of such land has been identified (IRENA, 2022e). In Latin America, this figure is estimated to be more than 100 million hectares, including land freed up by the optimisation of cattle farming (increasing the current average of 1.0 head per hectare by 2.0 heads per hectare, for example) (FAOSTAT, 2023). Ideally, a small proportion of this land may produce a significant volume of feedstock for sustainable biofuels, but this would require innovative thinking to transform existing industries and optimise outputs. With an integrated management approach, including agroforestry, silvopastoral, and various land uses and covers, biomass production for various uses can reduce land degradation and provide diversified incomes for local communities. This approach becomes particularly crucial for mitigating climate change, in the energy as well as carbon respects, when considering how biofuels can counteract unsustainable land use practices.

The successful implementation of this strategy hinges on addressing social and environmental factors. Much of this under-utilised land is occupied by local communities engaged in small-scale farming, which may not be captured by official data reporting on land use. Utilising these lands for sustainable fuel production may create new opportunities for smallholders, increasing income sources, technical assistance and market access, and, importantly, reducing the risks associated with unsustainable land use. The case of Viet Nam, as depicted in Box 4.5, demonstrates an example of having forest growth and increased production at the same time.

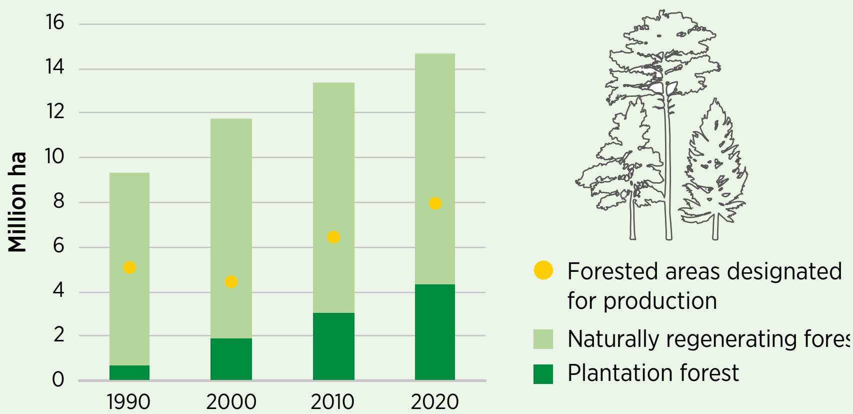
These economic opportunities derived from sustainable fuel deployment may incentivise improved resource governance, tapping into synergies with carbon and environmental management, as discussed in earlier.

In some cases, under-utilised land may have much greater value for local biodiversity (*e.g.* wildlife corridors, habitats of specific species), despite negligible economic value. Any efforts to transform these degraded or under-utilised lands should take into consideration biodiversity aspects and engage related organisations to avoid unwanted impacts on local biodiversity systems.

Box 4.5
Viet Nam: Boosting biofuel production through forest growth

For decades, Viet Nam's forestry and wood processing industry has been a cornerstone of the country's economic growth and employment generation. Plantation forests (most of them developed on degraded or under-utilised land) expanded , by over 4 million hectares from 1990 to 2020, as shown in Figure 4.4. This growth occurred alongside notable growth in naturally regenerating forests, exceeding 1 million hectares. At the same time, Viet Nam stands as the largest wood pellet producer in the region. Approximately 10% of the harvested woody biomass is processed into wood pellets (estimated up to 120 picojoules), which are then exported for energy purposes (IRENA, 2022a). These achievements position Viet Nam as a significant contributor to the global carbon stock as well as sustainable fuel production. The country places a strategic emphasis on forest management and active participation in international trade.

Figure 4.4 Changes in forested areas in Viet Nam, 1990-2020



Source: FAO (2021).

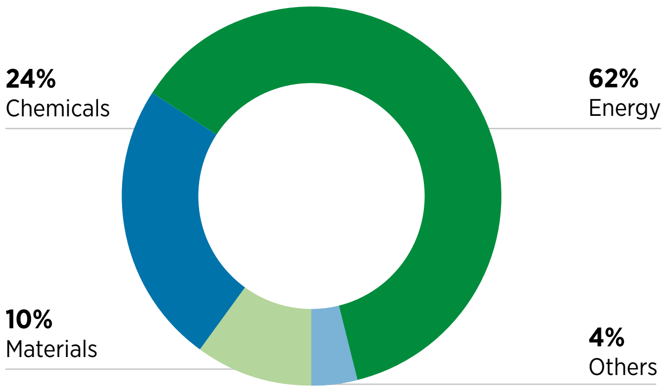
Source: (IRENA, 2022e)

4.6.2 Developing an innovative bio-based industry: A biorefinery approach

Besides upstream challenges, financial risks remain critical for downstream investment. Fluctuations in feedstock prices, uncertainty in market access and thin profit margins have prevented the materialisation of numerous biofuel projects. Integrating sustainable fuel production in downstream biochemical industries promises multiple outputs. Biorefineries constitute a broad class of processes designed to refine multiple forms of biomass into a variety of products, including chemicals and materials for various uses alongside heat, electricity or fuel production. As of 2022, energy products, comprising diverse fuel types, continued to stand out as the primary outputs from biorefineries globally. Concurrently, chemicals and materials play pivotal roles as significant co-products, as illustrated in Figure 4.5.

Such an approach offers a host of economic, environmental and operational advantages, making sustainable fuel production more feasible. A recent study by researchers from the European Commission and the Netherlands shows that biorefineries can significantly reduce GHG emissions because they follow an integrated approach to production by utilising biomass feedstock and waste, thus substantially reducing the environmental impact per product (Zuiderveen *et al.*, 2023).

Figure 4.5 Types of main products from biorefineries across the world as in 2022*



Source: (IEA Bioenergy, 2022).
Note: *In percentage of total number of refineries studied [1312].

Another key advantage of biorefineries is that they enable distributing feedstock risks and aid in revenue stream diversification. Because they process multiple feedstocks and produce a range of outputs, biorefineries can help tap into different markets and income sources. Such a model improves financial stability and mitigates the risks associated with fluctuations in prices and demand. From a carbon and resource circularity standpoint, this also aligns with the concept of optimising resource utilisation.

The integration of sustainable fuel production into broader bio-based economy value chains through an innovative biorefinery approach presents a strategic and logical choice. While certain products may face economic challenges at present, ongoing technological advancements continue to improve production processes. Biorefineries' scale-up potential ensures that as technologies mature, economically challenging products can become more feasible for large-scale production.

5. SOCIAL DIMENSIONS OF A JUST AND INCLUSIVE ENERGY TRANSITION

KEY MESSAGES

A renewables-based global energy transition presents opportunities for sustainable development for all. In many developing countries, cost-effective renewable energy solutions can help address basic deficits in access to electricity and clean cooking technologies. However, as described earlier in this report, half of the world's population lives in 150 developing countries that received just 10% of global energy transition investments in 2023. While renewable energy costs remain competitive worldwide, high upfront costs, debt burdens and limited fiscal space inhibit the ability to fully harness its social dividend potential in most EMDEs.

The G20 has a key role to play in solving this problem. Its countries account for the bulk of the world's current carbon footprint – and most of the globe's investment in renewable energy. The uneven geographic distribution of renewable energy investment mirrors the gaps in access and affordability, *i.e.* 685 million people without electricity and 2.1 billion without access to clean cooking – most of whom reside in Sub-Saharan Africa (IEA *et al.*, 2024a).

Addressing deficits in access to energy in isolation represents a missed opportunity; holistic approaches are needed to alleviate poverty, improve livelihoods and distribute the burdens and benefits of the transition fairly. Exploiting the full potential of the energy transition also depends on measures beyond the energy sector to ensure broad public acceptance, thereby addressing social tensions, economic exclusion and environmental degradation within and beyond the G20 (IRENA, 2023a). Securing public acceptance will depend on inclusive decision making in the form of public consultations, community dialogue, and well-designed environmental and social management plans.

