

TRIPLING RENEWABLE POWER AND DOUBLING ENERGY EFFICIENCY BY 2030 CRUCIAL STEPS TOWARDS 1.5°C



PREFACE

Since the Rio Earth Summit and the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, the Conference of the Parties to the Convention (COP) has convened signatory Parties each year to determine ambitions and responsibilities, and identify and assess the progress of climate measures. The 21st session of the COP (COP21) led to the Paris Agreement, which mobilised collective action to limit the increase in global average temperature to well below 2°C above pre-industrial levels, pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, and strengthen the global response to the threat of climate change.

COP28, and the first Global Stocktake of the Paris Agreement, can be the turning point on climate action over this critical decade to accelerate a transition that puts economies on the path toward a new low-carbon, high-growth, sustainable economic model in a way that is both transformational and just. COP28 has the vision to deliver on the pillars of the Paris Agreement, focusing on specific action on four paradigm shifts:

- fast-tracking the energy transition and slashing emissions before 2030;
- transforming climate finance, by delivering on old promises and setting the framework for a new deal on finance;
- putting nature, people, lives and livelihoods at the heart of climate action; and
- mobilising for the most inclusive COP ever.



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The International Renewable Energy Agency (IRENA) is an intergovernmental organisation, comprising 168 Member States and the European Union, that supports countries in their transition to a sustainable energy future. IRENA serves as a centre of excellence; a repository of policy, technology, resource and financial knowledge; and the principal platform for international co-operation 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 a global energy transition that delivers sustainable development, energy access, energy security and low-carbon economic growth and prosperity. www.irena.org



The Global Renewables Alliance (GRA) represents the leading international industry associations across renewable energy and serves as a unified renewable energy voice on a global scale. The alliance was established in 2022 and comprises founding members, the Global Wind Energy Council, the Global Solar Council, the International Hydropower Association, the International Geothermal Association, the Long Duration Energy Storage Council and the Green Hydrogen Organisation.

The GRA's mission is to increase ambition and accelerate the uptake of renewable energy across the world, in line with a credible 1.5°C pathway. As such, it collaborates and communicates with governments, investors, civil society and other key stakeholders on collective actions which can enable the broad scale-up of renewable energy. While each country and region will adopt a nationally determined approach to the energy transition, the GRA advocates for the acceleration of wind, solar, hydro and geothermal power, and essential technologies like long-duration storage and green hydrogen. This will ensure that future global energy systems are not only clean, but secure and just. www.globalrenewablesalliance.org/



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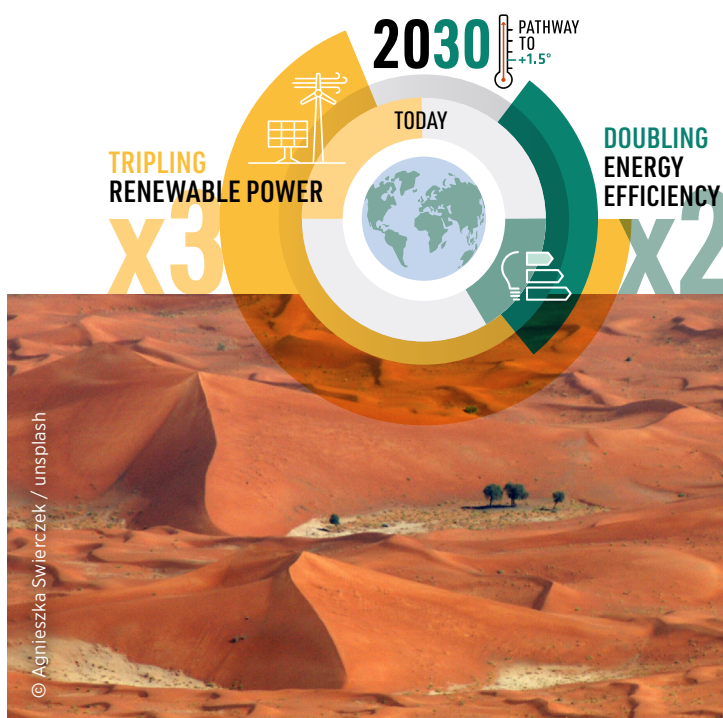
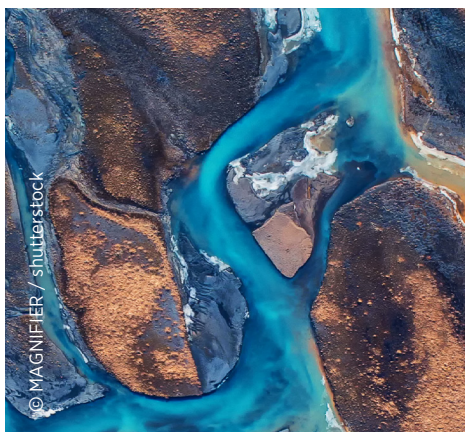
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PATHWAY TO  **+1.5°**



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FOREWORDS

Dr Sultan Al Jaber
COP28 President-Designate

Tripling the deployment of renewable power generation and doubling energy efficiency are amongst the most important levers to cut greenhouse gas emissions.

The world has already made great strides by expanding global renewable energy capacity and becoming more energy efficient; but progress so far has been too slow.

The Global Stocktake has told us exactly how far off track we are. We need to cut 22 gigatonnes of greenhouse gases in the next 7 years in order to keep 1.5°C within reach.

The phase-down of fossil fuels is inevitable and essential, but it must be responsible. To deliver a just and orderly energy transition while advancing socio-economic development and ensuring energy affordability, reliability and sustainability, we must rapidly accelerate our efforts to ramp up renewable energy. Now is the time to turbocharge solutions and meet the urgency of the moment with ambitious and determined action.

Ahead of COP28, we are building global momentum and consensus in support of our target to triple global renewable power generation and double energy efficiency.

This report outlines actionable solutions that can enable the progress we need and demonstrates that this target is ambitious but achievable.

I am now calling on everyone to come together, commit to common targets, and take comprehensive domestic and international action, as outlined in this report, to make our ambitions a reality.



Francesco La Camera

Director-General, International Renewable Energy Agency

Our mission is as clear as it is urgent: to keep the 1.5°C target within reach, we must triple renewable power capacity and double energy efficiency by 2030. IRENA's *World Energy Transitions Outlook*, which provides the analytical foundation for this report, warns that the energy transition is dangerously off-track, demanding immediate, radical collective action.

A significant acceleration of renewable energy deployment, coupled with tangible progress in energy efficiency and end-use electrification, is essential to put the world back on track to achieve the goals of the Paris Agreement. This will require concerted action to urgently address deeply entrenched systemic barriers across infrastructure, policy and institutional capacities stemming from systems and structures created for the fossil-fuel era.

We must now focus on building the necessary infrastructure and investing at scale in grids to accommodate a growing share of renewable energy; establish policy and regulatory architecture that can facilitate targeted public and private sector investments in the energy transition; and strategically realign institutional capacities to help ensure skills and capabilities match the energy system of the future. This is especially important for developing countries, where we must deliver on our commitments to sustainable development, ensuring no one is left behind.

COP28 marks the year of the first Global Stocktake, in which the world reflects on its progress in implementing the Paris Agreement. It is vital that collective action be galvanised following this key milestone in our journey toward a climate-safe existence to ensure the forthcoming round of Nationally Determined Contributions in 2025 represents a transformative leap forward, realigning us with the 1.5°C goal. This report outlines the essential actions governments must prioritise to achieve this objective.



Bruce Douglas
Chief Executive Officer, Global Renewables Alliance

This is the 'make or break' decade to avoid the most catastrophic impacts of climate change. A global energy transition that accelerates renewable energy and phases out fossil fuels is the only way to build a clean, secure and just future.

Double down, triple up: Tripling global renewable energy capacity and doubling energy efficiency rates by 2030 are the most impactful commitments we can undertake now to achieve a 1.5°C pathway. This would deliver cleaner electricity systems, access to affordable energy and green jobs for millions of people, billions of dollars in public and private capital to foster climate-resilient growth, and reduce loss and damage for nature and people wrought by harmful climate change.

To achieve these targets, we need to dramatically ramp up wind power, solar power, hydropower and geothermal power. This would set the stage to scale long-duration energy storage and green hydrogen, ensuring energy systems are not just clean, but secure and resilient. On average, 1 000 GW of renewables needs to be installed each year for the rest of the decade to bring total renewables capacity to 11 000 GW by 2030. As the growth curve will rise over the course of the decade, the renewables industry believes at least 1 500 GW of renewables capacity could be installed in 2030 alone.

Global leaders must commit to these targets at COP28. However, progress towards 2030 goals cannot be taken for granted. Policy makers must work hand-in-hand with industry and civil society to urgently implement the enabling actions in this report, centred on: infrastructure and system operation; policy and regulation; and supply chains, skills and capacities. Critically, these areas must be reinforced by low-cost financing and international collaboration.

This is a unique "once in a generation" opportunity, but we need urgent action to scale renewable energy in every region of the world. Only then can we protect the planet and secure a liveable future for all.



KEY RECOMMENDATIONS

TOTAL GLOBAL RENEWABLE POWER GENERATION CAPACITY WILL NEED TO TRIPLE BY 2030 to reach more than 11 000 GW under IRENA's 1.5°C Scenario in the *World Energy Transitions Outlook*, with solar photovoltaic (PV) and wind power accounting for about 90% of renewable energy capacity additions.

ENERGY EFFICIENCY IMPROVEMENTS MUST DOUBLE BY 2030 TO REMAIN ON A 1.5°C PATHWAY. In IRENA's 1.5°C Scenario this will be driven by a combination of efficient technologies in end-use sectors and extensive electrification. These vital milestones must be achieved to keep the global energy transition on track to meet Paris Agreement goals.

A COMPREHENSIVE MIX OF POLICIES IS NEEDED TO ACHIEVE THESE AMBITIOUS TARGETS. Aside from deployment and enabling policies, structural change is needed to ensure the transition to an energy-efficient economy and a renewables-based power system is just and fair, and provides benefits for all.

ENERGY EFFICIENCY POLICY MEASURES should include: the adoption of targets with specific time horizons; strong regulatory frameworks including building codes and energy efficiency standards for appliances; fiscal and financial incentives; and public campaigns to build awareness of the role of energy efficiency measures, public transport and green mobility for cost savings and collective decarbonisation goals.

RENEWABLE ENERGY DEPLOYMENT REQUIRES ENABLING MEASURES THAT GO BEYOND REGULATIONS OR FISCAL AND FINANCIAL INCENTIVES.

The organisational structures of power sectors must be reshaped to integrate a higher share of renewables. Procurement mechanisms must be designed in a way that strengthens value chains and trade, and industrial policies must be fit for building resilient supply chains. Education, training, re-skilling and up-skilling should be prioritised; women and under-represented groups must be empowered; and collaboration between industry, civil society, policy makers and other key stakeholders should be encouraged.

EXISTING ELECTRICITY INFRASTRUCTURE SHOULD BE EXPANDED AND MODERNISED TO CREATE A NEW ENERGY SYSTEM FIT FOR RENEWABLES.

There is an urgent need to boost cross-sector infrastructure planning, increase cross-border co-operation and develop regional power grids. Action is also needed to drive grid modernisation and expansion and ensure supply-side flexibility and demand-side management.

RENEWABLE POWER CAPACITY SHOULD BE INCREASED MORE RAPIDLY IN DEVELOPING COUNTRIES,

given their growing electricity demand and the important role of renewables in addressing the significant energy access deficit in these countries.

WE MUST RAPIDLY MOBILISE PUBLIC AND PRIVATE FINANCE TO TRIPLE RENEWABLE POWER CAPACITY AND DOUBLE ENERGY EFFICIENCY.

Annual average investment in renewable power generation must reach USD 1 300 billion by 2030, compared to 486 billion in 2022. In the developing world, we must minimise investment risks and provide access to low-cost financing. The global financial architecture must be reformed to support the energy transition in the Global South. Climate-related funding from multilateral development banks must be ramped up, and public capital should be redirected from the fossil fuels sector to renewable energy.

THIS WILL REQUIRE STRONG INTERNATIONAL COLLABORATION.

Immediate efforts are required to facilitate and contribute to multilateral initiatives that promote knowledge sharing and capacity building to deliver a just transition whilst also safeguarding nature and biodiversity. Collaboration is urgently required to foster collective action on governance, climate finance and innovation. North-South and South-South dialogues should be cultivated; groups like the G7 and G20 must mobilise support and investment; and just transition funds should be established and operationalised in emerging economies.

TRIPLING RENEWABLE POWER AND DOUBLING ENERGY EFFICIENCY BY 2030



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INTRODUCTION

The United Nations Intergovernmental Panel on Climate Change (IPCC), in its latest Assessment Report (AR6), sent a clear message to the world that this decade is critical to our success in limiting global surface temperature increase to 1.5°C above pre-industrial levels by the end of this century (IPCC, 2023). There is an urgent need for rapid and immediate action to reduce global net anthropogenic carbon dioxide (CO₂) emissions by almost 50% from 2019 levels by 2030, with a significant proportion of this reduction occurring within the field of energy.

