

A World Energy Transitions Outlook brief

TRACKING COP28 OUTCOMES

TRIPLING RENEWABLE POWER CAPACITY BY 2030



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The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. A global intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security, and low-carbon economic growth and prosperity.

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FOREWORD

COP28 was a watershed moment for the energy transition. The historic decision to transition away from fossil fuels, triple renewable power and double energy efficiency by 2030 is not only timely; it provides the only means available to align with a 1.5°C trajectory in line with IPCC findings. IRENA has long advocated this approach in its *World Energy Transitions Outlook* reports, and while the adoption of IRENA's 1.5°C Scenario pathway at COP28 represents a significant step forward, the world requires sober analysis of our progress to date and our priorities for the remaining years of the decade.

There is no time to waste; any delay simply magnifies the challenge. IRENA's annual monitoring of progress towards the 11 terawatts (TW) of renewable power capacity required by 2030 shows that the world is still falling short, with less than 480 gigawatts (GW) of new renewable power capacity deployed in 2023, compared to the required c. 1 000 GW. Consequently, that requirement is now climbing towards 1 100 GW of capacity additions each year for the remainder of the decade to keep 1.5°C within reach. Hence, the global energy transition remains clearly off track, and the urgency of a course correction increases. There are no 'magic bullets' or shortcuts available; global action must be focused, disciplined and aligned around key priorities.

First, we must overcome the structural and systemic barriers that impede progress by: modernising and expanding infrastructure; establishing regulatory frameworks and market design fit for the renewables era; and building institutional and human resource capabilities.

Second, we must speed up the deployment of all technologies in all geographies. Solar and wind continue to dominate renewables deployment, which remains concentrated in a limited number of markets. The vast majority of developing countries have been left out of the transition, despite their considerable energy requirements and abundant renewable potentials. Meanwhile, public finance is shrinking, underscoring the need for more strategic application and use.

We therefore require a 21st century architecture for international co-operation that ensures every actor plays their part in a global solution. Multilateral development banks and international financial institutions have a critical role to play, given the amount of capital that needs to be allocated to develop the infrastructure that will enable private investment.

We can no longer afford delays or generic statements, nor can we expect others to lead or take action. We have the knowledge, the technology and the means to correct our course; we are fully equipped to adjust the trajectory of the transition. This shift will not only reduce the carbon footprint of the global energy system but also pave the way to a more inclusive and equitable world. This brief serves as an invitation for all of us to do more - and to do it faster - under a new model of co-operation that ensures no one is left behind.



Francesco La Camera
Director-General, IRENA



KEY MESSAGES

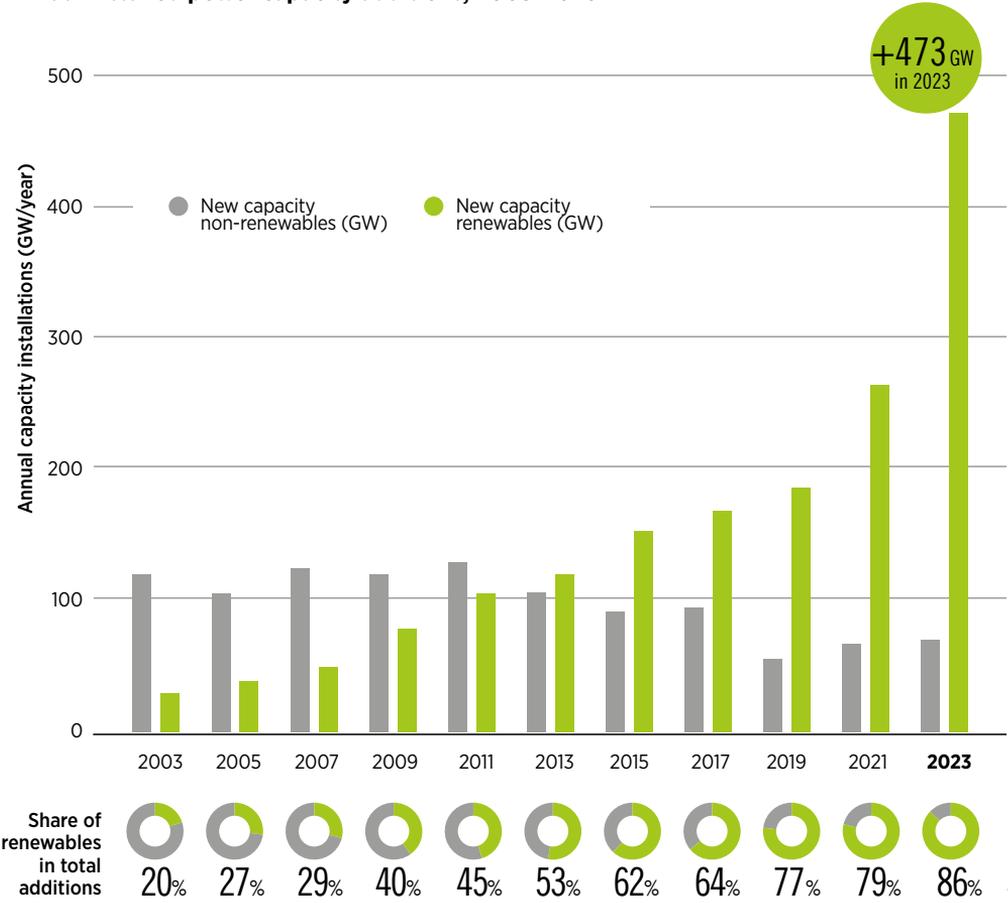
The COP28 Conference in the United Arab Emirates represented a landmark moment for global energy policy by pledging to transition away from fossil fuels, triple renewables and double energy efficiency by 2030. Collectively, more than 130 countries committed to radically transform the energy landscape by adopting IRENA's 1.5°C Scenario recommendation to triple installed renewable power capacity to at least 11 terawatts (TW) by 2030 and to double the energy efficiency improvement rate. This historic agreement brings a newfound urgency for policy makers, who must now implement the strategies and measures required to facilitate a rapid escalation in renewable energy deployment.