The G20 is in a position to deliver on the UAE Consensus. It can provide financing, support tailored policy making and foster both regional and international co-operation to boost collective efforts and raise global ambitions to achieve an energy transition that is just and inclusive, as well as beneficial to the environment. These include increasing official development assistance, reforming the international development finance system and strengthening local financial institutions.

Funding should be allocated to technologies but also to interventions that ensure social inclusion, such as education, training and (re-)skilling, social assistance, infrastructure development, and the implementation of inclusionary business models such as community energy schemes.

Radical action is needed to build an energy system that delivers the social, economic and environmental potential of the transition; as well as to ease the burdens of adjustment, especially among those countries and communities most reliant on fossil fuels.

To meet those imperatives, policies and financial measures must be devised to address justice and inclusion gaps in the energy transition. EMDEs have different capacities to adapt and take advantage of emerging opportunities. But in EMDEs and G20 countries alike, understanding the social dimensions of the transition can play an important role in making that transition fairer, cleaner and more beneficial for all. Empowering decision making by individuals and communities is essential for assuring the public support needed to pursue decarbonisation amid growing energy demand.

The measures needed to ensure a just, inclusive and comprehensive energy transition must be discussed, negotiated and ultimately implemented in specific social contexts. There is no 'one-size-fits-all' solution, no silver bullet to ensure that the transition is just and socially inclusive; but the following recommendations can be derived from the preceding discussion, with the understanding that they will be applied in specific national or local contexts.

Recommendation 1:
Strive to overcome societal and cultural biases that may hinder people's ability to take advantage of energy transition opportunities.

Recommendation 2:
Support workforce development and leadership empowerment, thereby strengthening the capacity of individuals and institutions to realise the socio-economic benefits of the renewables-based energy transition – including formal education, vocational training, upskilling and reskilling, and local value creation – while ensuring labour rights and standards are upheld.

Recommendation 3:
Commit to policies and programmes that enable historically disadvantaged regions and communities to take advantage of energy transition opportunities, to reorient people strongly dependent on fossil fuels and to provide social protection. These efforts should ensure that everyone – irrespective of gender, ethnicity or status – has equitable access to social protection, education, mentorship, professional networks, credit and entrepreneurship opportunities.

Recommendation 4:
Empower local communities – including indigenous peoples, marginalised groups and vulnerable populations – to grasp and embrace the implications of the energy transition in resource use, ownership structures and distribution of benefits. These efforts should include the imperative of free, prior and informed consent in decision-making processes.

Recommendation 5:
Enhance and strengthen infrastructure to ensure access to affordable energy for all, including grids and mini-grids, and other transmission or energy distribution networks.

5.1 INTRODUCTION

The current energy system is neither inclusive nor just. In the broadest sense, it must be radically transformed to avoid catastrophic climate impacts and adapt to the negative impacts already inflicted on the planet and its people (IPCC, 2019, 2022a, 2022b, 2023). In a practical sense, it must be transformed to remove inequitably distributed threats to human health (*e.g.* air pollution) and the environment. Renewable energy will be critical to this transformation (IPCC, 2023; IRENA, 2023a).

A just and inclusive energy transition must consider the social dimensions of different decarbonisation pathways. In the pursuit of comprehensive sustainable development, IRENA has highlighted the trade-offs between fossil-fuelled and renewables-based growth in emerging markets and developing economies (EDMEs), and questioned the terms 'just' and 'inclusive' in the context of the global energy transition (IRENA, 2024e, 2024f; IRENA and AfDB, 2022). IRENA research shows the need for a more comprehensive discussion of these elements to ensure the energy transition leaves no one behind (IRENA, 2023a).

Interpretations of these terms vary among the parties to the Paris Agreement; but efforts to establish consensus on their definitions continue in the wake of the Global Stocktake at COP28 in Dubai. As countries undertake the third update of their Nationally Determined Contributions (NDCs) in the run up to COP29 in Baku, there is a new opportunity to establish a framework on how these terms are reflected in decarbonisation pathways.

Renewable energy offers the promise of: greater social justice in the form of jobs and livelihoods for millions of people lacking access to modern forms of energy; the expansion of industrial growth; and the reduction of import dependence (IRENA, 2019a, 2020e, 2023a; IRENA and ILO, 2023). IRENA's 2023 *World Energy Transitions Outlook* shows that a 1.5°C-compatible pathway could generate an average annual increase in GDP of 1.5% and create 40 million additional jobs in the energy sector by 2050, compared with currently planned policies. Steps must be taken to ensure that this potential is realised for all (IRENA, 2022b).

This chapter sheds light on the elements of justice and inclusion related to a renewables-based energy transition. Section 5.2 examines the call by the G20 Brazil Presidency to assess notions of a just and inclusive energy transition. Against this background, Section 5.3 explores the cross-national and cross-regional differences in those notions. Sections 5.4 and 5.5 propose ways to narrow those differences by seizing opportunities in policy and finance.

5.2 EVOLVING NOTIONS OF A JUST AND INCLUSIVE ENERGY TRANSITION

There is no universal definition of a just and inclusive energy transition. The widespread of use of these terms in the decarbonisation discussion has not made them any clearer. The notion of the just transition was originally conceived by labour unions and civil society activists during the 1970s and 1980s in the United States; at the time, it pertained to the occupational safety and health of workers in the fossil fuel, chemical and nuclear industries (Morena *et al.*, 2019).

References to a "just transition" entered the mainstream discourse on climate action in the 2010s. A significant milestone was the publication of *Guidelines for a Just Transition Towards Environmentally Sustainable Economies and Societies for All* by the International Labour Organization (ILO, 2016), which involved representatives of trade unions, employers and governments. The guidelines are strongly rooted in the so-called '"decent work agenda", which encompasses social dialogue, social protection, rights at work and employment. While job-centric, the vision behind the guidelines also recognised broader goals, such as poverty eradication, social inclusion, economic growth, environmental sustainability and the needs of future generations. The guidelines also touched on energy and resource efficiency.

The concept of the just transition picked up momentum from advocacy by organised labour (*e.g.* the International Trade Union Confederation). It was included as a policy goal in the 2015 Paris Agreement (Morena *et al.*, 2019), which referred to the "just transition of the workforce". It was also referenced in other inter-governmental contexts at the time. One example is the *Charlevoix G7 Summit Communique* (G7, 2018). Subsequent decisions by successive COPs expanded this understanding (Johansson, 2023). Since 2019, a growing number of countries have sought to advance just transition efforts through national legislation and policies. Task forces and commissions were created in Australia, Canada, European Union, Germany, Ireland, New Zealand, Scotland, South Africa and the United States (Appalachia) (Heffron, 2021).

The Glasgow Climate Pact adopted in 2021 called on parties to "transition towards low-emission energy systems […] while providing targeted support to the poorest and most vulnerable in line with national circumstances and recognising the need for support towards a just transition" (UNFCCC, 2023b). The first ministerial meeting of the *Just Transition Work Programme* adopted at COP28 in Dubai in 2023 noted that just transition "encompasses pathways that include energy, socio-economic, workforce and other dimensions", and stressed its link to poverty eradication and sustainable development, the importance of inclusive participatory approaches, and the need to create decent work and recognition of labour rights (UNFCCC, 2023b). Explicit commitments to the transition away from fossil fuels came at around the same time.

As the Brazilian G20 presidency has highlighted, the understanding of the terms 'just' and 'inclusive' must consider more than the need to retrain workers made redundant by the "phase-down and phase-out of some industries". It must also recognise the impacts of clean energy investments on local communities and ecosystems, as well as in global trade and economic development. In this sense, "the challenges EMDEs face in pursuing just and inclusive energy transitions will almost certainly vary from those of developed countries" (G20 Brazil, 2024).

5.3 IDENTIFYING SOCIAL CHALLENGES OF THE ENERGY TRANSITION

Justice and inclusion acquire meaning within specific contexts. Injustice and exclusion are pervasive in the current fossil-fuelled system and will be perpetuated by any system (renewables-based or other) that replaces it, unless they are understood and effectively tackled by policy makers, businesses and civil society.