However, the energy transition remains off-track and global greenhouse gas emissions have reached record levels. IRENA's flagship report, *World Energy Transitions Outlook 2023: 1.5°C pathway*, shows that even if current pledges and plans made by national governments – including Nationally Determined Contributions (NDCs), long-term low greenhouse gas emission development strategies (LT-LEDS) and other commitments – are fully implemented, this would serve to reduce CO₂ emissions by only 6% in 2030 compared to 2022 levels. This is far below the emission reductions required to place the world on a 1.5°C pathway. The message is clear: **we cannot limit global surface temperature increase to 1.5°C above pre-industrial levels by the end of this century without rapid, sustained and concerted action.**

COP28 marks the year of the first Global Stocktake (GST), through which policy makers, industry, financial institutions, civil society and other stakeholders will reflect on the progress achieved in implementing climate pledges since the adoption of the Paris Agreement in 2015. The *World Energy Transitions Outlook 2023* concludes that a significant acceleration in the deployment of renewable energy, energy storage and renewable fuels, coupled with tangible progress in energy efficiency and electrification of end-use sectors, are required to put the world back on track in this decade to meet global climate goals (IRENA, 2023a).¹

1) A reduction in the use of fossil fuels for power generation – particularly in carbon-intensive generation fleets without abatement measures – is vital to the success of the energy transition, albeit beyond the scope of this report. By 2030, fossil-fired electricity generation would fall by around 47% from the 2022 level, while coal-and-oil-based generation would fall to zero by mid-century, under the IRENA 1.5°C Scenario (IRENA, 2023a).

The global energy transition requires a significant reduction in carbon emissions across the entire energy industry, as well as in end-use sectors. Leveraging low-cost solar PV, onshore and offshore wind, and other renewable electricity generation sources, the power sector must lead the way as solutions in other sectors scale up. Accelerating the progress of the transition worldwide requires a holistic approach, backed by systemic innovation to transform existing structures and systems built for the fossil fuel era.

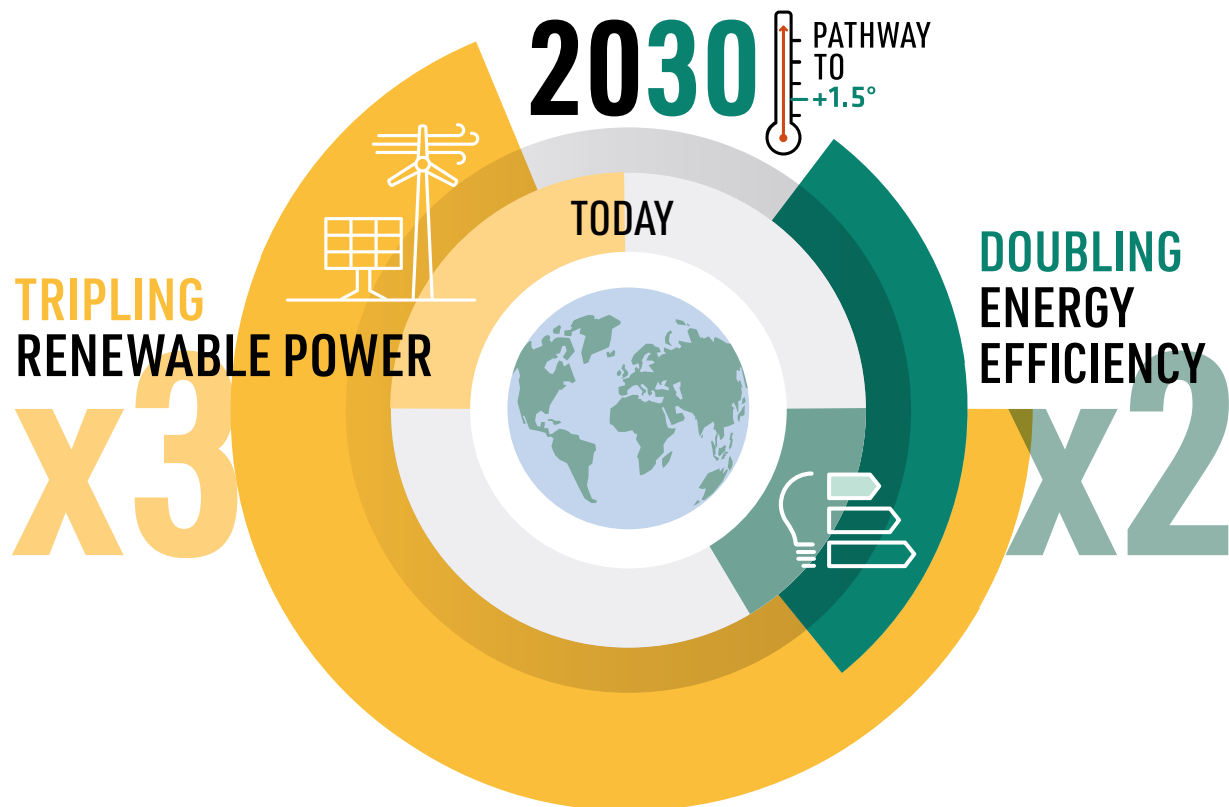
Whilst the phase down of fossil fuels is both essential and inevitable, it must also be responsible. The transition needs to be delivered in a way that ensures energy security, accessibility and affordability, while also sustaining socio-economic development and adopting nature-positive approaches. The speed at which the transition is achieved will be determined by how quickly zero-carbon alternatives can be introduced and scaled up.

Greater ambition and stronger collective action are immediately required to accelerate progress, particularly in renewable energy and energy efficiency. Against this backdrop, policy makers, energy authorities, industry and civil society have an opportunity to align at COP28 to agree global targets to triple renewable power generation capacity and double the energy efficiency improvement rate by 2030. These goals represent some of the most important levers for change to advance the energy transition this decade.

This report consolidates high-level analysis of these targets, detailing existing shortfalls and identifying key enablers to resolve them. It represents global perspectives within the renewable energy and climate change space, with the COP28 Presidency, the International Renewable Energy Agency (IRENA) and the Global Renewables Alliance (GRA) uniting to provide concrete recommendations on the means to meet these renewable power and energy efficiency targets.

The solutions presented are technologically mature, cost-competitive and commercially available, and can be scaled up rapidly in most countries around the world; indeed, utility-scale solar PV and onshore wind are already the most cost-competitive sources of new electricity supply in most countries today (IRENA, 2023b). Accelerating progress in renewable energy deployment and energy efficiency improvement measures this decade would contribute to a cleaner energy system, improve energy security and reduce exposure – both in industry and for consumers – to the damaging risks of highly volatile fossil fuel prices. It would also improve air quality and reduce health costs; deliver universal access to clean affordable energy; and provide greater collective security and well-being. With the right policies in place, the global energy transition will also bring extensive socio-economic benefits, including in the form of job creation and income generation.



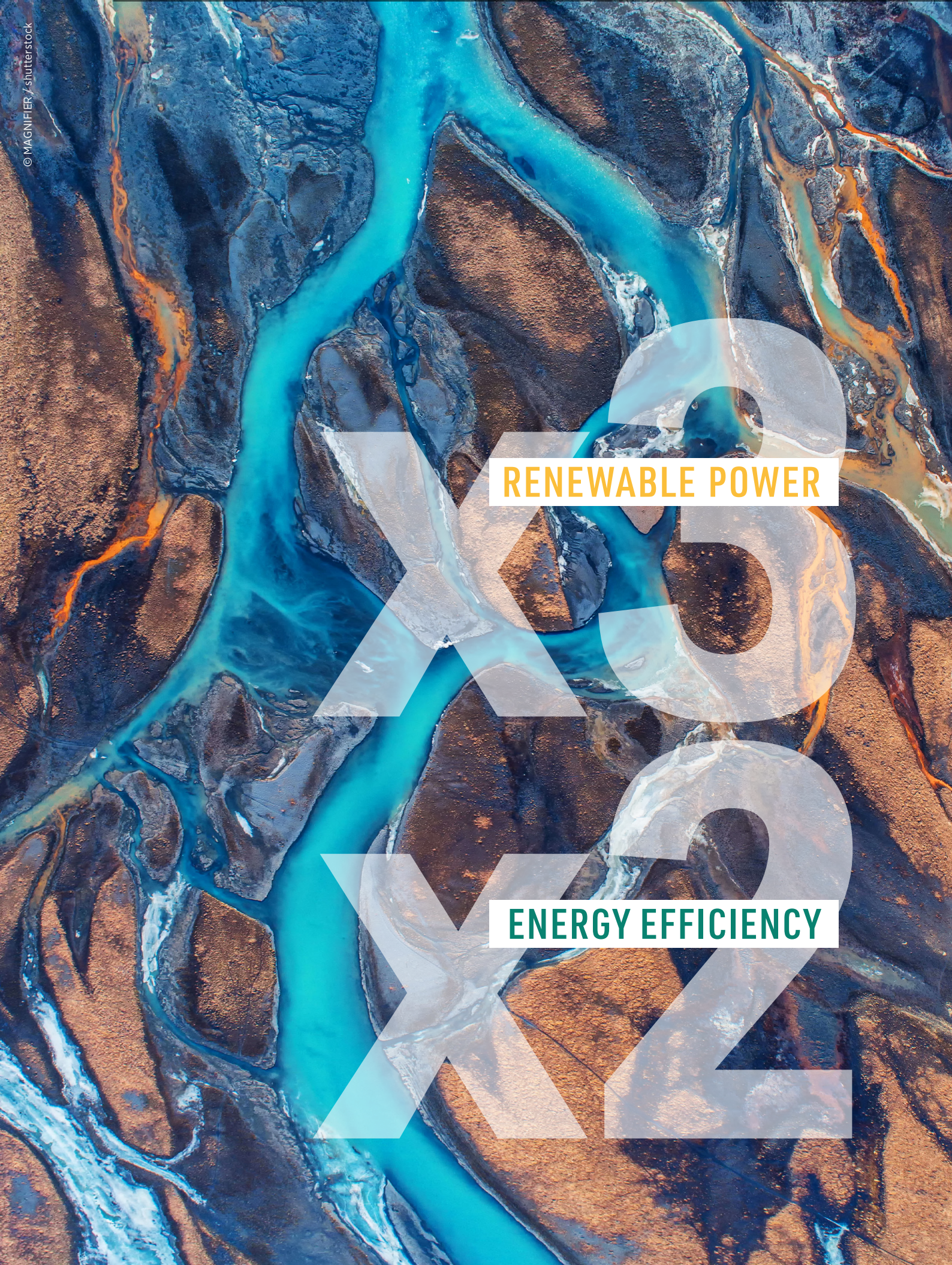


The key enabling frameworks, policies and recommendations detailed in this report provide concrete advice to governments around the world on the necessary steps required between now and 2030 to meet these targets. Realising the targets, in accordance with IRENA's 1.5°C Scenario, would require a cumulative global installed renewable electricity generation capacity of over 11 000 GW, and a doubling of the annual energy efficiency improvement rate from the current level by 2030 (IRENA, 2023a).

It is essential that global leaders convening at COP28 demonstrate the collective will to set a new pace for action this decade by committing to these targets; in short, this is a critical step in a critical decade to keep the 1.5°C target within reach. This will require accelerated actions in many areas, in particular modernising and expanding physical energy infrastructure; improving power system operations; establishing the right policies and regulatory frameworks; building resilient supply chains; and developing skills and institutional capacities. These actions must be underpinned by a significant increase in public and private financing, particularly to support the developing world.