Accelerated deployment of renewable energy, coupled with energy efficiency measures, provides the most realistic means to reduce global emissions by 43% by 2030, in line with the findings of the Intergovernmental Panel on Climate Change (IPCC). While a diverse selection of technologies is essential to fully decarbonise the energy system by 2050, the urgency of the 2030 deadline reduces the options available. Only renewable power and energy efficiency measures can be scaled up quickly enough to meet this approaching milestone. To ensure long-term success, however, this accelerated deployment must be complemented by continuous innovation and development across a much broader suite of technologies.

Tripling renewable power capacity by 2030 is technically feasible and economically viable but requires commitment, policy support and investment at scale. IRENA's monitoring and analysis of renewable energy development and deployment has shown that the technological maturity achieved in the field of renewables - underpinned by enabling policies, competitiveness and widespread resources - has positioned the industry at the very heart of climate, development and energy security strategies. Since 2015, renewable power additions have consistently outpaced new fossil fuel and nuclear power installations combined, reaching an estimated 473 gigawatts (GW) in 2023 alone. However, tripling renewables globally will also require considerable progress elsewhere, including accelerated investments in infrastructure and system operation (e.g. power grids, storage); updated policies and regulations (e.g. power market design and regulation, streamlining permitting); measures to strengthen supply chains and develop transition-related skills; and a major scale-up of investment, including public funds supported by international collaboration.

Renewable power additions saw unprecedented growth in 2023, accounting for 87% of newly installed capacity.

Annual installed power capacity additions, 2003-2023



Note: GW = gigawatt.

The latest IRENA data indicates that 2023 set a new benchmark in renewable power deployment, adding 473 GW to the global energy mix, with solar energy accounting for 73% of this growth. New capacity was concentrated in China, the European Union (EU) and the United States, which collectively accounted for 83% of additions. China reached a new milestone in 2023, with 85% of its new capacity originating from renewable sources, driven by the decreasing costs of utility-scale solar and wind power, which are now competitive against coal and gas powered generation (The State Council, 2024). China's rapid progress in recent years can be attributed, in part, to its supportive energy and industrial policies. Elsewhere, amid the price spikes of the global energy crisis - which inspired significant utility-scale deployment - distributed (mostly rooftop) solar photovoltaic (PV) for residential and commercial systems saw record growth in several countries, including Australia, France, Germany, India, the United States and the United Kingdom.

Conducive policies, together with geopolitical developments and falling costs, have catalysed rapid renewable energy growth in the world's fastest-expanding markets. The EU experienced an extraordinary surge in renewable energy deployment, driven by enhanced policy focus, heightened energy security concerns and the increasing cost-competitiveness of renewables compared to their fossil fuel counterparts. This has led to a 37% increase in solar PV capacity since 2022 (+56 GW) and an additional 17 GW in wind power compared to the previous year (Ember, 2024). In the United States, the 2022 Inflation Reduction Act has been driving investment in renewables through a range of tax credits. Similar examples can be seen in all rapidly-expanding markets, demonstrating the critical role of government intervention in the deployment of renewables.

 Policies, falling costs and geopolitics are key drivers of the rapid expansion of renewable power.



TRACKING PROGRESS

Despite record renewable power capacity additions, progress in the energy transition is insufficient and its trajectory is markedly off course. IRENA's 1.5°C Scenario, a key element in the underlying intellectual framework of the Agency's *World Energy Transitions Outlook*, shows that nothing short of a systemic, comprehensive transformation of the energy system is required across all sectors (IRENA, 2023a). The latest data show inadequate progress, especially in relation to the tripling of renewable power capacity by 2030, the development of electric vehicles, electrolyser capacity for green hydrogen production and the scaling up of investments in renewable power generation, grids and flexibility (Table 1).