For instance, the lived experiences and priorities of energy workers and communities in developing countries are markedly different to those in advanced economies, despite potential parallels and similarities. Those differences call for considering the full range of distributional consequences of energy transition processes, climate imperatives and development needs – alongside existing and anticipated inequalities. Socio-economic benefits and costs in existing energy systems are not borne equally (IRENA, 2023d). In addition, ownership of, and profits from, the resources underpinning the current fossil-fuel dominated energy system are highly concentrated in the hands of a few large companies, energy exporting companies and financial institutions (Biswas *et al.*, 2022). Control over energy projects and infrastructure – and over how revenues are distributed – has implications for justice and inclusion.

Another issue relates to financing; it matters how rapidly energy transition finance can be scaled up across regions and countries. Renewable electricity is cost-competitive in a growing number of contexts (IRENA, 2023e); but renewable project development in many EMDEs is still associated with high upfront costs and exchange rate risks.[14] Additionally, the source of, and responsibility for, funding new infrastructure and services made necessary by the transition to renewables (*e.g.* power grids, system flexibility, energy efficiency) is equally important.

The challenges of financing the transition in a fair way can be met through the effective use of public resources (IRENA and CPI, 2023). Yet, public resources are limited and their continued use to support fossil fuels is deeply ingrained in governance systems. While precise estimates vary, the imbalance between financial support for fossil fuels and that for renewable energy is evident.

The International Monetary Fund estimates that subsidies for fossil fuel industries rose to a record USD 7 trillion in 2022 (IMF, 2023c). Redirecting this spending to transition pathways is critical to avoid catastrophic climate impacts (IRENA, 2023a).

Significant gaps in energy availability and affordability also persist. Around 80% of the world's population who lack basic access to electricity reside in Sub-Saharan Africa, and 2.3 billion people worldwide continue to rely on harmful cooking technologies and fuels (IEA *et al.*, 2024) . Setbacks delay progress. For example, "75 million people who had recently gained access to modern energy are at risk of losing it due to affordability issues", and higher costs following the war in the Ukraine led to 31 million of households unable to heat their homes in 2021 (IEA *et al.*, 2023; Igawa and Managi, 2022).

Socio-economic impacts such as energy transition job losses also need careful examination – particularly if fossil fuel workers are not retrained (IRENA and ILO, 2023). Yet, job losses in the fossil fuel sector are widely expected to be offset by gains in renewables, energy efficiency, power grids and flexibility, vehicle charging infrastructure and hydrogen; gains can also be achieved in terms of local value creation and environmental improvements (Bloch *et al.*, 2023; IRENA, 2023a).

5.4 OPPORTUNITIES FOR A SOCIALLY INCLUSIVE ENERGY TRANSITION: POLICY CONSIDERATIONS

Driving just and inclusive energy transition in line with global climate and development objectives requires a wide range of policy measures. These include policies that support the scaling up of renewable energy capacities; policies that integrate renewables into power grids and other end-use sectors; structural and just transition policies, industrial policies, and education and training strategies; labour market measures; and community investments – all with adequate financing (IRENA, 2021c, 2023a).

5.4.1 Sustainable and affordable energy for all

Decentralised renewable energy solutions can provide the least-cost option for reaching much of the remaining population without access in remote areas (IRENA, 2023h). Because high upfront costs can be an obstacle for households and small businesses (ESMAP, 2019), competing private providers are unlikely to enter the market. Government must determine which decentralised renewable-based energy solutions are best positioned to tackle energy access deficits and achieve universal access to modern energy by 2030. With strong collaboration between donor and recipient governments, scaling up public finance can induce the private sector to mobilise resources for deployment, maintenance and operation of decentralised

[14] *Upfront costs for renewable energy projects are typically paid in major reserve currencies; however, EMDEs often repay debt in less stable domestic currencies, exposing them to unpredictable exchange rates.*

renewables-based solutions. To ensure social inclusion, programmes need to be tailored to the specific needs and challenges of beneficiaries, with a focus on progressive energy pricing structures, connection subsidies and microfinance solutions tailored to remote energy access and social support. A holistic approach that considers the intersection between energy, housing, poverty reduction, and income levels will also be key. For example, Brazil's 2009 Minha Casa Minha Vida program required social housing units to be equipped with solar water-heaters to reduce poor families' energy bills (Linke, 2018).

5.4.2 Livelihoods, poverty reduction and sustainable development

Providing electricity without linking it to services that alleviate poverty, support livelihoods and improve quality of life will fail to harness the socio-economic potential of renewables (IRENA and SELCO Foundation, 2022). Nearly 1 billion people depend on healthcare facilities with no (or unreliable) electricity access (WHO *et al.*, 2023); the educational outcomes for 168 million children are hampered by lack of electricity in schools (UNICEF, 2023); agricultural communities supporting the livelihoods of over 2.5 billion people do not have access to technologies, powered by modern forms of energy, that would help them improve productivity, incomes and resilience, while reducing waste (IRENA and FAO, 2021).

Development policies should prioritise integrated planning that links electrification plans with productive uses of electricity in health, education and micro-business (notably for women). Key elements include stimulating demand, strengthening market access for goods and services, developing product and service value chains, raising awareness, building capacity, supporting entrepreneurs, facilitating equitable access to financing, and applying a gender lens across programmes (IRENA and SELCO Foundation, 2022).

5.4.3 Equitable ownership and benefit sharing

Community-owned energy systems create local value, enable economic development and build public support for renewables, enhancing social cohesion. For example, a community-owned mini-hydro and distribution grid in Nicaragua not only provides affordable energy but also reinvests profits in environmental and social projects, such as education scholarships and access to drinking water (IRENA Coalition for Action, forthcoming).

Community participation, ownership, and benefit-sharing mechanisms can promote social justice and sustainability through renewable energy projects. For example, the Kipeto wind project in Kenya involves a community trust funded by income received from a 5% ownership of the project. Large-scale solar and onshore wind energy projects in Sub-Saharan Africa have been structured to provide substantial community benefits (IRENA, forthcoming-b).

5.4.4 Inclusive workforce development and energy leadership

Job losses in fossil fuel industries can be more than offset by greater gains in transition-related sectors – including renewables, energy efficiency, power grids and flexibility, vehicle charging infrastructure and hydrogen (IRENA, 2023a). But to maximise this net-gain potential, proactive measures are needed to overcome spatial, temporal and skills-related gaps between job losses and gains, while also making sure wages, salaries, and working conditions of newly created jobs are attractive. Governments, the private sector and labour representatives should collaborate to ensure observance of international labour standards, social protection policies, and regulations pertaining to safety and transparency. Companies that engage in social dialogue to gain insights into community needs, priorities and concerns benefit from a smoother energy transition (IRENA Coalition for Action, 2023).

Women make up 32% of the overall workforce in the renewable energy industry (IRENA, 2019b, 2020f, 2022f). Whilst this is not a balanced share, it is greater than the proportion of female workers in the traditional energy sector, at 16% (IEA, n.d.). In the solar and wind sectors, women hold, respectively, only 30% and 13% of managerial responsibilities. This dips further to 13% and 8% in senior management roles (IRENA, 2020f, 2022f).

Establishing clear goals and targets for enhancing diversity within the renewable energy workforce (with regard to gender, age or any other social dimension) not only commits an organisation to collect disaggregated data but also to pursue measurable goals that can be tracked to demonstrate progress. For instance, gender quotas can be effective for women's representation in managerial or technical roles, if set in hiring processes and decisions (IRENA, 2019b).

Tailored skills development initiatives for men and women can help address some of these imbalances while improving the overall capacity of communities and local economies to exploit the full employment potential of renewable energy deployment (IRENA, 2023i). Support schemes targeted at women and youth can round out a whole-of-society approach to employment. Locally grown solutions matched to the socio-economic circumstances that renewable energy systems are meant to serve are especially effective.