To ensure the energy transition is both just and inclusive, greater international collaboration is also needed. Worldwide, around 675 million people still lack access to electricity and 2.3 billion lack access to clean cooking methods (IEA *et al.*, 2023). Providing renewable energy to those populations would contribute significantly to achieving Sustainable Development Goal 7 to *Ensure access to affordable, reliable, sustainable and modern energy for all.*



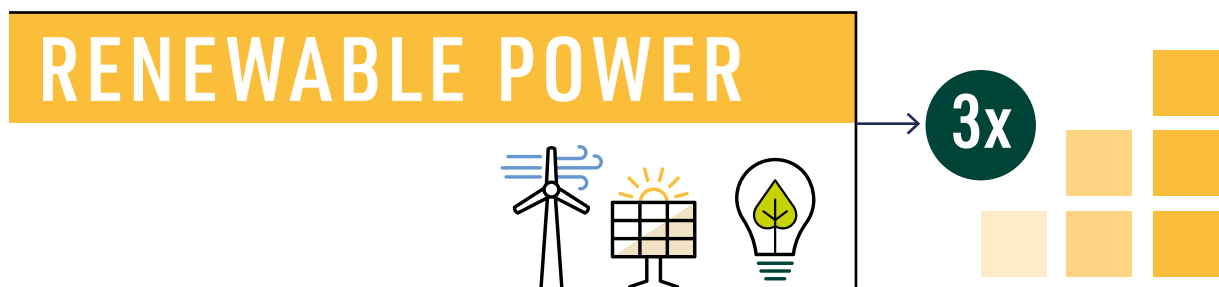


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RENEWABLE POWER

ENERGY EFFICIENCY

TRIPLING UP, DOUBLING DOWN RENEWABLE POWER AND ENERGY EFFICIENCY IMPROVEMENTS TO 2030

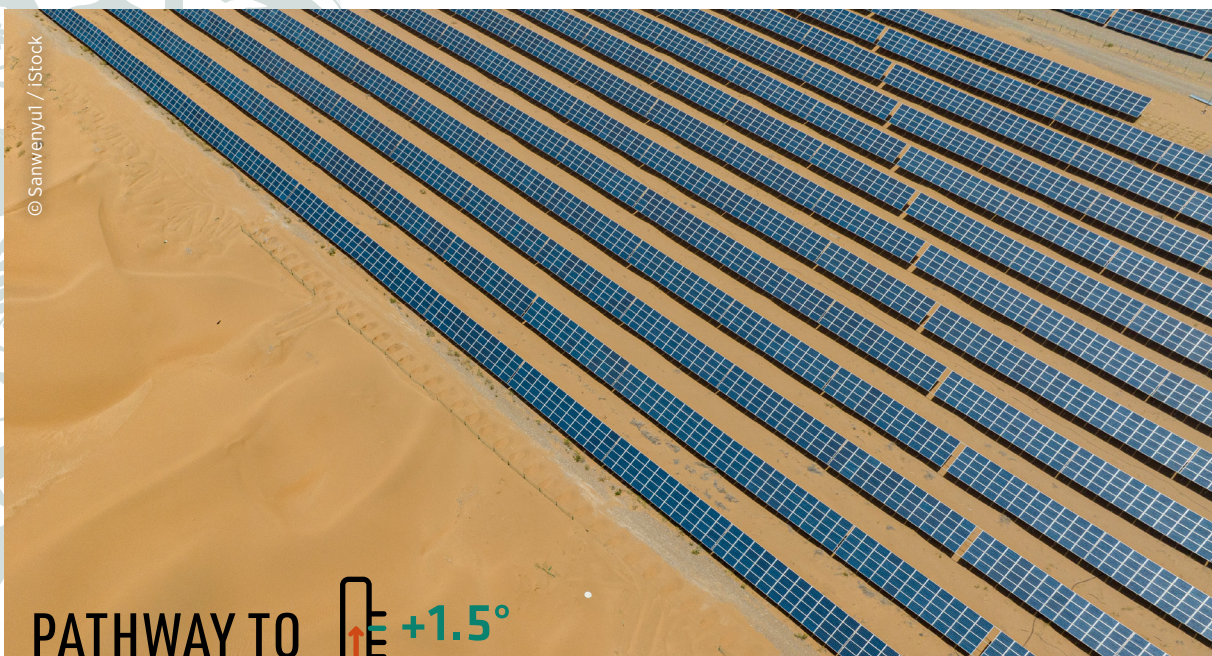


Our success in reducing greenhouse gas emissions this decade will determine whether global temperature rise can be limited to 1.5°C. According to IRENA's *World Energy Transitions Outlook 2023*, global energy-related CO₂ emissions would need to decline significantly to 23 gigatonnes of CO₂ (GtCO₂) in 2030, from the record high of 36.8 GtCO₂ in 2022 (IRENA, 2023a).

IRENA's 1.5°C Scenario identifies a technically and economically feasible pathway to an energy future that is consistent with Paris Agreement goals. It concludes that energy efficiency and electrification powered by renewables, clean hydrogen and direct use of renewables are driving the transition; but the sheer scale and extent of this transition requires a rapid and systemic transformation of the energy system.

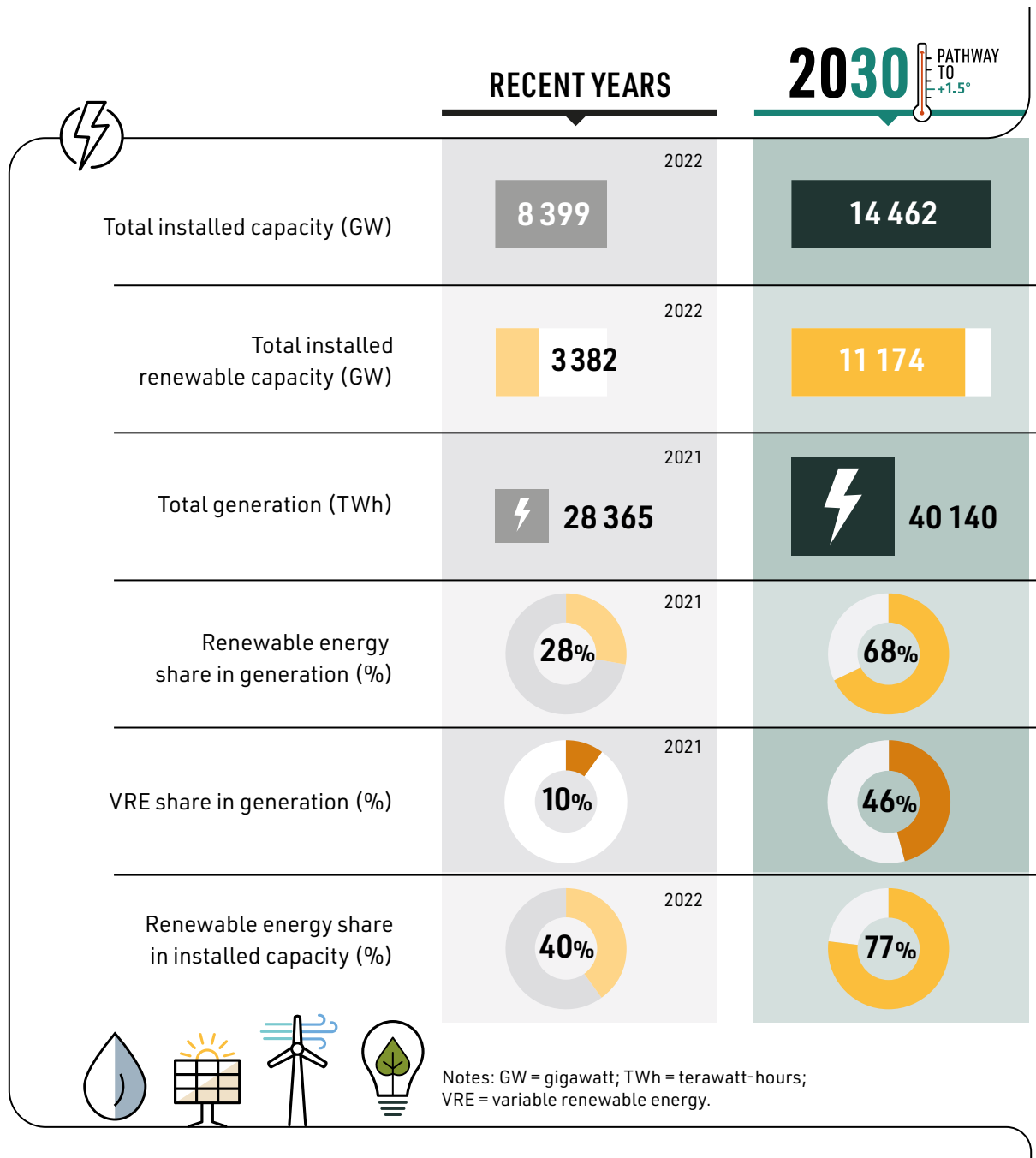
Despite the progress achieved to date, the current deployment of energy transition technologies is insufficient in speed and scale to achieve the Paris Agreement goals. The energy transition requires an urgent and significant acceleration across energy supply, end-use sectors and enabling technologies - particularly the deployment of renewable power generation systems in more countries and regions.

By 2030, global total installed renewable power generation capacity would need to expand more than three-fold, from 3 382 GW in 2022 to 11 174 GW, according to IRENA's 1.5°C Scenario. Specifically, installed solar PV capacity would rise to more than 5 400 GW, from 1 055 GW in 2022, and wind installations would surpass 3 500 GW (3 040 GW onshore and 500 GW offshore), up from 899 GW in 2022, over the same period (IRENA, 2023a, 2023c). The share of variable renewable energy (VRE) – such as solar PV and wind power – in electricity generation would rise from 10% of the total electricity generated in 2021 to 46% by 2030, requiring additional flexibility in the operation of the energy system. After solar PV and wind power, the third-largest increase in generation capacity would be in hydropower; by 2030, global installed hydropower capacity (excluding pumped hydro) would grow by almost 17% from the 2022 level, reaching 1 465 GW under the IRENA 1.5°C Scenario.



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FIGURE 1 Key performance indicators for achieving the 1.5°C Scenario in the Decade for Action



Based on: (IRENA, 2023a, 2023c).

This suggests average renewable energy capacity additions of approximately 1 000 GW each year in the current decade – more than three times the installed renewable capacity added in 2022 (292 GW, including 189 GW of solar and 73 GW of wind power) (IRENA, 2023c). With average annual additions of 551 GW of solar PV and 329 GW of wind power to 2030, solar PV and wind power would dominate annual power generation capacity additions this decade. Energy storage capacity would expand in tandem, with cumulative global battery storage increasing by a factor of 21, from 17 GW in 2020 to 359 GW in 2030 (IRENA, 2023a).

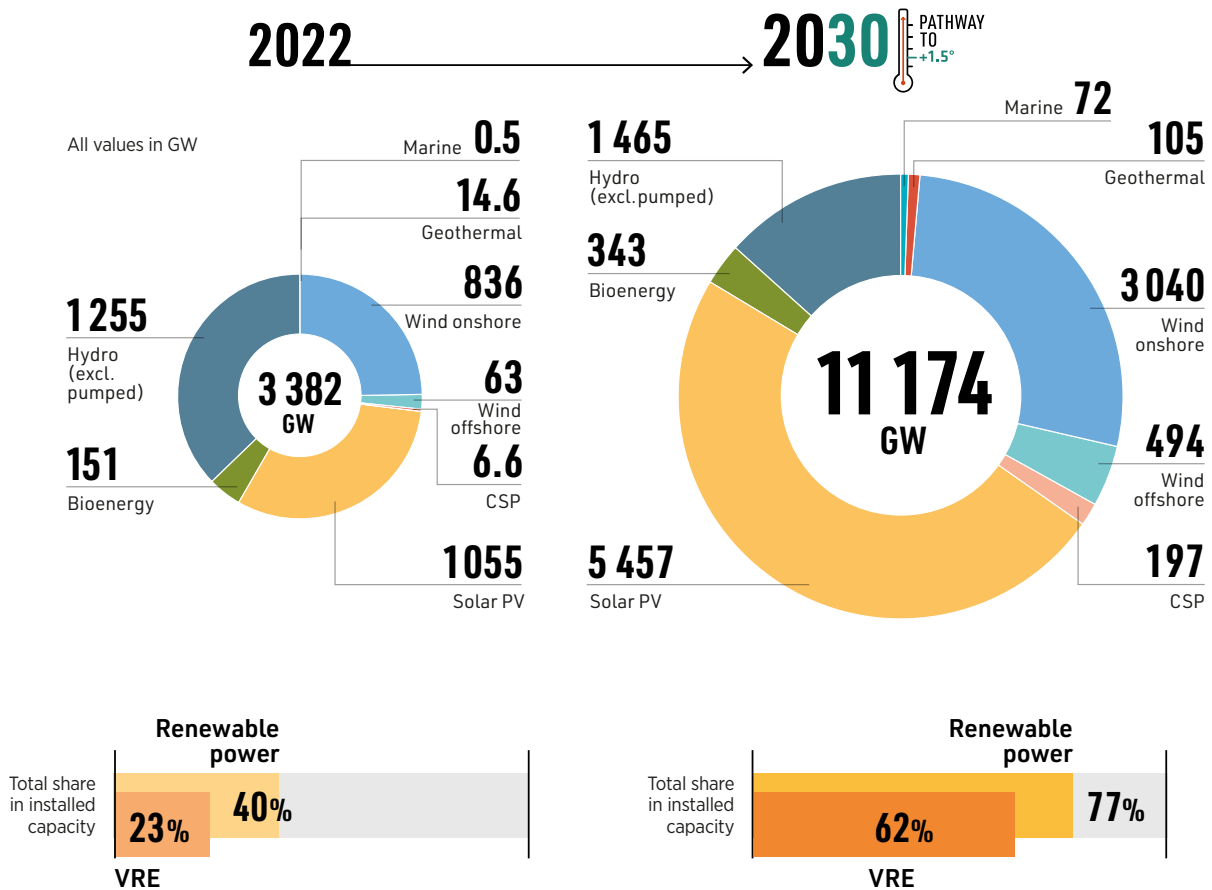
Renewable power additions this decade may not be linear, however, with many factors impacting the rate of growth. Given that annual installation levels in 2022 were less than one-third of the 1 000 GW average annual installation rate required to 2030 under IRENA's 1.5°C Scenario, growth of renewable power technologies over the remaining period of this decade will need to accelerate immediately (IRENA, 2023a). Some projections of solar growth foresee that 1 000 GW of annual solar PV installations alone may be reached as soon as 2028 (Haegel *et al.*, 2023). To meet the tripling renewable power target, annual renewable additions need to ramp up as fast as possible, and as early as possible, in this decade.

Countries and regions will follow different trajectories in accelerating the deployment of renewable power capacity. Those with lower barriers to investment, higher renewable energy resource potential and more mature power markets – among other key enabling factors – should aim for greater increases in renewable capacity and economy decarbonisation. This will allow them to assist others by sharing lessons learnt, technological and technical know-how, and experiences in establishing the right conditions for the scaling up of renewables.