Consolidated global figures conceal ongoing patterns of concentration in both geography and technology. These patterns threaten to exacerbate the decarbonisation divide and pose a significant barrier to achieving the tripling target. The deployment trend established over the past two decades endures, primarily focused in China, the EU and the United States. This concentration means that many countries in the developing world continue to miss out on the opportunities renewables offer in overcoming development and energy access challenges, particularly in Sub-Saharan Africa where 567 million people were still without electricity access in 2021 (IEA *et al.*, 2023). Furthermore, to meet the tripling target, it is essential that all forms of renewable energy and their associated technologies be leveraged.

The world's ability to achieve the tripling target is far from assured, as an additional 7.2 TW of renewable power must be deployed to reach the required 11 TW by 2030. Global data indicates positive trends in renewable power expansion and the record annual deployment of 473 GW in 2023 is timely. However, current projections for the coming seven years suggest we will miss the tripling target without urgent policy interventions. Under IRENA's 1.5°C Scenario, the Group of 20 (G20) alone would need to grow its renewable power capacity from less than 3 TW in 2022 to 9.4 TW by 2030, accounting for more than 80% of the global total. The commitments made as of October 2023 in Nationally Determined Contributions (NDCs) to the Paris Agreement are less than half of that required to deliver on the global commitment to triple renewable power capacity, whilst those made in national energy plans and policies fall short by some 30%.

Progress in transport electrification in 2023 fell short of the required pace. Road transport is the subsector with the highest potential for electrification; under IRENA's 1.5°C Scenario, the electrification rate in the global transport sector would rise to almost 7% by 2030. Successful launches of new EV models, financial incentives and improving charging infrastructure have been strong drivers; yet the current battery electric vehicle (BEV) and plug-in hybrid electric vehicle (PHEV) stock would need to increase from around 40 million today to 360 million by 2030, a target that cannot be achieved at current growth rates.

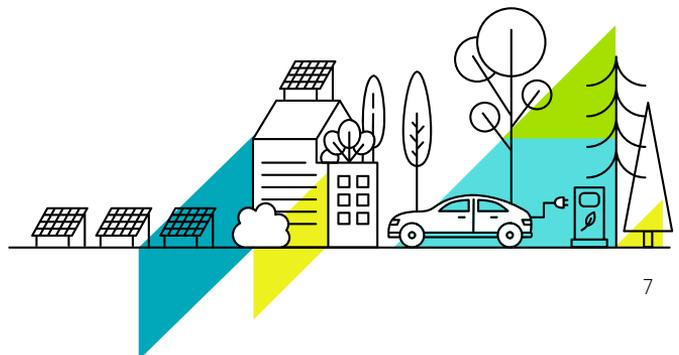


TABLE 1 Tracking COP28 outcomes: Tripling renewable power capacity by 2030

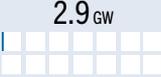
Tripling renewable power capacity: Key Indicators		2023 ¹⁾	2030 (1.5°C Scenario)	On track
RENEWABLES	Total installed renewable capacity	3870 GW	11 174 GW	✓
	Renewables share in installed capacity	43%	77%	✓
	Renewable energy share in generation	28% ²⁾	68%	✓

+		2023 ¹⁾	2024-2030 (1.5°C Scenario)	On track
RENEWABLE CAPACITY ADDITIONS	Renewable power capacity additions	473 GW	1 043 GW/yr	✓
	Annual solar PV additions	346 GW	578 GW/yr	✓
	Annual wind energy additions	116 GW	360 GW/yr	✓
	Annual hydropower additions	7 GW	28 GW/yr	✓
	Annual bioenergy power additions	4 GW	28 GW/yr	✓
	Annual geothermal power additions	0.2 GW	13 GW/yr	✓
	Annual ocean energy power additions	0.002 GW	10 GW/yr	✓

▶ continued

TRACKING COP28 OUTCOMES
TRIPLING RENEWABLE POWER CAPACITY BY 2030

TABLE 1 Tracking COP28 outcomes: Tripling renewable power capacity by 2030

Additional Indicators		2023	2030 (1.5°C Scenario)	On track
INDICATORS	Electric and plug-in hybrid light passenger vehicles stock	 40 million ³⁾	 360 million	
	Electrolyser capacity stock	2.9 GW ⁴⁾ 	428 GW 	

Additional Indicators ⁵⁾		2023	2024-2030 (1.5°C Scenario)	On track
FINANCE AND INVESTMENT	Investment in renewable power generation capacity ⁶⁾	 570 USD billion	 1550 USD billion/yr	
	Investment in power grids and flexibility ⁷⁾	 368 USD billion ⁸⁾	 720 USD billion/yr	

Notes: [1] Estimation based on (IRENA, 2024); [2] data for 2022 (IRENA, 2023b); [3] estimation based on (IEA, 2023b); [4] estimation based on (IEA, 2023c, 2023d); [5] US GDP deflator as a proxy for economy-wide inflation based on (IMF, 2023); [6] IRENA estimation as of March 2024; [7] includes investments in transmission and distribution networks, smart meters, battery storage and pumped hydro; [8] estimation based on (IEA, 2023e); GW = gigawatt; yr = year; PV = photovoltaic.