5.4.5 Protection for vulnerable groups

Protecting human rights is one of the cornerstones of a just transition, the principle of free, prior and informed consent should be applied to the indigenous peoples and other marginalised groups who have so often seen their land rights and cultural heritage violated in the course of energy development and mining (CCSI, 2020). Where a renewable energy project is sited or located, and how land used for a project is owned and accessed, should involve consultation and negotiation (IRENA, forthcoming-b).

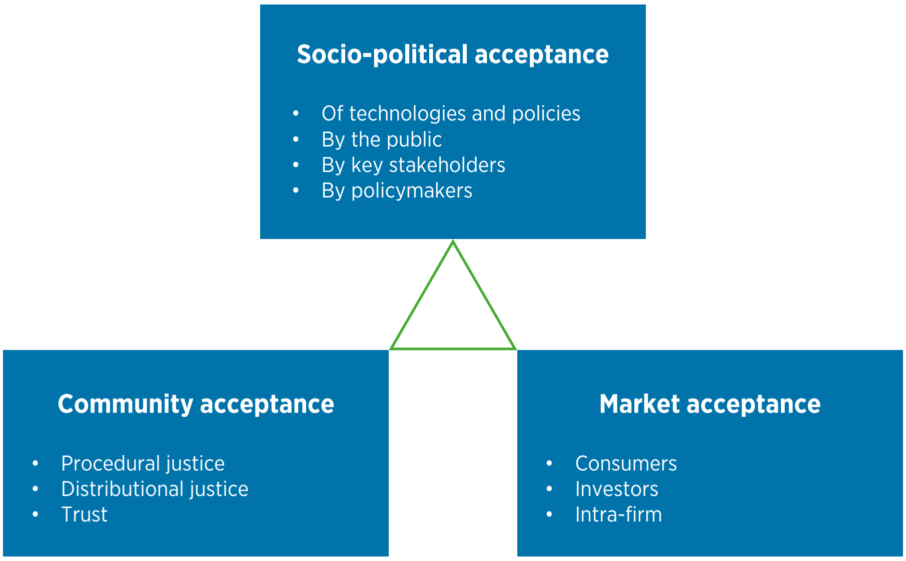
Those groups most affected often have the least economic and political influence to change practices and institutions; but policy making can ensure that projects contribute positively to their wellbeing and can encourage local adaptation (IRENA, 2023j). When people have a stake in a project, they are more likely to support and promote it to others and invest their time and resources (IRENA Coalition for Action, forthcoming). Projects and policies can also facilitate energy independence and improve local economic conditions for indigenous peoples, while championing ecological stewardship for those who have traditionally lived on project sites (Agrawal *et al.*, 2023; REN21, 2023).

The proliferation of renewable energy projects directly owned by, or otherwise benefitting, indigenous peoples in Canada can be linked to a combination of factors, including proactive provincial policy and renegotiations over clean energy infrastructure on treaty lands (ICE, 2022; IISD and ICE, 2024; IRENA, 2023j).

5.4.6 Public awareness, participation and engagement

Stakeholder engagement can involve government, private companies and civil society organisations, using various forms of negotiation, consultation and information sharing. Transparent and meaningful decision-making processes that go beyond the mere provision of information are critical not only to make transitions just, but also to ensure the popular support necessary to drive changes to national and regional energy markets in the decades to come (Newell, 2021; Scherhaufer, 2021). Similarly, energy transition interventions that enable the active participation of local stakeholders help build trust and high levels of public acceptance. Attention should be drawn to the different dimensions of renewables-based transitions, as Figure 5.1 illustrates.

Figure 5.1 Social acceptance of renewable energy



Source: (Rolf Wüstenhagen *et al.*, 2007).

5.4.7 Commitment of G20 countries to a rights-based approach to the energy transition

Institutional mandates do not always include social elements . Governments, utilities and financing institutions have, in the past, based energy decisions largely on issues of technical feasibility and reliability, and to a certain extent, environmental impact (Shelton and Eakin, 2022). A clear commitment to a rights-based approach could be a powerful tool to equip and empower institutions.

5.5 OPPORTUNITIES FOR A SOCIALLY INCLUSIVE ENERGY TRANSITION: FINANCING CONSIDERATIONS

How finance is sourced and disbursed has inherent social dimensions. Both sourcing and disbursement must be looked at from a global perspective, and from a national and subnational perspective, to ensure that financing instruments (including derisking measures) benefit all groups.

5.5.1 The global perspective

As shown in Chapter 2, advanced economies making up 14% of the world's population accounted for 47% of global investments in the energy transition. Almost 43% went to three countries – China, India and Brazil – which make up 38% of the world's population. Meanwhile, half of the world's population, living in more than 150 developing countries, received just 10% of the world's investments (see Figure 2.2). Comparing advanced economies to the 154 EMDEs (excluding China) that make up more than two-thirds of the world's population, the advanced economies attracted 14 times more investment per capita than the EMDEs in the period between 2016 and 2019. Over the following three years (2020-2023), they attracted 18 times more.

The form in which investment comes matters as much as its raw amounts. Capital financing components (debt and equity) are typically made in hard currency, which constitutes a heavy financial burden and a currency risk for EMDEs. As noted in Chapter 2, what many EMDEs need are more grants and concessional loans to build the economic case for the energy transition in their respective countries, to the point where private investors will be drawn in.

Donor funds from philanthropies, development finance institutions – domestic, bilateral and multilateral – and funds replenished through carbon and wealth taxes can be used to fund energy transition projects in EMDEs that contribute to greater social equality. Domestic instruments would then be needed to channel funds into projects, infrastructure and the enabling environment to mobilise private capital.

Donor nations are already providing funding packages to support decarbonisation of economies under so-called Just Energy Transition Partnerships (JETPs). First announced at COP26 in Glasgow, the intended beneficiary countries include South Africa, Indonesia, Viet Nam and Senegal. However, JETPs represent only a fraction of the investment needed to meet climate goals, and too little of that fraction comes in the form of grants.

In South Africa, total financing requirements are projected to be USD 98 billion in 2023-2030. The JETP package offers USD 8.5 billion (IRENA, 2023k). The same applies to Indonesia, where the government estimates it will need at least USD 96 billion for new renewable energy generation and transmission and distribution, making the initial USD 20 billion commitment from the JETP minimal (JETP Indonesia, 2023).

5.5.2 National and sub-national perspectives

At the national and sub-national levels, public finance (sourced through international collaboration or nationally) is channelled towards the energy transition through a mix of policy and financing instruments (IRENA and CPI, 2023). How these instruments are designed and disbursed has various implications for development. Public loans are generally disbursed at market rate, at which risks and costs are high. Moreover, recipient governments are often required to provide guarantees or hedges against currency risks, adding to their debt burdens. Such circumstances limit the amount of funding available for social inclusion and sustainable development outcomes.

Grants and public investments – not only in infrastructure but also in the wider enabling environment, such as education and social protection – can fill the gap in funding whilst also ensuring a more equitable distribution of funds. For instance, provisions can be made to ensure grants or public investments do not concentrate the benefits among some communities over others.

Although capital subsidies, up-front price subsidies, tax incentives, value-added tax exemptions and rebates, among other measures, have been successful in advancing the energy transition[15], they typically benefit large industries (*e.g.* electric car manufacturers) and high-income consumers (*e.g.* people who can afford electric vehicles), yet they are funded by all taxpayers.

[15] *For example, in 2023, electric transport including EVs and charging infrastructure attracted USD 634 billion in 2023, a 31% annual increase from the previous year (BNEF, 2024b).*

REFERENCES

AfDB, A. D. (2023), "COP28: Global and African partners pledge $175m to the Alliance for Green Infrastructure in Africa (AGIA)", *African Development Bank Group*, Text, African Development Bank Group, https://www.afdb.org/en/news-and-events/press-releases/cop28-global-and-african-partners-pledge-175m-alliance-green-infrastructure-africa-agia-66513 (accessed 20 August 2024).