Under the IRENA 1.5°C Scenario, the global solar PV market would be dominated by G20 countries; but outside this group, cumulative capacity will need to surpass 900 GW by 2030, while the cumulative capacity in G20 countries would reach approximately 4 530 GW. For wind, China, the United States, Canada, Brazil and several European countries have high onshore wind potential, while the majority of expansions in offshore wind would be in four key markets (China, EU-27, the United States and India), accounting for more than 60% of offshore wind deployment by 2030. For hydropower, G20 countries together would account for 79% (over 1 150 GW) of global hydropower capacity by 2030, with almost 305 GW of total capacity spread across the rest of the world.



FIGURE 2 Global installed renewable electricity generation capacity in the 1.5°C Scenario, 2022 and 2030



Notes: CSP = concentrated solar power; GW = gigawatt; PV = photovoltaic; VRE = variable renewable energy. Bioenergy includes biogas, biomass waste and biomass solid.
Based on: (IRENA, 2023a).

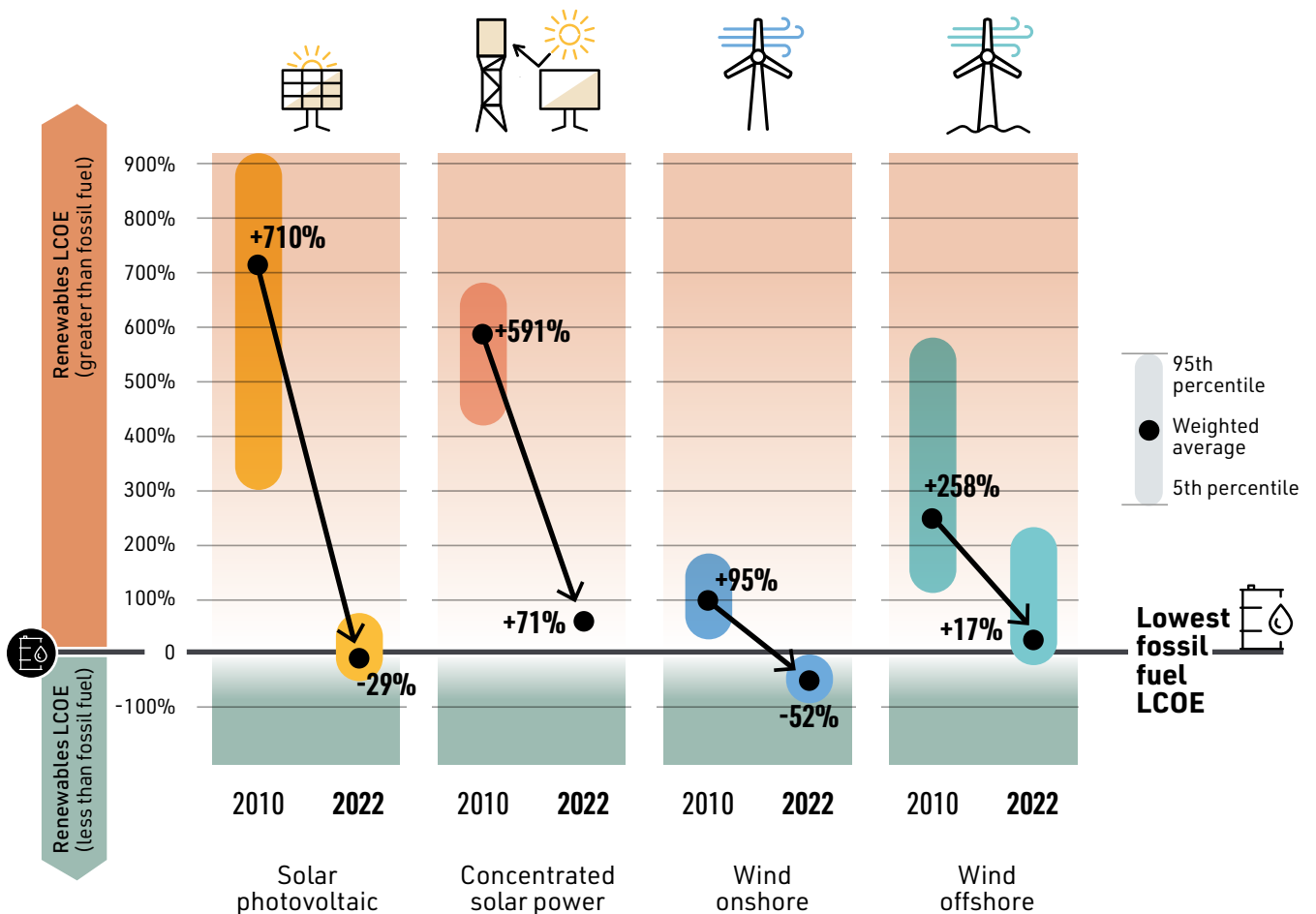
It is important that renewable power generation capacity, including both grid-connected and off-grid systems, expands more rapidly in the developing world, given its growing electricity demand; renewables can – and should – play an important role in addressing the significant energy access deficit in developing countries, through both grid and off-grid applications. Currently, despite vast potential, many developing countries are lagging behind in terms of their deployment of renewable power systems and related investments; for instance, of the cumulative investment of USD 2 841 billion in renewable energy in 2000–2020 worldwide, Africa only received USD 60 billion, or 2% (IRENA and AfDB, 2022).

Accelerating renewable power deployment is not only beneficial from a climate perspective; the economic case for this acceleration is now compelling, given the dramatic improvements in the competitiveness of renewable energy sources such as solar and wind power.

In 2010, the global weighted average levelised cost of electricity (LCOE) of onshore wind was USD 0.107/kilowatt hour (kWh) – 95% higher than the lowest fossil fuel cost of USD 0.056/kWh. Yet, by 2022, the global weighted average LCOE of new onshore wind projects was USD 0.033/kWh – 52% lower than the cheapest fossil fuel-fired option, at USD 0.069/kWh (Figure 3).

This improvement was surpassed by that of solar PV, however. In 2010, solar PV had a global weighted average LCOE of USD 0.445/kWh – 710% more expensive than the cheapest fossil fuel-fired option; but by 2022, a spectacular decline in costs – to USD 0.049/kWh – made solar PV’s global weighted average LCOE 29% lower than the cheapest fossil fuel-fired option (IRENA, 2023b).

FIGURE 3 Cost competitiveness of solar and wind power, 2010-2022



Note: LCOE = levelised cost of electricity.
Based on: (IRENA, 2023a).



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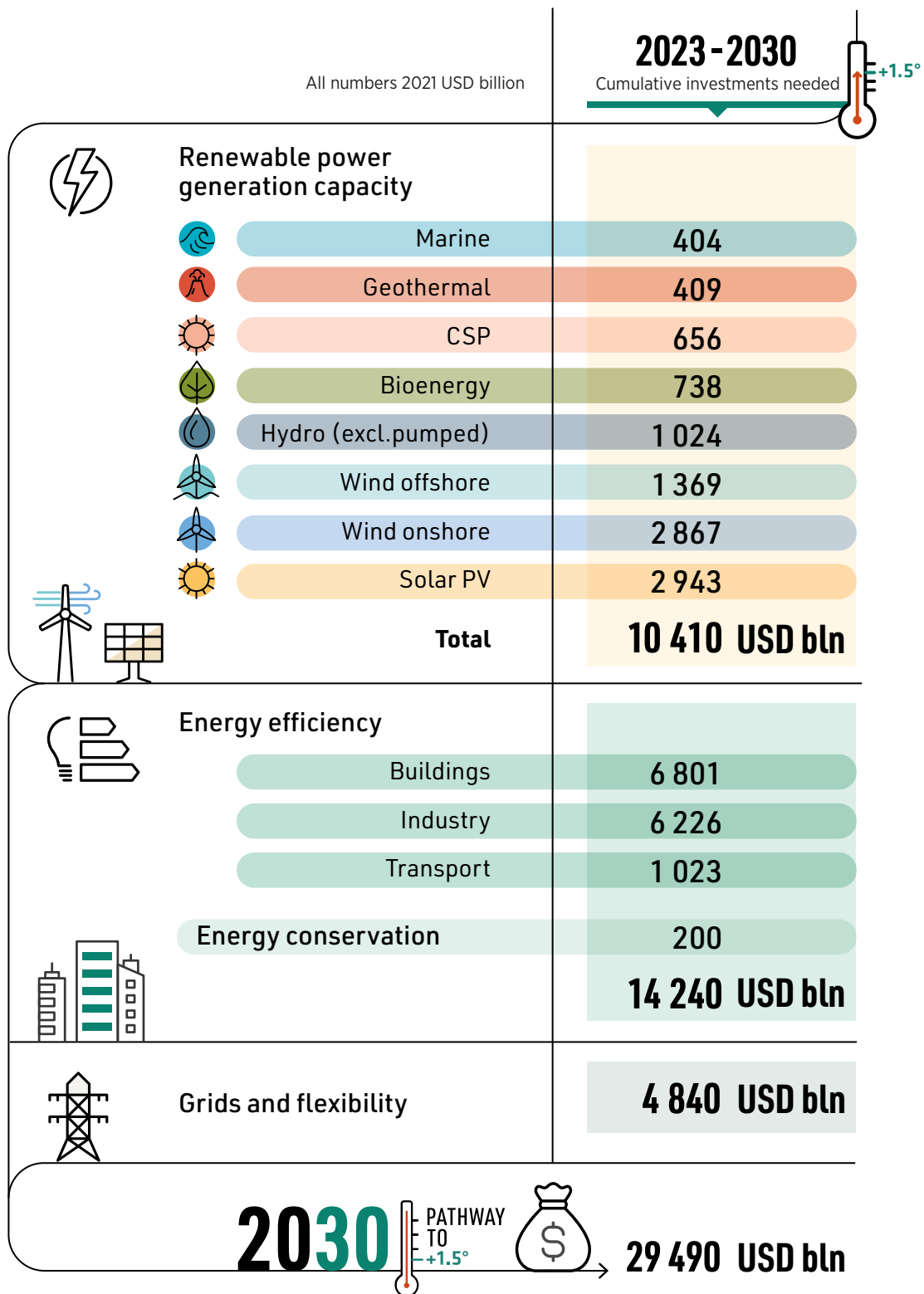
The global weighted-average LCOE of offshore wind fell from being 258% more expensive than the cheapest fossil fuel option in 2010 to being just 17% more expensive in 2022, with costs falling from USD 0.197/kWh to USD 0.081/kWh. Concentrated solar power (CSP) saw its global weighted-average LCOE fall from 591% higher than the cheapest fossil fuel option in 2010 to 71% higher in 2022 (IRENA, 2023b).

While hydropower's global weighted average LCOE increased in 2021-2022 to USD 0.061/kWh - largely owing to the development of more challenging and remote sites - it remains cheaper than new fossil-fuel fired options. This is also true for geothermal projects, with a global weighted-average LCOE of USD 0.056/kWh in 2022, as well as for bioenergy projects, at USD 0.061/kWh (IRENA, 2023b).

It is equally important to consider the wider economic and environmental benefits of renewable power in reducing fossil fuel imports, improving a country's balance of payments and enhancing security of affordable energy supply by reducing exposure to volatile fossil fuel prices in global markets.² As 2022 showed, the indirect economic benefits of this enhanced energy security can be significant; yet they are typically not valued in current policy.

2) It is important to note that renewables offer a fundamentally different hedge to rising fuel costs. Hedging fossil fuel prices comes at a cost, because fossil fuel prices are inherently volatile and investors must be compensated for taking on the risk. With renewable power, the opposite is true; the cheapest renewable electricity comes when the project's lifetime generation is contracted for, as this reduces project risk and ensures the lowest cost of capital. Hedging the electricity supply system with renewables therefore comes at a discount, not a cost addition.

FIGURE 4 Investments required to meet the 1.5°C goal



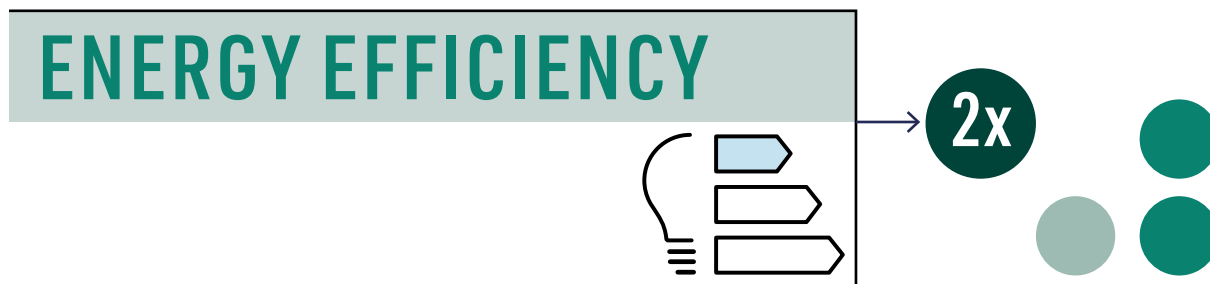
Source: (IRENA, 2023a).