Heat pump sales, essential for decarbonisation of the heating sector, are showing signs of a slow-down. Sales of heat pumps grew by 11% globally in 2022 - notably in Europe, where they increased 38%, partly driven by energy security concerns. However, preliminary data shows that heat pump sales decreased in most European markets in 2023, where sales fell by around 5% in 2023 compared to 2022. The decline in sales from 2.77 million to 2.64 million was the first decline of the past decade (Azau, 2024). While sales still saw a significant increase in Germany, they dropped in Poland - one of the fastest growing heat pump markets globally in 2022. Global sales of heat pumps decreased by 3% while China was the sole major market to see a strong 12% increase, fuelled by the lifting of COVID-19 restrictions on consumer activity (IEA, 2024).

Tripling installed renewable power capacity by 2030 requires a parallel commitment to significantly increase electricity storage capacities. Implementing a battery storage system is crucial to achieving flexible and resilient power systems. In 2022, global total capacity of grid-scale battery storage reached 28 GW, marking a 75% increase compared to 2021, with China and the United States accounting for the majority of capacity additions (IEA, 2023a). Some major economies are promoting the deployment of battery storage through financial incentives, subsidies, targets and funds for research and development. Pumped hydro storage is also a well-established, economic feasible and validated technology; by 2023, global total installed pumped hydro storage capacity reached 140 GW¹.

The renewables industry currently faces significant challenges. Rising financing costs, supply chain issues - bottlenecks for some technologies and market oversupply in others - and other barriers are broadly affecting the industry. The wind sector, especially, has faced setbacks due to auctions continuing to focus too narrowly on price reduction and thereby missing opportunities to fortify supply chains, increase resilience against price fluctuations and reduce wholesale electricity supply costs with renewable power that is cheaper than fossil fuels. This is most pronounced in the offshore wind sector, which is yet to achieve full competitiveness with other renewables and still depends on government to develop robust, competitive regional supply chains. Policy makers must address these new challenges head on. The UK government, for example, has responded by increasing the maximum strike price for offshore wind in its contract-for-difference auctions, following a round where no bids were received (UK Government, 2023).

Meanwhile, government support and investment trends must change rapidly in light of the commitment made at COP28 to transition away from fossil fuels. A key requirement under IRENA's 1.5°C Scenario is that increased renewable energy use must be coupled with a corresponding decline in fossil fuel reliance. Both aspects are lagging. In 2022, fossil fuels received USD 1.3 trillion in subsidies (Black *et al.*, 2023) - the equivalent annual investment needed in renewable generation capacity to achieve a three-fold increase by 2030. Planned new oil- and gas-fired power capacity increased by 13% in 2022 (Martos and Joly, 2023), whilst the United States set a new global oil production record for the sixth year in a row in 2023 (EIA, 2024). G20 members alone provided a record USD 1.4 trillion in public funds to support fossil fuels in 2022, including fossil fuel subsidies (USD 1 trillion), investments by state-owned enterprises (USD 322 billion), and lending from public financial institutions (USD 50 billion). This more than doubles the pre-COVID-19 and pre-energy crisis levels of 2019 (Laan *et al.*, 2023).

¹ Estimation based on (IRENA, 2024).

OVERCOMING BARRIERS TO THE ENERGY TRANSITION

A systemic global energy transition is required to overcome structural barriers impeding progress.

Key enablers include the establishment of supporting infrastructure, robust policy frameworks and the development of institutional and human capacities, backed by scaled-up financing and strong international co-operation. A tripling of renewable energy capacity will require conditions conducive to accelerated progress, as numerous obstacles persist, particularly in terms of physical infrastructure, policies and regulations, and skills development. Action is therefore needed to:

- **Modernise and expand infrastructure.** Lagging infrastructure development, inefficiencies in grid systems and slow permitting procedures represent significant hindrances in certain markets, impeding the energy transition. In the power sector, the mismatch between grid capabilities and the rapid deployment of variable renewables is leading to increased curtailment of wind and solar PV. Grid reinforcements, storage capacities, digitalisation and smart solutions are all lagging behind the pace required to foster variable renewable energy deployment. Critically, prioritising the expansion of grids in emerging and developing markets is crucial to unlocking untapped renewable potential and facilitating green industrialisation and development priorities.
- **Adapt policies and regulations.** Siloed policy making also continues to hinder the systemic shifts required in energy policy and planning. Particularly, enhancements are required in the energy sector's legal and regulatory frameworks. These reforms should prioritise the expansion of renewables and the integration of variable renewables in the power sector; the promotion of sector coupling solutions; the implementation of innovative strategies to enhance flexibility and electricity storage capacities; and the strengthening of measures to support the direct use of renewables in end-use sectors. Fossil fuel cost inflation in 2022 was an order of magnitude higher than for renewable power, but challenges in supply chains, rising commodity and financing costs all impacted long-lead time projects disproportionately (especially for offshore wind). Policy makers now need to adapt support mechanisms to the new reality, wherein the economic benefits of renewable power have increased dramatically. Current frameworks are still built around driving down costs, and policy considerations therefore must now adopt a focus on the economic benefits associated with renewables.