Agrawal, H., *et al.* (2023), *Enabling a Just Transition: Protecting Human Rights in Renewable Energy Projects*, Columbia Center on Sustainable Investment, New York, https://ccsi.columbia.edu/content/enabling-just-transition-protecting-human-rights-renewable-energy-projects (accessed 2 July 2023).

ATI (African Trade Insurance Agency) (2018), *The Regional Liquidity Support Facility (RLSF) for Sub-Saharan African independent power producers*, www.ati-aca.org/wpcontent/uploads/2018/04/RLSF-Teaser.pdf.

Bloch, C., *et al.* (2023), *Realizing the Green Jobs Promise: The Benefits of a Regenerative Approach*, Rocky Mountain Institute, https://www.esi-africa.com/wp-content/uploads/2023/02/Realizing-the-Green-Jobs-Promise.pdf

BMME (2023), "Brazilian Ministry of Mines and Energy", https://www.gov.br/mme/pt-br/assuntos/secretarias/petroleo-gas-natural-e-biocombustiveis/renovabio-1/renovabio-ingles

BNEF (2022), *Energy Transition Investment Trends 2022*, Bloomberg New Energy finance, https://about.bnef.com/energy-transition-investment/

BNEF (2023), "Energy Transition Investment database", https://www.bnef.com/interactive-datasets/2d5d59acd9000005 (accessed 14 January 2023).

BNEF (2024a), "Energy Transition Investment Trends 2024", *BloombergNEF*, https://www.bnef.com/insights/33273/view (accessed 1 February 2023).

BNEF (2024b), "Power Assets (subscription required)", *BloombergNEF*, https://www.bnef.com/assets/power?region=bra&input=aaa73b20&input=a4e3fa66&input=b71fcfb7&input=e48f6cda&input=c7b15239&input=273c83a1&asset-technology=90482291&asset-technology=988db714&asset-technology=12e43a35&asset-status=3eb4e726&date-type=financing&date%5Blte%5D=2023-12-31&date%5Bgte%5D=2012-12-31&sort=capacity.desc&_= (accessed 3 May 2024).

Brady, M.A. *et al.* (2024), "Bioenergy sustainability in the global South: Constraints and opportunities", The Center for International Forestry Research and World Agroforestry (CIFOR-ICRAF, https://doi.org/10.17528/cifor-icraf/008846

Caiado Couto, L. (2023), *How to boost international private climate finance*, Royal Institute of International Affairs, https://doi.org/10.55317/9781784135607

CCSI (2020), *Government Briefing: Incorporating Free, Prior and Informed Consent into Investment Approval Processes*, Columbia Center on Sustainable Investment, https://ccsi.columbia.edu/sites/default/files/content/Briefing-FPIC%20and%20investment%20approval%20(July%202020).pdf

Chami, R., *et al.* (2022), "Toward a Nature-Based Economy", *Frontiers in Climate*, vol. 4, pp. 855803, https://doi.org/10.3389/fclim.2022.855803

Climate Bonds Initiative (2021), "Record $269.5bn green issuance for 2020: Late surge sees pandemic year pip 2019 total by $3bn", *Climate Bonds Initiative*, https://www.climatebonds.net/2021/01/record-2695bn-green-issuance-2020-late-surge-sees-pandemic-year-pip-2019-total-3bn (accessed 15 August 2024).

Climate Policy Initiative (2023), "Global Landscape of Climate Finance 2023", *CPI*, https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2023/ (accessed 21 November 2023).

Coelho, S. (2024), "Sugarcane cultivation and advanced bioenergy technologies in an integrated food and energy system in Brazil: sugar, ethanol 1G/2G biomethane, hydrogen for SAF and BECCS", *Presentation at 11th GBEP Bioenergy Week. June 2024*, Rome, Italy.

COP28, IRENA and GRA (2023), *Tripling renewable power and doubling energy efficiency by 2030: Crucial steps towards 1.5°C*, (p. 62), International Renewable Energy Agency, Abu Dhabi, www.irena.org/-/media/Files/IRENA/Agency/Publication/2023/Oct/COP28_IRENA_GRA_Tripling_renewables_doubling_efficiency_2023.pdf?rev=9831037db9e44aa5976b582af19a90da

COP28 Presidency, *et al.* (2023), *Tripling renewable power and doubling energy efficiency by 2030: Crucial steps toward 1.5°C*, International Renewable Energy Agency, COP28 Presidency and Global Renewables Alliance, Abu Dhabi, www.irena.org/Publications/2023/Oct/Tripling-renewable-power-and-doubling-energy-efficiency-by-2030

CPI (2024), "Global Landscape of Climate Finance Database", *Climate Policy Initiative*, London, https://www.climatepolicyinitiative.org/resources/publications/climate-finance-tracking/

EC (n.d.), "Renewable Energy Directive", https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en.

ESMAP (2019), *2019 Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers – Executive Summary*, ESMAP Technical Report, No. 014/19, World Bank, Washington D.C., http://hdl.handle.net/10986/31926

ESMAP (2023), *How to Unlock Pipelines of Bankable Renewable Energy Projects in Emerging Markets and Developing Countries*, World Bank Energy Sector Management Assistance Program, https://www.esmap.org/Pipelines-of-Bankable-RE-Projects

European Commission (2019), "The European Green Deal COM(2019) 640 final", https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN (accessed 15 August 2024).

FAO (2023), "Bioeconomy for sustainable food and agriculture", https://www.fao.org/in-action/sustainable-and-circular-bioeconomy/en/ (accessed 1 May 2024).

FAOSTAT (2023), "FAOSTAT Database", https://www.fao.org/faostat/en/#data/QCL

Foster, V., *et al.* (2023), "Data-to-Deal: How can Countries in the Global South Afford the Climate Transition?", Climate Compatible Growth, https://climatecompatiblegrowth.com/wp-content/uploads/Affording-the-Climate-Transition.pdf

G7 (2018), "The Charlevoix G7 Summit Communique", https://www.international.gc.ca/world-monde/international_relations-relations_internationales/g7/documents/2018-06-09-summit-communique-sommet.aspx?lang=eng (accessed 3 February 2023).

G20 Brazil (2024), *G20 Energy Transitions Working Group Issue Note*, Brazil, http://www.g20.org/pt-br/documentos/issue-note-energy-transitions.pdf/@@download/file

Goh, C. S., *et al.* (2020), "Rethinking sustainable bioenergy development in Japan: decentralised system supported by local forestry biomass", *Sustainability Science*, vol. 15, pp. 1461–71.

Government of India (2022), *Framework for Sovereign Green Bonds*, https://rbidocs.rbi.org.in/rdocs/content/pdfs/FSGB06012023.pdf

Heffron, R.J. (2021), "Achieving a Just Transition to a Low-Carbon Economy", Springer International Publishing, Cham, https://doi.org/10.1007/978-3-030-89460-3

IATA (n.d.), "Sustainable Aviation Fuels", https://www.iata.org/en/programs/environment/sustainable-aviation-fuels/

ICE (2022), *Waves of change: Indigenous clean energy leadership for Canada's clean, electric future*, Indigenous Clean Energy, https://indigenouscleanenergy.com/wp-content/uploads/2022/06/ICE-report-ENGLISH-FINAL.pdf

IEA (2023), "Emissions in advanced economies fell to their level of 50 years ago – CO_2 Emissions in 2023 – Analysis – IEA", *International Energy Agency*, www.iea.org/reports/co2-emissions-in-2023/emissions-in-advanced-economies-fell-to-their-level-of-50-years-ago (accessed 19 August 2024).