Similarly, the economic benefits of reducing pollution, and thereby improving climate, environmental and health outcomes, are almost never properly valued in policy-setting (IRENA, 2023b). These unpriced benefits significantly improve the competitiveness of renewable power and make the business case for accelerated deployment even more compelling.

Under IRENA's 1.5°C Scenario, the power systems of tomorrow would integrate a broad range of renewable sources, with each technology playing a key role in meeting electricity demand; but solar and wind power will dominate capacity expansion. This represents a transformative shift in power system supply dynamics and poses new challenges to power system operations. These may be met by adopting new operational strategies and mechanisms, accelerating the scale-up of smart demand response schemes and deploying technologies that support power system flexibility, including hydropower with reservoirs and pumped storage; energy storage; and sector coupling technologies.

In recent years, hydrogen produced from renewable electricity – known as 'green hydrogen' – and its derivatives have been identified as industrial feedstocks for decarbonising hard-to-abate sectors. Hydrogen has also been recognised as an energy carrier that can be used to balance electricity demand with supply from variable renewable energy, thereby providing the increasing flexibility required by grids. Scaling up green hydrogen therefore offers significant potential for integrating higher shares of renewable energy in grids, and can also provide a solution for seasonal energy storage.





A rapid scale-up in renewables is only part of the energy transition equation. The transition should also aim to deliver reduced energy intensity across the economy through a range of more energy efficient technologies, complemented by structural and behavioural changes. These measures can often generate economic and environmental co-benefits. A range of measures will be needed across all end-use sectors, including modal shifts from private passenger cars to collective transport, and from passenger aviation and road-based freight to rail, as well as the adoption of circular economy principles, improved building insulation, heat pumps and efficient electric motors – especially for industrial end-use sectors.

Energy efficiency (measured in terms of energy intensity improvement rates³) in IRENA's 1.5°C Scenario is largely a result of a combination of efficient technologies in end-use sectors and extensive electrification. The electrification of end-use sectors – such as in transport and buildings – would see a rise in direct use of electricity in total final energy consumption from 22% in 2020 to 29% in 2030.

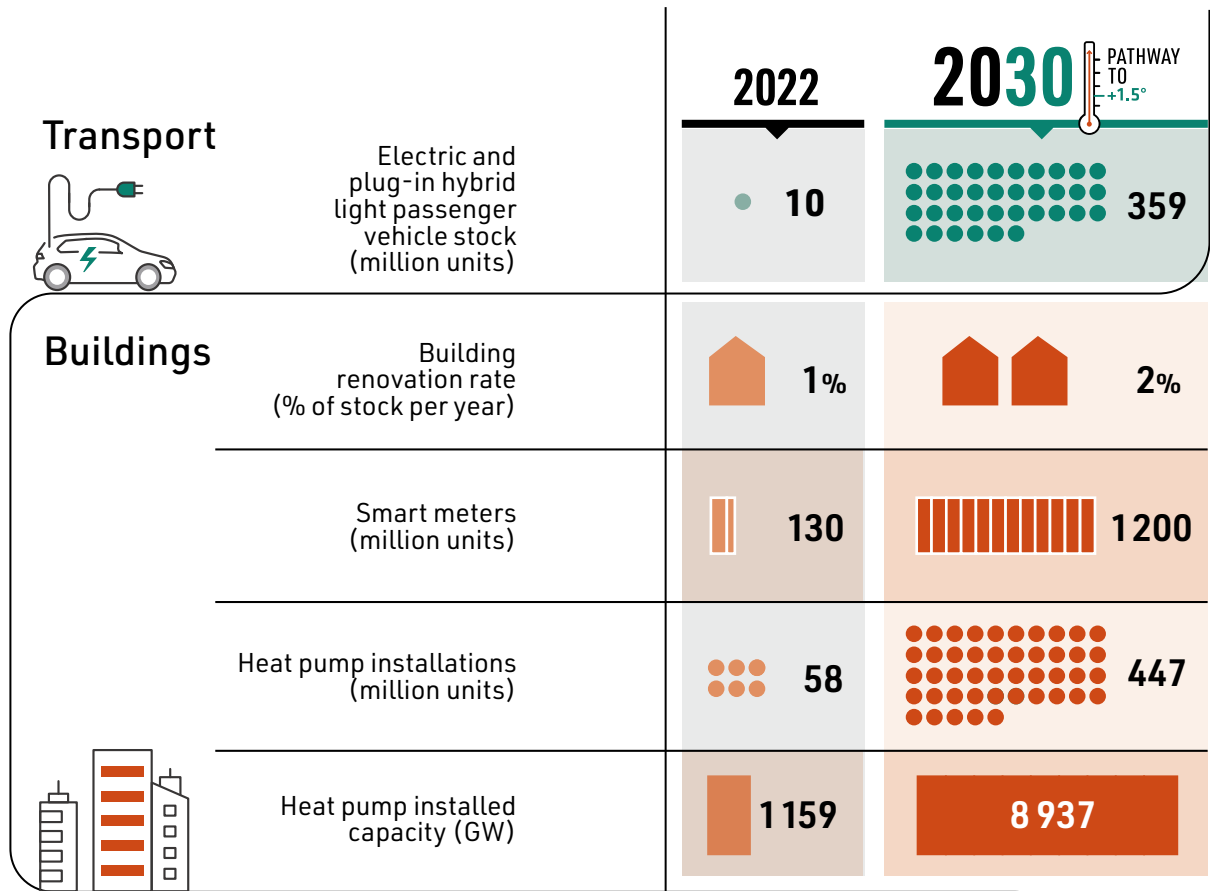
Technical energy efficiency improvements embodied by heat pumps, more efficient appliances and electric vehicles – together with flexible, smart electrification strategies and deployment of decentralised energy – are of tremendous importance in decarbonising end-use sectors such as buildings and transportation. For industrial sectors, continued energy efficiency improvements play an important role in keeping the overall energy consumption by industry close to unchanged in 2050 from present levels (IRENA, 2023a).

To align with IRENA's 1.5°C Scenario, the global annual rate of energy intensity improvement should double by 2030 from the current level, which is also in line with the assessment of the International Energy Agency (IEA, 2023). If this rate is achieved, global final energy consumption would experience minimal growth over the same period.

With renewables and energy efficiency best placed to meet climate commitments as well as energy security and energy affordability objectives, governments must redouble their efforts to ensure sufficient investments are made.

3) Energy intensity improvement rates are a proxy for energy efficiency improvement rates. The *World Energy Transitions Outlook* defines energy intensity as total primary energy supply (TPES) divided by GDP; and energy intensity improvement as the compound rate at which energy intensity declines annually at the global level.

FIGURE 5 Energy intensity: Indicators in transport and buildings in 2030



Based on: (IRENA, 2023a).



ENERGY TRANSITION ENABLERS AND POLICY PRIORITIES

INFRASTRUCTURE AND SYSTEM OPERATION

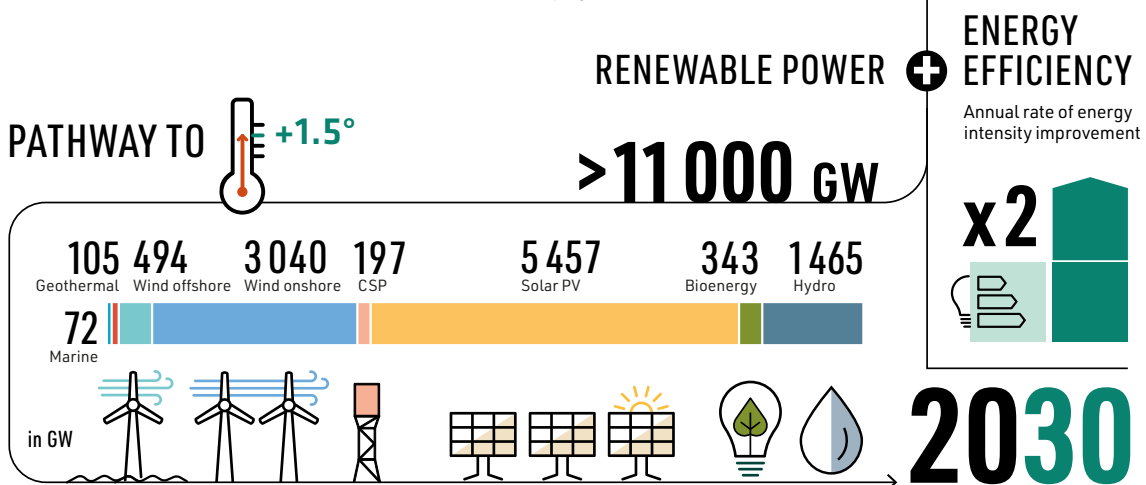
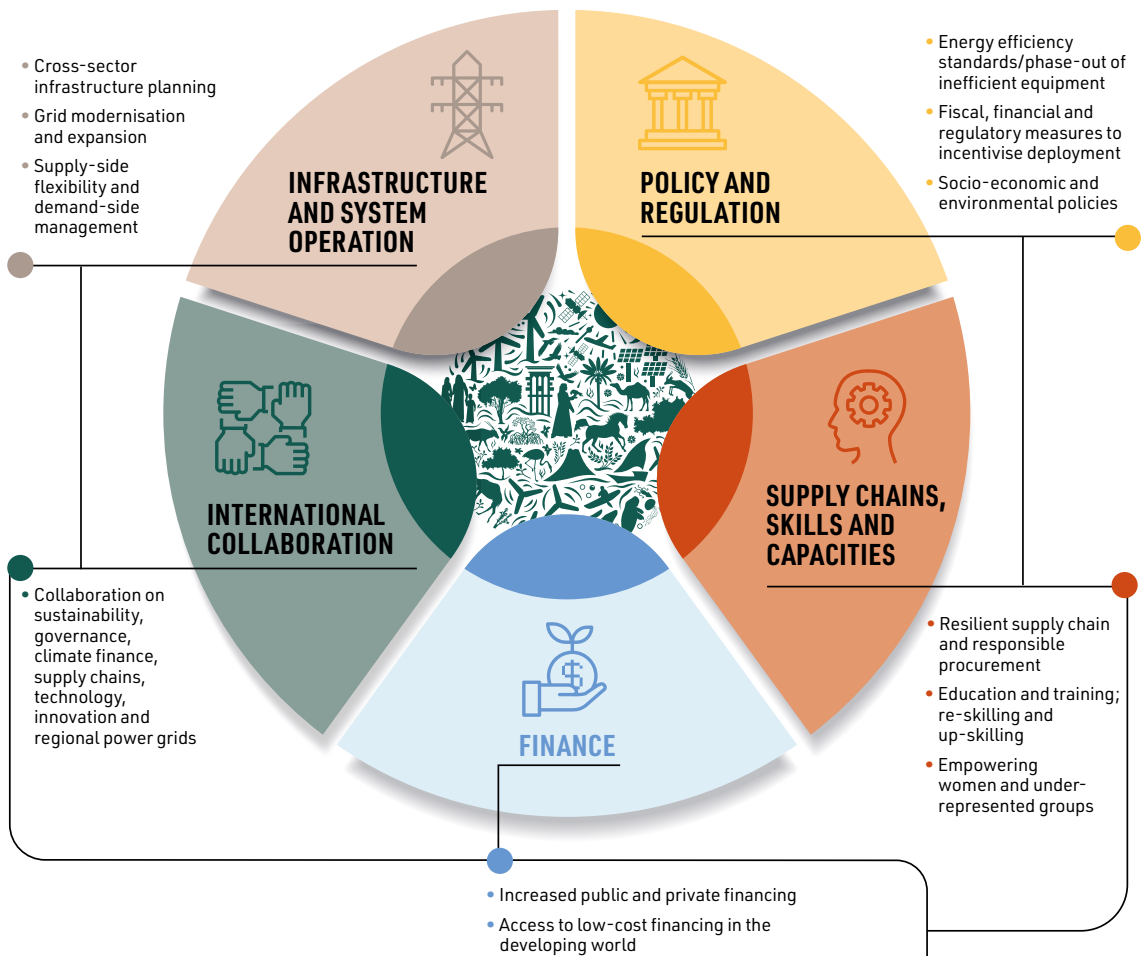
Wind and solar power are the fastest growing sources of power worldwide, but there is also a need to accommodate a more diverse range of renewable energy sources in the power mix – including hydropower with reservoir storage and biomass-based power plants. This will require enhancements to – and expansion of – current power grid systems, and the modernisation and upgrading of power system operations.

With VRE sources becoming the major source of power in a 1.5°C-compatible world, countries must start upgrading and expanding their power grid infrastructure to prepare for increasing end-use sector electrification. Multiple measures are required, including:

- Innovative power planning, grid expansion, modernisation and enhancement, and addressing interconnection backlogs (projects awaiting connection to the grid).
- Changes in grid operation and management, potentially also including new market design.
- Increased interconnectors between countries and regions.
- Growth in electricity storage; comprising short-duration storage for increasing grid flexibility and long-duration storage to enhance energy security (e.g. pumped storage).
- Measures to allow greater integration of demand-side management and behind-the-meter (consumer) flexibility options (e.g. distributed storage).
- Introducing other flexibility sources (e.g. green hydrogen, hybrid renewable parks combining wind/solar/storage, etc.).