- **Develop a skilled workforce.** The expansion of renewables and energy transition-related solutions requires concurrent efforts to expand the workforce. This entails forecasting evolving needs and aligning them with the education sector, so as to avoid significant skills gaps. Matching supply and demand for skills may require proactive government co-ordination. Building an adequate future workforce involves the training and preparation of new labour market entrants; the upskilling and reskilling of existing workers; and support to assist workers in acquiring the necessary – and sometimes costly – certifications and re-orienting their careers. Many countries are already facing shortages in tradespeople such as electricians and grid engineers. The same applies to the workforce responsible for overseeing the energy sector – policy makers, energy planners, regulators and system operators – which is facing mounting pressure to enhance its understanding and integration of energy transition elements into roles and processes. This situation also offers a strategic opportunity to create new jobs and economic activities, most notably in countries with growing, young populations.
- **Scale up financing dramatically, backed by intensified international collaboration.** Renewable energy investments are mainly reliant on private capital and policies that focus on mobilising private capital. This means that the higher the risks (real or perceived), the higher the costs; hence the lowest income populations pay the highest costs for often basic energy needs, directly undermining the universal energy access target of the United Nations' Sustainable Development Goal 7 (SDG7). International collaboration is essential to strengthen global finance flows, capacities and technologies in an equitable manner; albeit the exact measures that are needed to overcome these barriers will vary by country and region.



Developing countries (excl. China) received only 14% of global energy transition investments in 2023.

ENERGY TRANSITION URGENT ACTIONS



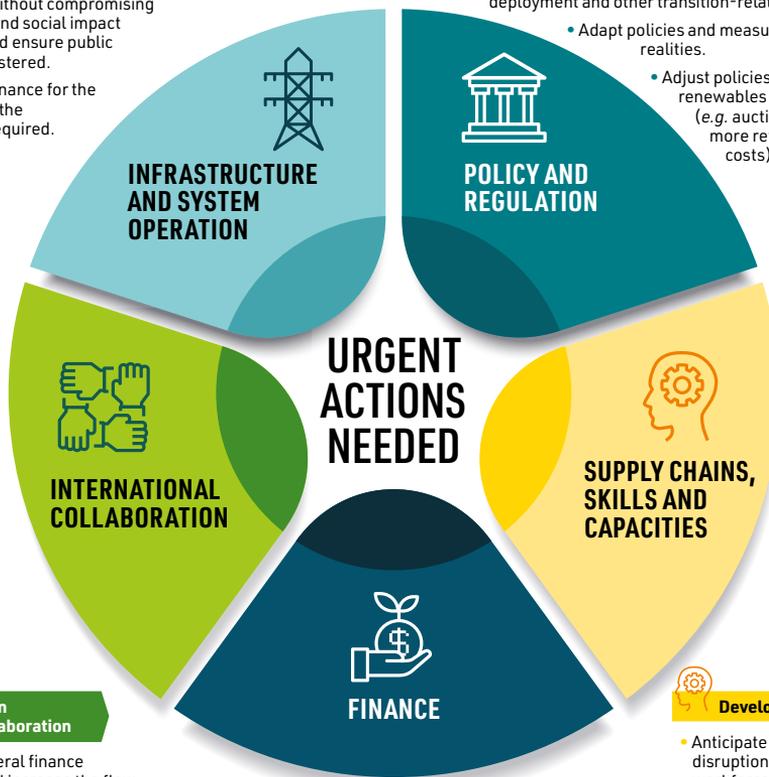
Modernise and expand infrastructure

- Provide incentives for infrastructure investments where market barriers exist.
- Streamline permitting procedures for large-scale infrastructure without compromising environmental and social impact assessments and ensure public acceptance is fostered.
- Provide public finance for the development of the infrastructure required.



Adapt policies and regulations

- Place the energy transition at the core of national economic/development strategies.
- Align sector/cross-sector policies to promote renewable deployment and other transition-related solutions.
 - Adapt policies and measures to market realities.
 - Adjust policies to support renewables industry (e.g. auction ceiling prices more reflective of true costs).



Strengthen international collaboration

- Reform multilateral finance mechanisms and increase the flow of international public funds and low-cost finance.
- Prioritise fair and equitable development in the Global South; support policies for industrialisation and local value creation.
- Support the development of institutional and human capacity through sharing knowledge and experience.



Scale-up and expand the distribution of financing

- Increase the strategic use of public funds.
- Implement policies that support the financial viability of projects, leveraging public and private capital.
- Implement risk mitigation strategies and explore innovative solutions such as blended finance.



Develop a skilled workforce

- Anticipate labour market disruptions and address workforce gaps.
- Prepare new labour market entrants; upskill and reskill existing workers.
- Allocate greater resources and training to energy sector governance (e.g. policy makers, energy planners, regulators).