IEA, *et al.* (2023), *Tracking SDG7: The energy progress report 2023*, International Energy Agency, International Renewable Energy Agency, United Nations Statistics Division, the World Bank and World Health Organization, Geneva, www.irena.org/Publications/2023/Jun/Tracking-SDG7-2023

IEA, *et al.* (2024a), *Tracking SDG7: The energy progress report 2024*, International Energy Agency, International Renewable Energy Agency, United Nations Statistics Division, the World Bank and World Health Organization, Geneva, www.irena.org/Publications/2023/Jun/Tracking-SDG7-2023

IEA, *et al.* (2024b), *Tracking SDG7: The energy progress highlights; SDG7 Global Stocktake*, International Energy Agency, International Renewable Energy Agency, United Nations Statistics Division, the World Bank and World Health Organization, Geneva, www.un.org/sites/un2.un.org/files/sdg7-highlights2024-041224-web.pdf

IEA (n.d.), "A critical issue in energy employment and access: Energy and gender", *International Energy Agency*, www.iea.org/topics/energy-and-gender

IEA Bioenergy (2022), *Global biorefinery status report 2022*, International Energy Agency, https://www.ieabioenergy.com/wp-content/uploads/2022/09/IEA-Bioenergy-Task-42-Global-biorefinery-status-report-2022-220712.pdf

IFC (2018), *Nubian Suns (Egypt): Scale At Speed*, International Finance Corporation, https://www.ifc.org/content/dam/ifc/doc/mgrt/scaling-infra-egypt-10.pdf

Igawa, M., and Managi, S. (2022), "Energy poverty and income inequality: An economic analysis of 37 countries", *Applied Energy*, vol. 306, pp. 118076, https://doi.org/10.1016/j.apenergy.2021.118076

IISD (2024), *Mapping India's Energy Policy 2023*, International Institute for Sustainable Development, https://www.iisd.org/publications/report/mapping-india-energy-policy-2023

IISD, and ICE (2024), *Sustainable Jobs for Indigenous Clean Energy Action*, International Institute for Sustainable Development and Indigenous Clean Energy, https://indigenouscleanenergy.com/wp-content/uploads/2024/08/sustainable-jobs-for-indigenous-clean-energy.pdf

ILO (2016), *Guidelines for a just transition towards environmentally sustainable economies and societies for all*, International Labour Organization, https://www.ilo.org/publications/guidelines-just-transition-towards-environmentally-sustainable-economies

IMF (2023a), "World Economic Outlook Database: Groups and aggregates information", *International Monetary Fund*, https://www.imf.org/en/Publications/WEO/weo-database/2023/April/groups-and-aggregates#oem

IMF (2023b), "Green Bonds", *International Monetary Fund | Climate Change Dashboard*, https://climatedata.imf.org/datasets/8e2772e0b65f4e33a80183ce9583d062_0/about (accessed 20 August 2024).

IMF (2023c), *Debt Relief Under the Heavily Indebted Poor Countries Initiative*, International Monetary Fund, https://www.imf.org/en/About/Factsheets/Sheets/2023/Debt-relief-under-the-heavily-indebted-poor-countries-initiative-HIPC (accessed 25 June 2023).

IMF (2024), "World Economic Outlook (April 2024) – Population", *International Monetary Fund*, www.imf.org/external/datamapper/LP@WEO (accessed 19 August 2024).

IMF (n.d.), "World Economic Outlook Database – Groups and Aggregates", *IMF*, https://www.imf.org/en/Publications/WEO/weo-database/2023/April/groups-and-aggregates (accessed 29 May 2024).

InfraCo Africa (n.d.), "Chad: Djermaya Solar", https://infracoafrica.com/project/djermaya-solar/

IPCC (2019), *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, Intergovernmental Panel on Climate Change.

IPCC (2022a), *Climate change 2022: Impacts, adaptation and vulnerability-Summary for policymakers*, Intergovernmental Panel on Climate Change, https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_SummaryForPolicymakers.pdf

IPCC (2022b), *Climate Change 2022: Mitigation of Climate Change Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Intergovernmental Panel on Climate Change, Geneva, https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf (accessed 27 March 2023).

IPCC (2023), *Synthesis Report of the IPCC Sixth Assessment Report (AR6)*, Intergovernmental Panel on Climate Change, Geneva, www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_LongerReport.pdf

IRENA (2013), *Renewable energy auctions in developing countries*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2013/Jun/Renewable-Energy-Auctions-in-Developing-Countries

IRENA (2015), *Renewable energy auctions: A guide to design*, International Renewable Energy Agency, Abu Dhabi, http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=603

IRENA (2016), *Unlocking renewable energy investment: The role of risk mitigation and structured finance*, 2016, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2016/Jun/Unlocking-Renewable-Energy-Investment-The-role-of-risk-mitigation-and-structured-finance

IRENA (2019a), *A New World: The Geopolitics of the Energy Transformation*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/publications/2019/Jan/A-New-World-The-Geopolitics-of-the-Energy-Transformation

IRENA (2019b), *Renewable energy: A gender perspective*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2019/Jan/Renewable-Energy-A-Gender-Perspective (accessed 31 January 2022).

IRENA (2020a), *Renewable energy finance: Green bonds*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2020/Jan/RE-finance-Green-bonds

IRENA (2020b), *Renewable energy finance: Sovereign guarantees*, International Renewable Energy Agency, Abu Dhabi, https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jan/IRENA_RE_Sovereign_guarantees_2020.pdf

IRENA (2020c), *Mobilising institutional capital for renewable energy*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2020/Nov/Mobilising-institutional-capital-for-renewable-energy

IRENA (2020d), *Scenarios for the Energy Transition: Global experience and best practices*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/publications/2020/Sep/Scenarios-for-the-Energy-Transition-Global-experience-and-best-practices (accessed 25 June 2021).

IRENA (2020e), *The post-COVID recovery: An agenda for resilience, development and equality*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2020/Jun/Post-COVID-Recovery (accessed 31 January 2022).

IRENA (2020f), *Wind energy: A gender perspective*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2020/Jan/Wind-energy-A-gender-perspective

IRENA (2021a), *Reaching zero with renewables: Biojet fuels*, International Renewable Energy Agency, Abu Dhabi, https://irena.org/publications/2021/Jul/Reaching-Zero-with-Renewables-Biojet-Fuels (accessed 17 November 2021).

IRENA (2021b), *A pathway to decarbonise the shipping sector by 2050*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/Publications/2021/Oct/A-Pathway-to-Decarbonise-the-Shipping-Sector-by-2050

IRENA (2021c), *World energy transitions outlook: 1.5°C pathway*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2021/Jun/World-Energy-Transitions-Outlook

IRENA (2021d), *Renewable energy auctions Japan: Context, design and results*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/publications/2021/Jan/Renewable-energy-auctions-in-Japan

IRENA (2021e), *Renewable energy auctions in Colombia: Context, design and results*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2021/March/Renewable-energy-auctions-in-Colombia

IRENA (2022a), *Scenarios for the energy transition: Experience and good practices in Latin America and the Caribbean*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2022/Jul/Scenarios-for-the-Energy-Transition-LAC

IRENA (2022b), *World energy transitions outlook 2022: 1.5°C pathway*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/publications/2022/Mar/World-Energy-Transitions-Outlook-2022

IRENA (2022c), *Indonesia energy transition outlook*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2022/Oct/Indonesia-Energy-Transition-Outlook

IRENA (2022d), *Scaling up biomass for the energy transition: Untapped opportunities in Southeast Asia*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2022/Feb/Scaling-up-biomass-for-the-energy-transition-Untapped-opportunities-in-Southeast-Asia

IRENA (2022e), *Bioenergy for the energy transition: Ensuring sustainability and overcoming barriers*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2022/Aug/Bioenergy-for-the-Transition

IRENA (2022f), *Solar PV: A gender perspective*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2022/Sep/Solar-PV-Gender-Perspective

IRENA (2022g), *Renewable energy auctions: Southeast Asia*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2022/Dec/Renewable-energy-auctions-Southeast-Asia

IRENA (2023a), *World energy transitions outlook 2023: 1.5°C pathway*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jun/World-Energy-Transitions-Outlook-2023