FIGURE 6

KEY ENABLERS: TRIPLING RENEWABLE POWER & DOUBLING ENERGY EFFICIENCY



Power grids

Investments in the electricity grid have lagged behind those in renewable power and must now significantly ramp up in anticipation of the considerable renewable power additions required. Countries need to prepare for the large amounts of VRE that will come online in the next few decades, as grid investments must be made 3-5 years before renewable energy investments to mitigate the overall system costs of greater renewable penetration (LBNL, 2022).⁴ With clarity on grid infrastructure development plans and reasonable guarantees on connection availability, investors will feel more confident building new generation; meanwhile, consumers would be more likely to invest in electrification when a reliable supply of low-cost electricity can be made available.

When integrating higher shares of locally available variable solar and wind power, power systems will also need to innovate to become: increasingly decentralised, allowing electricity to be generated at locations closer to demand; and bi-directional, allowing electricity from distributed power generating facilities to be injected into the grid.

Modernised, smarter grids are required; in the European Union (EU), around 30% of the envisaged investment in grids by 2030 could be earmarked for digitalisation⁵ (European Commission, 2022). They will also need to be larger and more robust. Hence, grid costs are expected to increase over time (IRENA, 2023a). This will require fast-tracked permitting to ensure timely investments in modern grids. Adding more widely distributed power generation sources will also bring resilience, especially against increasingly intense extreme weather events owing to climate change (IPCC, 2023).

The electrification of transport also requires significant investments in enabling infrastructure. Electric vehicles will potentially account for more than 80% of all road transport activity by 2050; with 359 million electric and plug-in hybrid light passenger vehicles worldwide by 2030 and 2 182 million by 2050 (IRENA, 2023a); yet their market entry will be contingent upon co-ordinated investments in charging infrastructure and power grids.

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Ensure planning, timelines and assessments of investment needs for grids are aligned with long-term targets for renewable energy buildout and end-use sector decarbonisation, e.g. transport.
- Mobilise funds for long-term grid investment; channel donor finance to building capacity and infrastructure for integrating renewables; and streamline permitting procedures for new grid infrastructure and upgrades to existing transmission and distribution infrastructure.
- Develop modernised, decentralised (where suitable) and more resilient grid systems using digitalisation, smart applications for demand-side management and interconnections with neighbouring grid systems.

4) In some countries, renewable energy projects wait several years for an interconnection agreement from the grid authority, due to a backlog of project applications and insufficient capacity. In the United States, for example, the average time from interconnection request to a project reaching commercial operations is more than four years (LBNL, 2022).

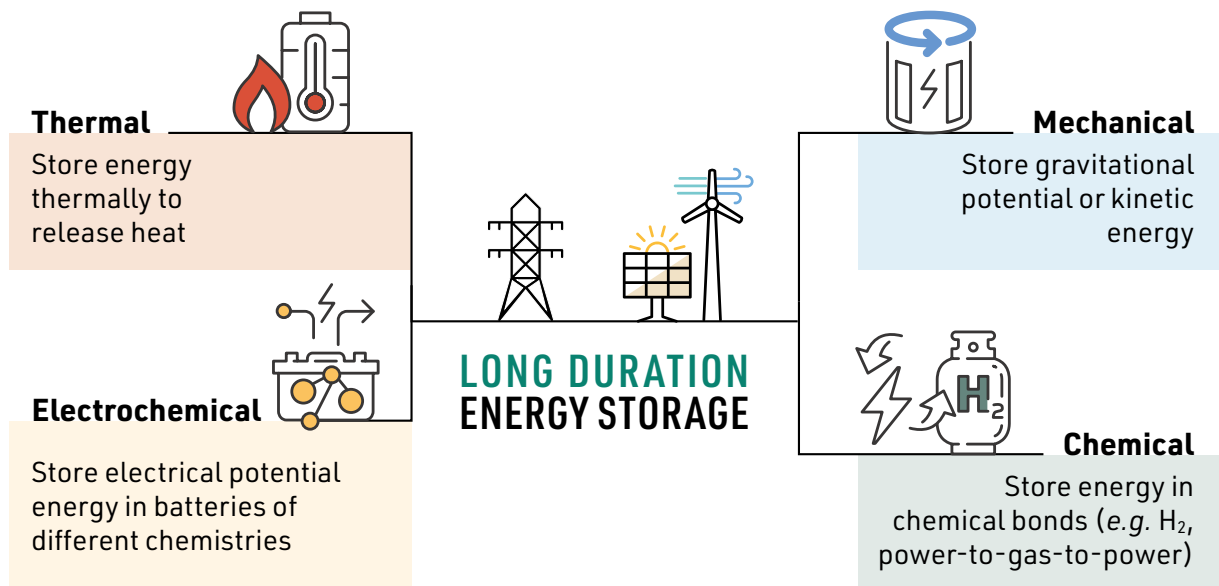
5) Digitalisation is a key amplifier of power sector transformation, enabling the management of large amounts of data and optimising increasingly complex systems. For the power sector, digitalisation helps to improve monitoring, operation and maintenance of assets using technologies such as the internet of things (IoT), artificial intelligence and blockchain (IRENA, 2019).

Energy storage

With a growing share of variable renewable power generation, energy storage is needed to ensure the electricity generated is successfully delivered when shortfalls between supply and demand occur. Historically, this has been provided by pumped storage and hydropower with reservoirs.

However, there are now many types of storage, including electro-chemical storage (batteries), thermal energy storage (which employs rocks, bricks or molten salts to store heat), mechanical technologies (employing compressed air, liquid air or gravitational potential) and chemical storage (storing energy in chemical bonds such as hydrogen or its derivatives). All of these technologies are undergoing rapid innovation.

FIGURE 7: Long duration energy storage technologies



Based on: (LDES Council and McKinsey & Co., 2021).



Long-duration energy storage (LDES) provides the means to store energy for hours,⁶ days, weeks or even seasons when renewable generation is abundant relative to load, and releasing it when demand is greater than generation (e.g. saving energy from spring days with low loads and abundant solar to deploy during high load days in the summer; or from windy autumn days to deploy during high load cloudy winter days). Diverse storage technologies enhance the resilience of grids that are subject to extreme weather for prolonged periods, help relieve grid congestion, provide transmission services and shore up local area reliability.

LDES, including storage technologies spanning 10+, 24+, 100+ and 150+ hours in duration and providing both power and heat, is also able to provide other grid services including black start (restarting parts of the grid where power has been lost in a blackout) and micro-grid level assistance for areas or key infrastructure that may lose power. Storage durations can span weeks or months in the case of pumped storage and reservoir hydropower. As the largest form of installed flexibility at over 175 GW worldwide, pumped storage hydropower can play an important role in providing LDES and vital grid services, with substantial potential for off-river pumped storage to be developed in the coming decades (IHA, 2023). Some LDES technologies are commercially available today, while others are still in the early stages of development. Numerous companies are signing contracts (e.g. with utilities, airports, data centres, industrial users, etc.) and are deploying LDES at grid-scale quantities, and pumped storage has been successfully deployed for decades.

One emerging LDES technology is hydrogen storage. Hydrogen's true competitive strength lies in its unique ability to store energy for long periods of time in large quantities. As green hydrogen displaces fossil fuels in some end uses, hydrogen storage could become increasingly critical to energy security, in the same way that natural gas storage is today in many regions. Hydrogen storage will be needed primarily to meet variation in supply (rather than demand), as green hydrogen is created using VRE sources. Long-term hydrogen storage can play an important role in strengthening energy security and system resilience (IRENA, 2023d). Support for the continued development of these technologies is critical for decarbonisation.

In many places, however, legacy market arrangements and policy frameworks do not incentivise investment in storage at scale. Action from policy makers can drive progress in this sector, such as: assessing energy storage and flexibility needs; setting LDES mandates for medium- and long-term capacity targets; updating criteria for marketplaces; providing innovation grants and subsidies for pre-feasibility studies; and establishing public-private partnerships.

Other market innovations can also foster a healthy storage market, such as the introduction of congestion management trading platforms, ancillary services markets to support the grid, and awarding additional value for features such as flexibility in capacity payments and capability to provide peaking power (e.g. storage technologies that can replace a natural gas peaking plant should be reflected in system modelling).

6) Typically more than ten hours, while the benchmark for lithium-ion batteries is four.

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Conduct technical assessments of system decarbonisation needs and timelines, and ensure the planned buildout of renewables is complemented by storage resources of varying duration, as well as other sources of flexibility.
- Collaborate with regulators and the renewables sector to enhance power market planning and ensure price signals, clear targets and procurement incentivise longer duration storage.
- Encourage investment and innovation in diverse storage technologies to suit different users, such as by establishing research, development and innovation (RDI) grant programmes, encouraging public-private partnerships and setting medium- and long-term capacity targets.

End-use electrification and sector coupling

With solar and wind power scaling up rapidly in this decade, electrification has become a vital decarbonisation pathway. Green hydrogen and its derivatives, produced by electrolyzers using low-cost renewable power, can be used to decarbonise end-use sectors that are difficult to electrify directly – such as iron and steel making, and shipping – and to provide seasonal energy storage solutions.

However, electrification needs to be accelerated by systemic innovation, making it not only faster but smarter. Smart electrification – through sector coupling and enhanced flexibility – prevents a higher peak electricity load on the power system. It also enables the power system to accommodate new loads while allowing integration of a higher share of variable renewable electricity in a cost-efficient manner. This can help sustain renewables-based electrification without jeopardising energy system operation, thus making the power system robust and resilient. To harness all these benefits, systemic innovation should involve the entire energy value chain across four key dimensions: technology and infrastructure; market design and regulation; system planning and operation; and business models (IRENA, 2023d). Smart charging for electric vehicles is a good example in this regard.

Sector coupling (integrating electricity grids, transport systems, heating in buildings and thermal energy grids) provides more opportunities to economically optimise overall operation as a single system, provided that the economic incentives are put in place and upgraded energy management systems are available (IRENA Coalition for Action, 2022).

The benefit of this will be smarter, more intelligent demand-side management, achieved by deploying more advanced digital technologies both behind-the-meter (by energy consumers) and in power systems. Demand response would become more agile and inter-operational through sector-coupled technologies such as energy storage systems and electric vehicles (EVs) connected to smart charging facilities. This would enable increased integration of variable renewable electricity in local energy networks and maximise overall benefits by automating the monitoring and operation of assets (IRENA, 2021a; IRENA Coalition for Action, 2022).



End-use electrification, sector-coupling and the rapid scale-up of variable renewable electricity all require integrated cross-sectoral infrastructure planning – a process for optimising the co-development of increasingly connected infrastructure in various sectors.⁷ The European Hotmaps project offers an open-source toolbox to support public authorities, energy agencies and urban planners as they plan heating and cooling at local, regional and national levels. It allows users to map cooling and heating demand, as well as supply, in the 27 EU Member States and the United Kingdom, and provides renewable energy generation and industrial waste heat potentials (Hotmaps, 2021). This facilitates the integration of heating and cooling with waste-to-energy and renewable energy, including power-to-heat. However, this planning approach requires incentives for infrastructure investments where market barriers exist, given that different infrastructures operate under different legislative, regulatory and policy regimes.

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Adopt a sector-coupling approach to the decarbonisation of economies by pursuing smart electrification of the transport, buildings and industry sectors.
- Create fora for co-ordinated planning among relevant authorities on infrastructure development, including renewable energy projects, grid and transmission assets, electric vehicle charging infrastructure and heat networks.
- Introduce economic incentives for smart electrification and demand-side response (such as tax credits and innovation grants) to encourage private investment in sector-coupling solutions.

7) For example, power grids, electric vehicle charging infrastructure and power-to-heat solutions at small and large scales, including thermal networks, all linked to optimise variable renewable electricity.

Demand-side management

Electricity systems are complex; in addition to the grid infrastructure planning required to unlock the benefits of sector coupling, distributed grid planning and operations will need well-defined energy management schemes on both sides of the end-user meter. These schemes apply to both the supply side (power management) and demand side (load management).

Demand-side management (DSM) comprises a set of strategies traditionally aimed at reducing peak demand, which will be increasingly needed to incentivise consumption in periods of high VRE generation. DSM addresses various challenges, including VRE integration, rising electricity costs and environmental impacts. For example, DSM can employ time-of-use pricing to encourage customers to shift electricity usage to off-peak hours, while demand response programmes can financially reward customers for reducing electricity usage during peak hours or consuming electricity during high VRE generation periods. Critical-peak pricing, real-time pricing and critical-peak rebates are also among the strategies available. These approaches are crucial for optimising energy efficiency in both residential and industrial buildings.

As the transition advances, DSM will also provide flexibility to alleviate the need for more costly requirements. Several challenges persist, however – particularly in Latin America, the Middle East and North Africa, and other Global South regions. Notable issues include physical grid and digital technology infrastructure gaps, as well as complex and inconsistent regulations and policies. Financing challenges also hinder progress; attracting investment in clean energy enablers like DSM solutions requires innovative financing models and incentives.

Intelligent load control, demand response and energy efficiency are pivotal in enabling a secure and resilient renewables-based power system. Continued investment and innovation in these areas will further drive the adaptation of demand to supply in a renewable energy-driven future.