ENHANCING INTERNATIONAL COLLABORATION AND FINANCE

Scaling up finance for developing countries is a key priority. Despite the significant environmental and socio-economic benefits that the energy transition can bring for emerging market and developing economies (EMDEs),¹ they have received disproportionately low levels of investment. In 2023, energy transition-related investments are estimated to have exceeded USD 2 trillion² (BNEF, 2024; IEA, 2023e), with EMDEs accounting for just over half of global investments. EMDEs excluding China, however, accounted for just 14% of global investments; and when Brazil and India are excluded, EMDEs accounted for only 10% of global investments. On a per capita basis, advanced economies (comprising 38 countries and making up 14% of the world's population) attracted five times more investment per capita than the 154 EMDEs (excluding China) that make up two-third of the world's population. When it comes to renewable energy, in 2022, 120 developing nations attracted only 15% of global investment.

Sub-Saharan Africa receives the least investment in renewables, although it is home to around 567 million people who still lacked access to electricity in 2021. Access rates in 23 African countries is below 50%, and 923 million people continued to cook with only basic stoves and traditional fuels in 2020 (IEA *et al.*, 2023). Sub-Saharan Africa received less than 1.5% of the USD 2.8 trillion invested in renewable energy projects globally between 2000 and 2020 (IRENA and AfDB, 2022) and its share fell further to less than 1% of the global total, as investments dropped from USD 5.3 billion in 2019 to less than USD 3.6 billion in 2022. This is despite the world emerging from the COVID-19 pandemic having witnessed the critical role energy plays in enabling health care, sanitation and resilient livelihoods (IRENA and CPI, 2023).

In many developing countries, renewable project developers face very high capital costs, owing to both real and perceived risks. For example, renewable energy projects in Brazil, India, Indonesia, Mexico and South Africa had a weighted average cost of capital (WACC)³ of 3.6-7.2% (real, post-tax) in the period 2021-2022, which, depending on the country, is up to five times higher than the WACC in China and advanced economies (IRENA, 2023c). Countries in Sub-Saharan Africa face some of the highest costs of finance in the world (IRENA, 2023d), demonstrating the need for further international collaboration including engagement of multilateral development banks and an increased role for public finance. These challenges should be viewed against the backdrop of the competitiveness of solar PV and onshore wind. Whilst these sectors have experienced relatively modest cost inflation, this was more than offset by the soaring cost of fossil fuels in 2022. Expectations that fossil fuel prices - notably for fossil gas - will remain above pre-pandemic levels, further underscore the economic advantage of these renewable sources for developing countries, many of which have severely constrained budgets.

¹ As defined and classified by the International Monetary Fund.

² Including investments in renewable energy, power grids, electrified heat, electrified transport, hydrogen, carbon, capture and storage (CCS) and energy storage from (BNEF, 2024) and energy efficiency investments from (IEA, 2023e)

³ The weighted average cost of capital (WACC) for a specific project or business is typically used to calculate the cost of electricity for that project or business, but actual returns may be above or below this value.

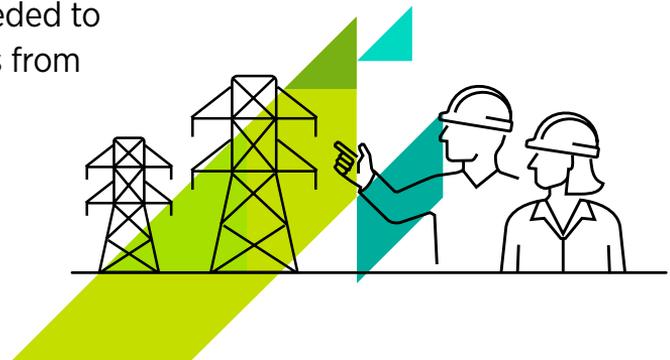
Structural changes, notably the reform of multilateral finance mechanisms, are essential to effectively support energy transition efforts and local value creation in developing countries. Increased international support to developing countries is vital, as they face specific challenges such as the prohibitively high cost of capital and their inability to attract private investment. The strategic use of public finance will be essential to attract investment at scale to deliver inclusive energy transitions that bring socio-economic benefits to all. International co-operation is required on many fronts:

Scaling up and broadening access to low-cost finance. This entails increasing the number of projects that receive financing and ensuring policies make these projects financially viable, leveraging both public and private capital, implementing risk mitigation strategies and exploring innovative solutions such as blended finance.

Developing renewable energy supply chains where these add economic value. Prioritising fair and equitable development in the Global South is essential. This includes support for industrialisation policies; the diversification of manufacturing, minerals and hydrogen value chains; and modern bioenergy and synfuels.

Enhancing institutional and human capacities. Regional and country-specific energy transition roadmaps are required to harness indigenous resources and support local value creation. Efforts should also focus on expanding and training a skilled workforce, including policy makers, regulators and those involved in permitting processes, across sectors and government ministries.

 Greater international collaborative effort is needed to ensure everyone benefits from the energy transition.