IRENA (2023b), *NDCs and renewable energy targets in 2023: Tripling renewable power by 2030*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Dec/NDCs-and-renewable-energy-targets-in-2023-Tripling-renewable-power-by-2030

IRENA (2023c), *The cost of financing for renewable power*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/May/The-cost-of-financing-for-renewable-power

IRENA (2023d), *Low-cost finance for the energy transition*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/May/Low-cost-finance-for-the-energy-transition

IRENA (2023e), *Scenarios for the energy transition: Experience and good practices in Africa*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jan/Scenarios-for-the-energy-transition-Experience-and-good-practices-in-Africa

IRENA (2023f), *Long-term energy scenarios and low-emission development strategies: Stocktaking and alignment*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jan/LTES-and-low-emission-development-strategies-Stocktaking-and-alignment

IRENA (2023g), *Agricultural residue-based bioenergy: Regional potential and scale-up strategies*, Abu Dhabi

IRENA (2023h), *Off-grid renewable energy statistics 2023*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/Publications/2023/Dec/Off-grid-Renewable-Energy-Statistics-2023

IRENA (2023i), *Renewable energy benefits: Leveraging local capacity for small-scale hydropower*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Sep/Renewable-energy-benefits-Leveraging-local-capacity-for-small-scale-hydropower

IRENA (2023j), *Renewable energy for remote communities: A guidebook for off-grid projects*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Nov/Renewable-energy-for-remote-communities-A-guidebook-for-off-grid-projects

IRENA (2023k), *Socio-economic footprint of the energy transition: South Africa*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Nov/Socio-economic-footprint-of-the-energy-transition-South-Africa

IRENA (2023l), Creating a global hydrogen market: Certification to enable trade, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jan/Creating-a-global-hydrogen-market-Certification-to-enable-trade

IRENA (2024a), *Small island developing states at a crossroads: The socio-economics of transitioning to renewables*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2024/Mar/SIDS-at-a-Crossroads-The-socio-economics-of-transitioning-to-renewables

IRENA (2024b), *Tripling renewable power by 2030: The role of the G7 in turning targets into action*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/Publications/2024/Apr/Tripling-renewable-power-by-2030-The-role-of-the-G7-in-turning-targets-into-action

IRENA (2024c), *Advancing renewables-based clean cooking solutions: Key messages and outcomes*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/Publications/2024/Mar/Advancing-renewables-based-clean-cooking-solutions-Key-messages-and-outcomes

IRENA (2024d), *Sustainable bioenergy pathways in Latin America: Promoting bioenergy investment and sustainability*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2024/Jan/Sustainable-bioenergy-pathways-in-Latin-America-Promoting-bioenergy-investment-and-sustainability

IRENA (2024e), *Small island developing states at a crossroads: Towards equitable energy access in least-electrified countries*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2024/Mar/SIDS-at-a-Crossroads-Towards-equitable-energy-access-in-least-electrified-countries

IRENA (2024f), *Small island developing states at a crossroads: The socio-economics of transitioning to renewables*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2024/Mar/SIDS-at-a-Crossroads-The-socio-economics-of-transitioning-to-renewables

IRENA (2024g), Decarbonising hard-to-abate sectors with renewables: Perspectives for the G7, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/Publications/2024/Apr/Decarbonising-hard-to-abate-sectors-with-renewables-Perspectives-for-the-G7

IRENA (n.d.a), "Renewable Energy Auctions", *International Renewable Energy Agency*, https://www.irena.org/Energy-Transition/Policy/Renewable-Energy-Auctions

IRENA (n.d.b), "National Energy Transition Planning Dashboard", *International Renewable Energy Agency*, www.irena.org/Energy-Transition/Planning/Long-term-energy-planning-support/National-Energy-Transition-Planning-Dashboard

IRENA (n.d.c), "Long-term energy scenarios (LTES) for developing national clean energy transition plans in Asia", *International Renewable Energy Agency*, https://www.irena.org/Events/2023/Aug/LTES-for-developing-national-clean-energy-transition-plans-in-Asia (accessed 19 August 2024).

IRENA (n.d.d), "National Energy Transition Planning Dashboard", https://www.irena.org/Energy-Transition/Planning/Long-term-energy-planning-support/National-Energy-Transition-Planning-Dashboard (accessed 19 August 2024).

IRENA (n.d.e), "Bioenergy and biofuels", *International Renewable Energy Agency*, https://www.irena.org/Energy-Transition/Technology/Bioenergy-and-biofuels

IRENA (forthcoming-a), *Long-term energy scenarios and low-emission development strategies: Alignment at country level*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jan/LTES-and-low-emission-development-strategies-Stocktaking-and-alignment

IRENA (forthcoming-b), *Just Energy Transitions for communities: Large-scale wind and solar projects in Sub-Saharan Africa*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications

IRENA and AfDB (2022), *Renewable energy market analysis: Africa and its regions*, International Renewable Energy Agency and African Development Bank, Abu Dhabi and Abidjan, www.irena.org/publications/2022/Jan/Renewable-Energy-Market-Analysis-Africa

IRENA and BNDES (2024), *Development banks and energy planning: Attracting private investment for the transition*, International Renewable Energy Agency and Brazilian Development Bank, Abu Dhabi, www.irena.org/publications/

IRENA Coalition for Action (2023), *Finding common ground for a just energy transition: Labour and employer perspectives*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Aug/Finding-common-ground-for-a-just-energy-transition-Labour-and-employer-perspectives

IRENA Coalition for Action (forthcoming), *Community energy benefits: Powering universal wellbeing*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/

IRENA, and CPI (2023), *Global landscape of renewable energy finance 2023*, International Renewable Energy Agency and Climate Policy Initiative, Abu Dhabi, www.irena.org/Publications/2023/Feb/Global-landscape-of-renewable-energy-finance-2023

IRENA and FAO (2021), *Renewable energy for agri-food systems: Towards the Sustainable Development Goals and the Paris Agreement*, IRENA and FAO, Rome, Italy, https://doi.org/10.4060/cb7433en

IRENA, IEA Bioenergy and FAO (2017), *Bioenergy for Sustainable Development*, IRENA, IEA Bioenergy and FAO, Abu Dhabi, https://www.ieabioenergy.com/wp-content/uploads/2017/01/BIOENERGY-AND-SUSTAINABLE-DEVELOPMENT-final-20170215.pdf

IRENA and ILO (2023), *Renewable energy and jobs: Annual review 2023*, International Renewable Energy Agency and International Labour Organization, Abu Dhabi, www.irena.org/Publications/2023/Sep/Renewable-energy-and-jobs-Annual-review-2023 (accessed 23 March 2022).

IRENA and Methanol Institute (2021), *Innovation outlook: Renewable methanol*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2021/Jan/Innovation-Outlook-Renewable-Methanol

IRENA, and SELCO Foundation (2022), *Fostering Livelihoods with Decentralised Renewable Energy: An Ecosystems Approach*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Livelihood_Decentralised_Renewables_2022.pdf

Jaramillo, M., *et al.* (2023), Data-to-Deal (D2D): Open Data and Modelling of Long Term Strategies to Financial Resource Mobilization – the case of Costa Rica, DOI-10.33774/coe-2023-sqbfm

JCAF (2021), "Jurisdiction Collective Action Forum (JCAF), Dialogue #1: The state of jurisdictional approaches in Southeast Asia"

JETP Indonesia (2023), "JETP Investment Plan Launched; Indonesian Government Aims for Swift Implementation", https://jetp-id.org/news/just-energy-transition-partnership-jetp-investment-plan-launched-indonesian-government-aims-for-swift-implementation

Johansson, V. (2023), "Just Transition as an Evolving Concept in International Climate Law", *Journal of Environmental Law*, vol. 35/2, pp. 229–49, https://doi.org/10.1093/jel/eqad017

Köppen, S., *et al.* (2022), "Linking bioenergy and the bioeconomy: The GBEP Sustainable Bioenergy Indicators and Sustainable Bioeconomy Indicators – Similarities, Differences and Perspectives for Convergence. A technical paper prepared as a contribution to the programme of work of the Global Bioenergy Partnership (GBEP). ifeu, Heidelberg", https://www.fao.org/3/cc7557en/cc7557en.pdf

Kruger, W., *et al.* (2019), "Namibia Country" Report 3: Energy and Economic Growth Research Programme, Power Futures Lab, University of Cape Town, https://gsb.uct.ac.za/files/Namibia_Country_Report.pdf

Kusuma, R. T., *et al.* (2022), "Sustainable transition towards biomass-based cement industry: A review", *Renewable and Sustainable Energy Reviews*, vol. 163, pp. 112503.