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Assess the cost-benefit of investment in DSM programmes, accounting for the energy and cost savings it can provide instead of investing in grid infrastructure expansion.
- Ensure grid planning prioritises modernisation and DSM technology to close critical technology gaps as infrastructure expands. Developing economies can explore innovative financing models – such as blended finance – to mobilise investment in grid and DSM solutions.
- Improve data availability within the wider electricity system to enable innovation in DSM and access to applications like smart meters by consumers and third parties.

POLICY AND REGULATION

Governments have a crucial role to play in tripling renewable power capacity and placing the world on a 1.5°C pathway. All too often, the energy transition discourse relegates governments' responsibilities to creating an enabling environment for private investments through predictable and stable policies, and the creation of instruments that de-risk investment projects. Although this is crucial, a much broader and more integrated policy approach is required to facilitate the adoption of an entire spectrum of energy transition solutions needed to achieve the 1.5°C target and unlock its socio-economic benefits (Figure 8).

Governments need to be far more engaged in shaping and guiding the energy transition, including through policies for ambitious public investment programmes and sufficient forward-planning for renewables scale-up, system integration and grid build-out.

Cross-cutting approaches covering all renewable technologies, electrification technologies and others are needed to facilitate the energy transition (*e.g.* energy storage), include enabling policies that set ambitions and send clear signals to stakeholders, eliminate distortions, incentivise the uptake of solutions and facilitate access to affordable financing. They also include policies that ensure the integration of renewables within energy systems, economies, nature and societies, as well as specific deployment policies for various technologies. Planning for transmission infrastructure, inter-regional power trading, workforce recruitment and training, flexibility services and end-use sector decarbonisation should all be aligned with overall climate and renewable energy targets to ensure renewable power can be efficiently integrated and dispatched to areas of demand.

Transitioning to a renewables-based economy may also bring challenges in the form of financing gaps, labour market disruptions and energy sector insecurity. These misalignments, if not well-managed, risk inequitable outcomes and a slower pace of the energy transition. Therefore, a set of structural and just transition policies, along with the creation of strong institutions to ensure policy co-ordination and cohesion, is required to manage potential misalignments.

Finally, a holistic global policy framework that entails international collaboration including North-South and South-South co-operation is needed to bring stakeholders from countries around the world together to commit to a just transition that leaves no one behind and strengthens international finance flows, capacities and technologies in an equitable manner.

This section focuses on the key policies and regulations needed to accelerate energy efficiency and renewable power technologies; phase down fossil fuel generation and replace inefficient equipment; shape power market design to integrate higher shares of renewables; and maximise social and environmental benefits.

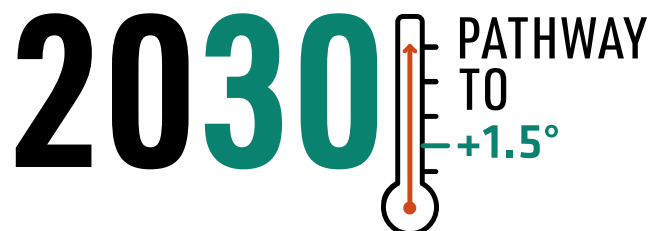
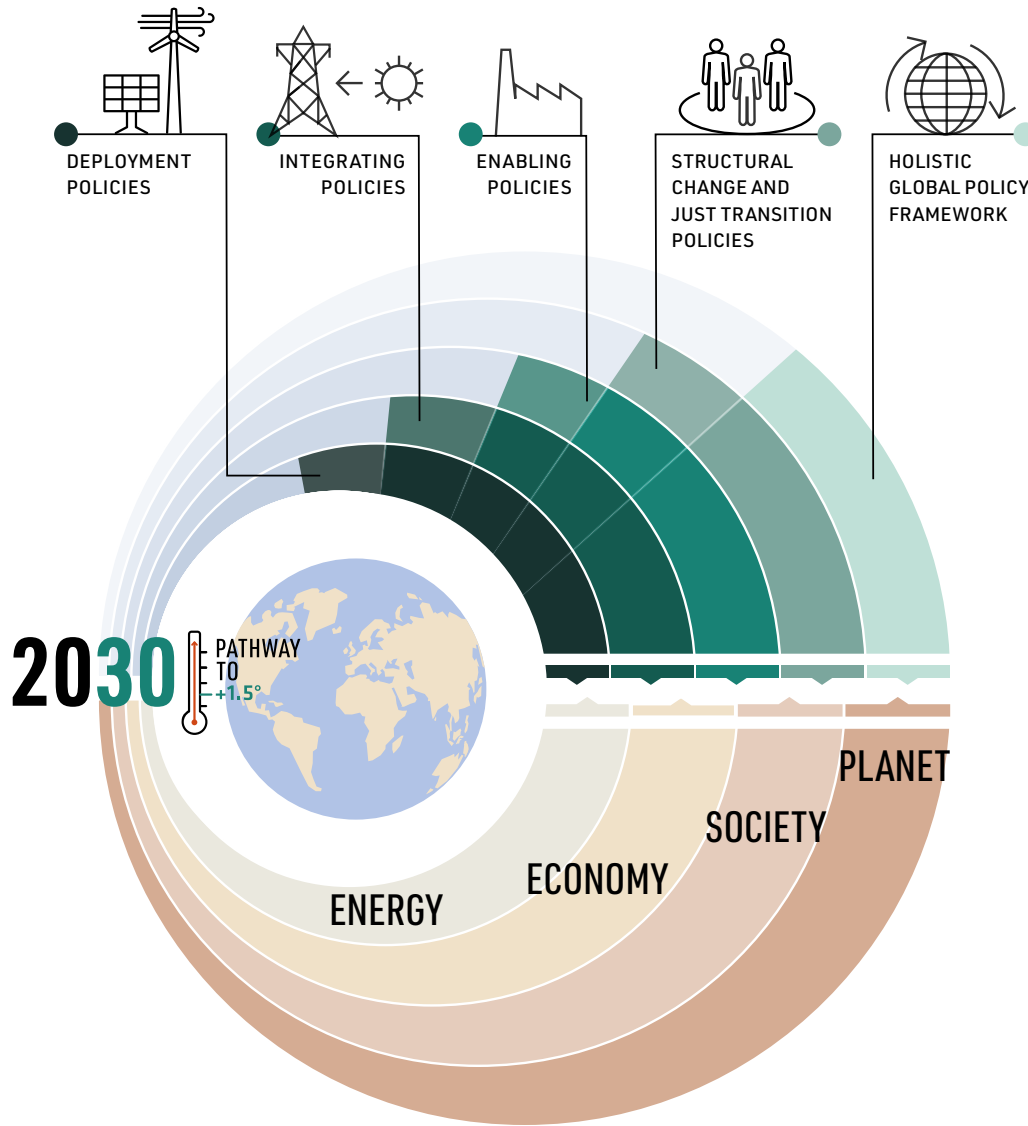


FIGURE 8 The IRENA holistic policy framework for a just and inclusive energy transition



Based on: (IRENA, 2021b).



Improving energy efficiency

Improving energy efficiency could deliver around a quarter of the emissions reductions needed by 2050, according to IRENA's 1.5°C Scenario. Enhanced energy efficiency is a crucial enabler for making high levels of end-use electrification feasible and affordable. Measures related to reducing energy demand and improving efficiency are needed across all end-use sectors.

Minimum energy performance standards (MEPS) can support industrial, commercial and residential users to procure and switch to more energy efficient appliances or equipment such as electric heating/cooling technologies. Building codes can set energy performance requirements by specifying insulation standards, thereby reducing heating and cooling demands. They can also specify greenhouse gas emission targets and carbon footprints. For renovation, in particular, codes can be coupled with financial incentives.

It is also important to address prevailing challenges associated with building ownership structures, equitable access and benefit-sharing of energy efficiency investments and policies. "Green loans" could carry lower interest rates and protect low-income energy consumers from energy price fluctuations and inflationary environments. Awareness campaigns for end-users also play an important role in the adoption of energy efficiency and energy conservation measures.

In the transport sector, significant improvements can be achieved by promoting energy efficient mobility (e.g. public transport such as railways, metros and buses, and car-sharing), as well as active (non-motorised) transport such as cycling and walking in urban areas. Public campaigns can be undertaken by national and local governments to encourage green mobility modes. Other policies, such as differentiated parking fees and highway tolls, can encourage a shift to public transport, complemented by dedicated driving lanes for car-sharing. Public transportation fleets also offer the opportunity to utilise cost-competitive renewable fuels or electricity.

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Adopt ambitious targets for energy efficiency improvement with specific time horizons and outline clear avenues for implementation.
- Strengthen regulatory frameworks, including building codes that specify low energy performance and appliance energy efficiency standards.
- Expand the availability of financial incentives and affordable lending schemes for meeting standards on energy efficiency, such as tax credits or green loans with favourable interest rates for building renovation or modernisation.
- Establish public campaigns to build awareness of the role of energy efficiency measures, public transport and green mobility for cost savings and collective decarbonisation goals.

Market incentives and fiscal policy

While renewables have become increasingly competitive, they still face barriers compared to fossil fuels. Rising fossil fuel prices have acted as an important catalyst for energy efficiency measures; yet, energy efficiency improvements and renewables deployment still face financial and other obstacles, such as access to capital or long pay-back periods. Fiscal and regulatory incentives therefore play an important role in accelerating the deployment of both renewable energy and energy efficiency measures.

A progressive, supportive fiscal system can be achieved by eliminating market structures that favour the uptake of fossil fuels (e.g. phasing out direct and indirect fossil fuel subsidies) and reflecting environmental and social costs associated with the use of fossil fuels through taxation or other mechanisms. Such policies would improve the economic competitiveness of renewable energy and energy efficiency solutions.

Taxes and levies, subsidies or exemptions on duties for imported/exported components required by the renewables sector could kickstart private investment in renewables projects and manufacturing activity. Countries with fiscal restraints can benefit from donor finance to support building capacity and physical infrastructure for the integration of renewable power, among other important aspects that would assist those countries in advancing the energy transition.

The energy transition will only succeed if it is both deep and broad. Therefore, careful consideration of broader social and equity issues is also vital, particularly for low-income populations for whom energy constitutes a larger share of household expenditure. Financial support drawn from general taxation, tax on windfall profits and ongoing taxation of fossil fuel energy production and carbon pricing revenue can all be used to support the transition.

Regulatory policies, such as tariff-based procurement mechanisms – e.g. feed-in tariffs or auction schemes using a contracts for difference (CfD) mechanism, which provide stable prices over long periods – are also effective. The choice of instrument and its design should consider: the nature of the solution (e.g. utility-scale, distributed, off-grid); level of development of the sector; power system organisational structure; wider macroeconomic environment (e.g. impact of inflation and commodity price volatility); and broader policy objectives. It is important that price levels for public procurement schemes – and competitive auctions in particular – balance cost-efficient electricity supply to consumers with healthy, sustainable supply chain development for the renewables sector. However, any trade-offs in these areas must carefully consider the risk of non-delivery, given the very tight timeline to achieve the renewable power and energy efficiency targets for 2030.

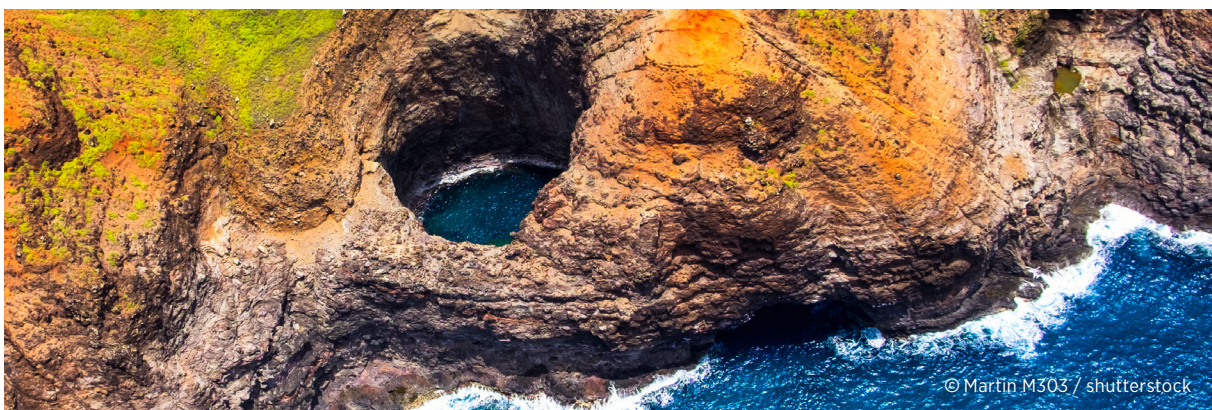


Private investments will continue to play a major role in the energy transition. As such, it is vital that policy makers ensure a policy and regulatory environment that de-risks investments and unlocks private capital flows to the renewables sector. Key factors include setting clear and ambitious capacity targets with a rolling schedule for procurement, as well as ensuring large volumes of land/seabed are made available – where under government control – for renewables development, and that permitting and environmental processes are efficient and streamlined (see below). This will help to provide predictability for investors, developers and supply chain actors, while enabling public authorities to efficiently plan for grid integration, workforce development and demand-side management.