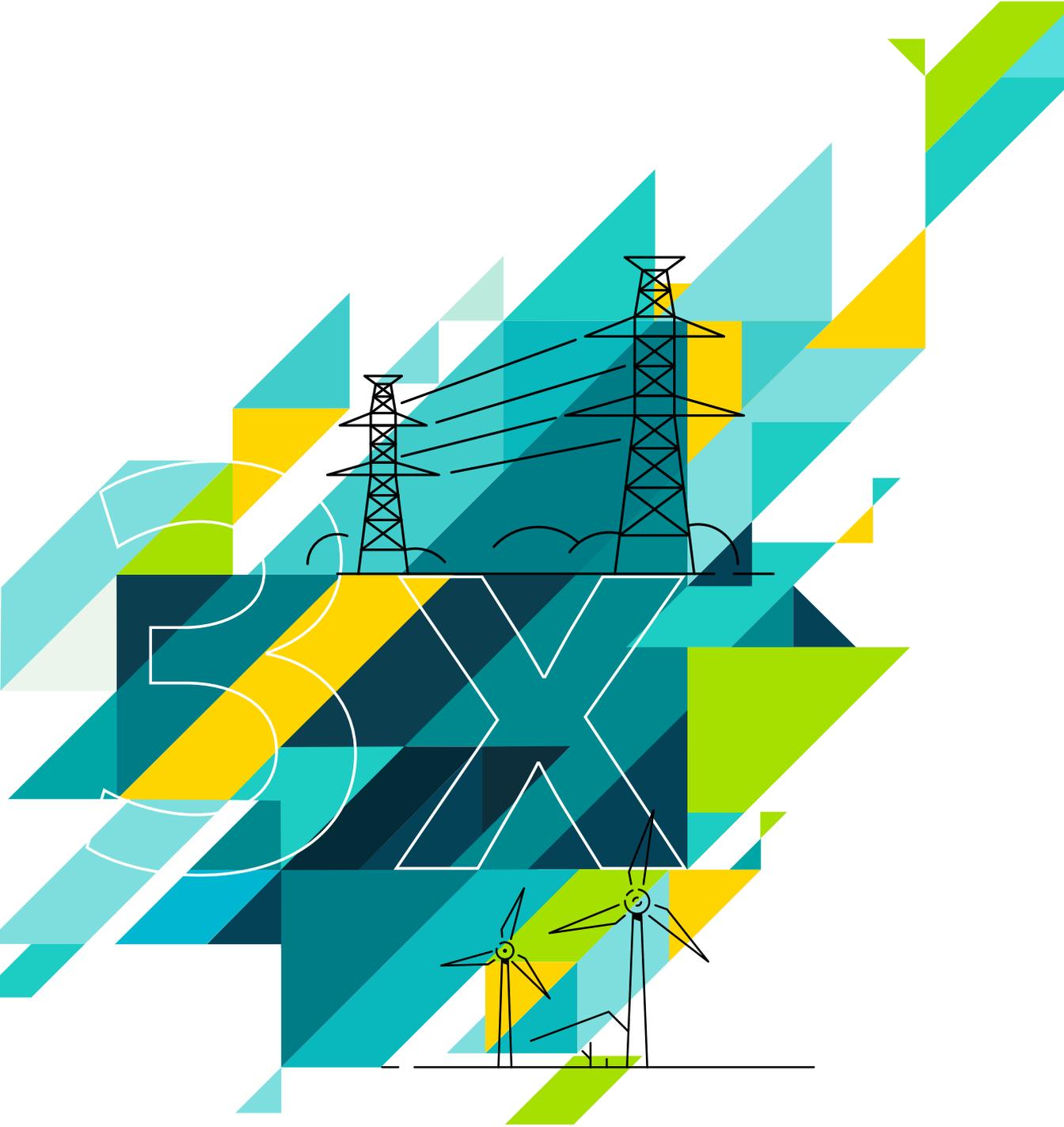
TRANSITIONING AWAY FROM FOSSIL FUELS

Countries that are considering fossil fuel production expansions must weigh the risks of this strategy in light of global shifts towards renewable energy sources. Fossil fuels hold significant economic importance in producing countries. This includes nations that have built their wealth on these resources, as well as emerging fossil fuel producers. The critical issue lies in predicting the rate of decline in fossil fuel markets and identifying which resources and stakeholders will remain competitive. Understanding the potential economic and political consequences is critical, as is considering the long-term sustainability and return on such investments. Equally important are strategies to ensure a just transition, especially for communities and economies heavily dependent on fossil fuels.

The shift away from fossil fuels towards renewable energy will unfold over time, but for certain sectors and countries, this shift can occur swiftly. According to IRENA's 1.5°C Scenario, oil consumption is projected to decrease by around 8% by 2030 compared to 2021, while the share of natural gas in total final energy consumption will reduce from 16% in 2021 to less than 10% in 2030. It is therefore crucial that countries and companies plan for the diversification of their economies and businesses now. The transport sector is already experiencing significant changes, notably in the electrification of road transport. Although growth lags behind that required under the IRENA 1.5°C Scenario, electric vehicle sales have surged, comprising nearly 20% of total vehicle sales in 2023 (IEA, 2023b), whilst the biofuels market also continues to grow. Oil companies must act swiftly to adapt to these changes. This involves accelerating their own transition by diversifying investments and significantly increasing their commitment to renewable energy sources (Asmelash and Gorini, 2021). Such proactive measures are essential for these companies to remain viable and competitive in an evolving energy landscape.