Le, L. (n.d.), "After renewables frenzy, Vietnam's solar energy goes to waste", *Al Jazeera*, https://www.aljazeera.com/economy/2022/5/18/after-renewables-push-vietnam-has-too-much-energy-to-handle (accessed 2 August 2024).

Linke, C. C. (2018), "Shortcomings of Brazil's Minha Casa, Minha Vida Programme", *URBANET*, https://www.urbanet.info/brazil-social-housing-shortcomings/

Morena, E., *et al.* (eds.) (2019), "The genealogy and contemporary politics of just transitions", *Just Transitions: Social Justice in the Shift Towards a Low-Carbon World*, Pluto Press, https://doi.org/10.2307/j.ctvs09qrx

Newell, P. (2021), "Power Shift: The Global Political Economy of Energy Transitions", Cambridge University Press.

OECD (2020), "Blended Finance in the Least Developed Countries 2020", *OECD*, https://www.oecd.org/en/publications/2020/12/blended-finance-in-the-least-developed-countries-2020_a314128d.html (accessed 15 August 2024).

OECD (2024), "Interest Rates: Long-Term Government Bond Yields: 10-Year: Main (Including Benchmark) for United States [IRLTLT01USM156N]", Retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/IRLTLT01USM156N, March 14, 2024, https://dx.doi.org/10.1787/data-00052-en

PBL (2019), *Trends in global CO_2 and total greenhouse gas emissions*, (p. 70), PBL Netherlands Environmental Assessment Agency, www.pbl.nl/sites/default/files/downloads/pbl-2020-trends-in-global-co2-and-total-greenhouse-gas-emissions-2019-report_4068.pdf (accessed 19 August 2024).

Power Futures Lab (2021), "Private Database" Graduate School of Business, University of Cape Town.

REN21 (2023), *Renewable Energy and Sustainability Report*, REN21, Paris, https://www.ren21.net/wp-content/uploads/2019/05/REN21-RESR-2023_LowRes.pdf

Rendón, J. R., *et al.* (2020), "Plan maestro de infraestructura de El Salvador: Un instrumento de planeación de infraestructura multisectorial a largo plazo que permitirá potenciar el desarrollo económico y social de El Salvador", *IDB Publications*, Inter-American Development Bank, https://doi.org/10.18235/0002141

RES4A *et al.* (2022), "Towards a prosperous and sustainable Africa: Maximising the socio-economic gains of Africa's energy transition", RES4Africa Foundation, Rome.

Reserve Bank of India (2023), "Reserve Bank of India – Press Releases", https://www.rbi.org.in/scripts/BS_PressReleaseDisplay.aspx?prid=55004 (accessed 20 August 2024).

Reuters (2023), "Brazil raises $2 billion in ESG sovereign bonds debut | Reuters", https://www.reuters.com/sustainability/sustainable-finance-reporting/brazil-prices-2-bln-first-ever-esg-bond-65-yield-source-2023-11-13/ (accessed 20 August 2024).

Reuters (2024), "India to remain on alert for 'hot money' after bond index inclusion – official", https://www.reuters.com/markets/rates-bonds/india-remain-alert-hot-money-after-bond-index-inclusion-official-2024-02-06/ (accessed 20 August 2024).

Rolf Wüstenhagen, *et al.* (2007), "Social acceptance of renewable energy innovation: An introduction to the concept", *Energy Policy*, vol. 35/5, pp. 2683–91.

Safarian, S. (2023), "To what extent could biochar replace coal and coke in steel industries?", *Fuel*, vol. 339, pp. 127401.

Scherhaufer, P. (2021), "The complex relations between justice and participation in collaborative planning processes for a renewable energy transition", *Routledge Handbook of Energy Democracy*, Routledge.

SEforAll (2020), *Energizing Finance: Missing the Mark 2020*, Sustainable Energy for All, Vienna, https://www.seforall.org/publications/energizing-finance-missing-the-mark-2020 (accessed 11 February 2022).

Shelton, R. E., and Eakin, H. (2022), "Who's fighting for justice? Advocacy in energy justice and just transition scholarship", *Environmental Research Letters*, vol. 17/6, pp. 063006, https://doi.org/10.1088/1748-9326/ac7341

SIFMA (2021), *Capital Markets Fact Book 2021*, Securities Industry and Financial Markets Association, https://www.sifma.org/resources/research/fact-book/

Sovereign Sustainable Finance (2023), *Brazil's Sovereign Sustainable Bond Framework*, https://sisweb.tesouro.gov.br/apex/f?p=2501:9::::9:P9_ID_PUBLICACAO_ANEXO:21043

UNCTAD (2023), *World Investment Report 2023*, https://unctad.org/system/files/official-document/wir2023_en.pdf

UNDP (2023), *Strengthening energy governance systems: An energy governance framework for a just energy transition*, (p. 29), United Nations Development Programme, www.undp.org/sites/g/files/zskgke326/files/2023-11/undp-strengthening-energy-governance-systems.pdf (accessed 19 August 2024).

UNFCCC (2023a), *Outcome of the first global stocktake*, revised advance version, No. FCCC/PA/CMA/2023/L.17; Draft decision CMA.5, United Nations Framework Convention on Climate Change, https://unfccc.int/sites/default/files/resource/cma2023_L17_adv.pdf

UNFCCC (2023b), "UAE Consensus", https://unfccc.int/cop28/outcomes (accessed 3 January 2024).

UNICEF (2023), *SDG 7: Affordable and Clean energy*, UNICEF, https://www.unicef.org/media/138096/file/SDG%207%202023%20rev.pdf

WAM (2023), "COP28 Presidency announces $4.5 billion UAE finance initiative to unlock Africa's clean energy potential", *Emirates News Agency*, https://www.wam.ae/en/details/1395303193442

WEF (2024), *Building trust through an equitable and inclusive energy transition*, White paper (p. 26), World Economic Forum, www3.weforum.org/docs/WEF_Building_Trust_through_an_Equitable_and_Inclusive_Energy_Transition_2024.pdf (accessed 19 August 2024).

WEF (n.d.), "Mato Grosso: reconciling production with preservation", https://www.weforum.org/forests-for-climate/mato-grosso-reconciling-production-with-preservation/

WHO, *et al.* (2023), *Energizing health: Accelerating electricity access in health-care facilities*, World Health Organization, Geneva, www.irena.org/Publications/2023/Jan/Energizing-health-accelerating-electricity-access-in-health-care-facilities

WMO (2024), "Climate change indicators reached record levels in 2023: WMO", *World Meteorological Organization*, wmo.int/news/media-centre/climate-change-indicators-reached-record-levels-2023-wmo (accessed 19 August 2024).

World Bank (2024), "World Development Indicators Database | GDP, PPP (constant 2017 international $)", *World Bank Open Data*, https://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD (accessed 29 May 2024).

WWF (n.d.), "Sabah: A Global Leader in Sustainable Palm Oil", Wolrdwide Fund for Nature, https://www.wwf.org.my/?28486/Sabah-A-Global-Leader-in-Sustainable-Palm-Oil

Zuiderveen, E. A. R., *et al.* (2023), "The potential of emerging bio-based products to reduce environmental impacts", *Nat Commun*, vols 14, 8521, https://doi.org/10.1038/s41467-023-43797-9

IRENA
International Renewable Energy Agency

www.irena.org