Policy makers play a crucial role in supporting the shift to renewable energy by adapting market structures, eliminating distorting fossil fuel subsidies and establishing effective carbon pricing mechanisms. Today's power systems, structured around large, centralised and dispatchable power plants, require a holistic approach to address all key aspects - from technology and economy to society and the environment. Accelerating the transition requires changes in many aspects of electricity markets, including the adaptation of their design and operation to support higher shares of variable renewables - namely solar and wind energy - as well as distributed power generation (IRENA, 2022). Although there has been progress in the adoption of carbon pricing, as indicated by the World Bank, these initiatives covered only 23% of global greenhouse gas (GHG) emissions in 2023 (World Bank, 2023), highlighting the substantial work still required. The expansion of carbon pricing regimes and the reduction of fossil fuel subsidies are therefore key topics for policy makers and the global agenda, as they would help reduce barriers and accelerate market-driven solutions for the energy transition aligned with global climate goals - albeit also ensuring reforms do not entail negative socio-economic impacts, especially for the most vulnerable populations.

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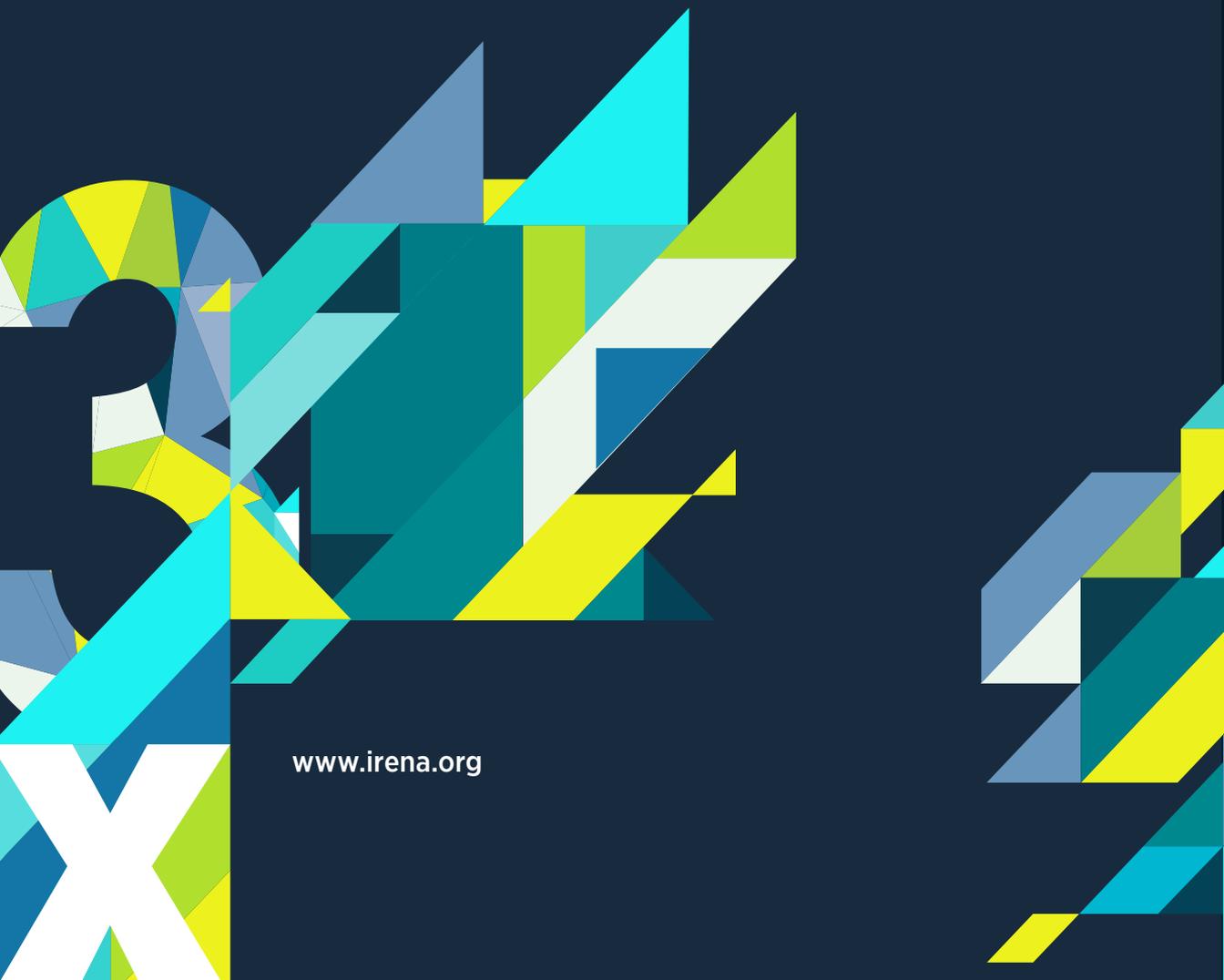
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