Where procurement is facilitated by CfDs, power purchase agreements (PPAs) or other mechanisms, these should meet international standards for bankability in terms of their coverage of dispute mechanisms, grid connection delays and curtailment risk. A mechanism to allow for bilateral power procurement between generators and private off-takers (such as industrial actors or corporates) can further strengthen the case for large deployment volumes.

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Ensure fiscal policy prioritises equity in the energy transition, for instance by investing proceeds from taxes on fossil fuel energy production and carbon pricing mechanisms in enabling infrastructure, or supplementing clean electricity access for low-income populations via green financing schemes and other instruments.
- Introduce tax credits, levies and/or exemptions on import/export duties for key materials and components in the renewable energy supply chain.
- Ensure procurement schemes, including tenders, provide adequate price signals for investment and balance long-term price/cost risk mitigation with socio-economic value creation, thereby providing cost-efficient electricity, and enabling forward-planning and investment in renewable energy supply chains.
- Consider the trade-offs between ‘lowest-price’ objectives, and other policy outcomes such as socio-economic development, system integration and industry sustainability.



Power market design and regulation

The world is entering a new era in which electricity systems will be increasingly dominated by zero-marginal-cost renewable technologies. Power markets must evolve and adapt to new market forces, such as corporate and industrial demand, and behind-the-meter (prosumer) generation. They must be organised in a way that incentivises new investment in renewable power generation and the flexibility to provide reliable electricity at a level required for the 1.5°C pathway. This requires governments and other stakeholders to undertake a close examination of their power systems' organisational structures, *i.e.* the institutions, processes and arrangements through which electricity services are exchanged and rewarded.

Wholesale power markets today are based on marginal cost pricing, where the most expensive generator (with the highest variable cost – typically fossil fuel-fired plants) determines electricity prices for the time period in which the market operates. This poses a number of challenges. As the share of renewable power grows, wholesale spot markets will see increased price volatility, as periods of high renewable power generation push clearing prices in the wholesale market close to zero. When renewable generation is less than demand, flexibility resources will be needed, potentially resulting in very high prices at certain times.

If wholesale markets are the main source of revenue, the economic feasibility of new investments will plummet, as even existing generators will struggle to recover their initial capital costs whilst prospective investors realise diminishing returns. The paradigm that relies on free markets to incentivise power supply investment decisions therefore needs to change.

Ultimately, a renewables-based power system requires enhanced flexibility; wholesale market design must deliver this as well as providing the volume of renewable power needed. Policy makers must therefore urgently create the enabling conditions for power grid and system flexibility to integrate increasing shares of wind, solar and other forms of renewable energy.

Power system organisational structures must evolve to better align with energy policy and decarbonisation goals. A “dual procurement” power market design could introduce long-term contract mechanisms (*e.g.* Auctions, CfDs, PPAs) as the backbone of renewable power procurement, alongside a short-term market to dispatch flexible resources in an affordable way (IRENA, 2022a). This holistic model would incentivise continued investment in large-scale, capital-intensive renewable energy projects, while assuring the flexibility needed for a resilient and reliable renewables-based power system.

This transformation is partially underway, as auctions are becoming the preferred tool to procure renewable energy, and wholesale markets are becoming more time and location granular (IRENA, 2023a); but there are meaningful actions authorities can take now to ensure the acceleration of this trend.

One way to achieve enhanced system flexibility is for power markets to allow flexibility technologies (such as batteries and pumped hydropower) to provide ancillary services and be rewarded accordingly. Ancillary services that serve to stabilise the grid network and will become increasingly important as dispatchable fossil fuel-based generation is phased out of the power mix. Today, many power systems reward the provision of energy but not ancillary services (where these services are not included in contractual obligations). They therefore need to be appropriately valued and reflected in power system design. Valuing, pricing and procuring ancillary services astutely can bring new players to the grid, with advantages for the whole power system. Examples of this include the enhanced frequency regulation auctions in the UK.

To achieve the energy transition, individuals, communities and businesses will also need to become active participants in the energy system. This includes growth in distributed renewable energy generation systems – notably using solar PV – but also community solar and wind projects. This will require electrical grids that allow energy consumers to easily install and utilise small- to mid-scale renewable energy projects to cover their consumption, and/or inject power into the grid through connection schemes like net-metering and feed-in-tariffs. Such measures can maximise the socio-economic benefits of renewable energy, insulate consumers from price volatility, create local supply chains and job opportunities, and enhance public perceptions of renewables.

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Ensure price signals encourage sufficient investment in additional renewable capacity to meet climate and energy transition targets; and adopt renewable power procurement approaches that recognise the net benefits and costs of social, environmental, system integration and energy security factors.
- Design auctions that balance competitive price discovery and long-term delivery of affordable electricity. Auctions should also be run for sufficiently large and ambitious volumes, with consistent, transparent tendering schedules to effectively foster competitive bidding.
- Create a capacity market for flexibility services (including ancillary services and storage capacities of varying duration) with a long time horizon aligned to targeted renewable energy penetration of the power mix.
- Rethink participation rules to allow new technologies to engage in the power market as flexibility providers, including storage and demand side aggregators.
- Encourage investment in distributed renewable energy systems that allow consumers to become “prosumers” by both using and producing clean electricity.
- Reorganise power market structures to ensure policies for accelerating renewables deployment account for system flexibility as well as sustainable returns to generators and investors.



Streamlining permitting

The time and cost constraints imposed by permitting procedures represent a major bottleneck impacting the deployment of renewable energy projects in many countries. It is essential that permitting procedures are fit-for-purpose and keep pace with renewable and climate targets, without compromising environmental and social impact standards. Experiences from the public and private sectors indicate that best practices in permitting centre on four areas: administrative consolidation; digitalisation; policy support; and public engagement (European Commission, 2023).

Renewable energy developers often need to consult numerous authorities at national, sub-national and sometimes village or prefecture level for the necessary permits to build a project. This process can be lengthy and extremely bureaucratic; for instance, the global average time required for permitting an offshore wind project is nine years. Onshore wind and utility-scale PV permitting processes can also be long, although they are typically shorter than those for offshore wind. Similar obstacles exist for hydropower projects and smaller scale distributed projects for end consumers using renewable energy technologies like rooftop solar.

Creating dedicated, centralised authorities is one way to streamline this process by ensuring developers can refer to a single focal point. Countries like Denmark and the Philippines have already adopted a “one-stop shop” model to accelerate renewables deployment, but this model only works if it is adequately resourced. In addition, digitalised processes to submit and track applications would enable developments to progress more efficiently, while access to digitised local consenting and historical dispute records would allow developers and authorities to screen sites that could be high-risk or unsuitable at an early stage (IRENA, 2023h).

An overarching best practice is the introduction of legislation mandating a maximum lead time for the permitting of renewable energy projects. Revisions to the EU Renewable Energy Directive in 2023, for instance, set a maximum two-year lead time for permitting new renewables projects, and one year for repowering (refurbishing or replacing) wind and solar projects. Gaining social acceptance through public engagement with relevant stakeholders is critical in the consenting and constructing stages of a renewable energy project. This includes early and continuous consultation by authorities and developers with local communities to communicate the benefits and considerations brought by a project to the area, as well as a transparent conflict resolution mechanism that sincerely addresses community concerns.

Comprehensive and efficient permitting frameworks represent a clear win-win, allowing renewable energy development to expand this decade while cultivating acceptance with other interests in land and sea spaces. The Planning for Climate Commission has produced a nine-point plan for tackling climate change through fast and fair permitting for renewable energy and green hydrogen that provides best practices and can be consulted by policy makers worldwide (GHO, 2023).

Recent studies indicate that adopting best practices in permitting could cut consenting time for utility-scale wind and solar projects by more than half; for example, onshore wind farms could be permitted in one year, offshore wind farms in 1.5 years and solar farms in as little as three months (ETC, 2023). This makes permitting a high-impact enabler for the energy transition, where the necessary investment in resource, policy support and capacity will bring enormous value to countries in accelerating renewables growth and securing associated socio-economic and environmental benefits.

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Create a centralised authority to oversee permitting of renewables projects, consolidating information and requirements from all relevant authorities and issuing permits according to a transparent timeline.
- Mandate and enforce maximum lead times for applicants and authorities to complete the permitting stages of renewable energy projects, with discretionary additional time under exceptional circumstances for more complex projects.
- Allocate greater resources to permitting authorities, including human resources and investment in digitalisation and open-source databases, such as for land titles, mapping data and historical dispute records.
- Consider adopting efficient legal challenge processes by implementing a limited time window for raising disputes and establishing an authority to screen challenges, balancing public interests.
- Expedite processes for developers repowering assets on existing sites and provide the flexibility to adjust a proposed infrastructural, technological or social approach to projects without having to reapply for new permits.

Reducing negative impacts; maximising social and environmental benefits

Scaling up renewable energy deployment provides an opportunity to create widespread socio-economic benefits for communities around the world, including energy access, job creation, public health improvements and welfare generation. Renewable energy employment worldwide grew to an estimated 13.7 million direct and indirect jobs in 2022 (IRENA and ILO, 2023); under the 1.5°C pathway, tens of millions of additional jobs could be generated worldwide by 2030 (IRENA Coalition for Action, 2023).

The energy transition will bring benefits to any economy, but also challenges in the form of misalignments that may occur in finance, the labour force and the energy sector itself. If not well managed, these misalignments risk inequitable outcomes, which could sow doubt among policy makers and the public concerning the advantages of the transition and lead to a fractured and unco-ordinated policy environment. Hence, there is a need for policies and measures that equitably distribute the benefits of the energy transition and raise public awareness about these positive impacts.

In terms of jobs, sectoral misalignments may arise due to potential shifts in value and supply chains during the energy transition. For instance, transitioning from fossil fuel power generation to solar energy may shift the focus from fuel extraction to the semi-conductor industry. The impact on employment depends on factors such as domestic production and labour productivity. Labour-market interventions encompass adequate employment services attuned to evolving circumstances and needs, along with measures to facilitate labour mobility (IRENA and ILO, 2023).

Community benefit schemes span countries from Costa Rica to Mali and adopt a range of structures, from shared ownership of renewable assets to industry sponsorship of critical social and economic infrastructure in host communities (IRENA Coalition for Action, 2020). Under the right conditions and policies, citizen and community participation in renewable energy projects can accelerate deployment while boosting support for local energy transitions.

Aligning policies and measures with the principles of a just and equitable transition will facilitate local value creation and socio-economic benefits in host communities, and on a larger scale, ensure political and social stability as renewable energy expands.

As part of a sensitive and efficient permitting framework, renewable development must be well integrated with the principles of sustainability, circular economy and reduced environmental impact – particularly on land use and biodiversity. This also applies to enabling infrastructure, with grid expansion into remote and biodiverse areas requiring careful siting.

Adopting sustainable end-of-life management policies, including waste management legislation, can help countries prepare for the anticipated volumes of equipment waste such as solar PV panels and batteries. Research and development programmes across the energy and waste sectors, and industrial clusters, can help to further scale waste management infrastructure on a national or regional basis (IRENA and IEA, 2016).

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Align policies and measures with the principles of a just and equitable transition and foster local value creation and socio-economic benefits in host communities, with a special focus on the inclusion of marginalised groups.
- Anticipate labour market disruptions and establish programmes that can address workforce gaps, minimise labour misalignments, create opportunities for targeted recruitment and labour mobility, such as relocation grants, and establish social protection programmes.
- Minimise adverse environmental impacts and encourage nature-positive approaches, for example by incentivising the uptake of sustainability standards for new renewable energy assets – such as the Hydropower Sustainability Standard – as part of procurement schemes.
- Ensure the impacts of mining activities and the use of relatively scarce components are mitigated through provisions for circular economy (end-of-life management, recycling and reuse of materials).
- Gather information on renewables' waste production through regular monitoring of waste produced by technology, the composition of waste streams, installed system performance and the causes and frequency of system failures, in order to adopt waste minimisation legislation suitable for the pace and scale of the transition.

PATHWAY TO  +1.5°



SUPPLY CHAINS, SKILLS AND CAPACITIES

Building resilient supply chains

The vulnerabilities of key energy industries to logistics bottlenecks, commodity price volatility, trade barriers, and commodity and component import dependencies have become increasingly apparent in recent years. Energy supply chains have become a priority agenda for policy makers, as demand and competition for critical raw materials, rare earth elements and production capacity become more acute.

Without well-functioning and cost-efficient industrial supply chains, the energy transition will not materialise. If not well managed, competition, security and scarcity challenges in renewable energy supply chains could lead to a disorderly transition, characterised by slower rates of renewables deployment at inflated costs. A mismatch between supply and demand for several critical minerals is already evident, with particularly high levels observed for lithium – a key material required for the short-duration energy storage and electric transport sectors (IRENA, 2023e). Bottlenecks for key components in the wind industry – e.g. nacelles, blades and gearboxes – are set to emerge by the second half of this decade in Asia and the Americas (GWEC, 2023). High concentration risk in the global renewables supply chain also raises the prospect of price or security of supply uncertainty in the future.

Robust and resilient global supply chains are required to support a 1.5°C pathway. The mining and processing of critical materials including lithium, copper, nickel and other rare earth metals are constrained within specific geographies, exposing these supply chains to geopolitical tensions and concentration risks (IRENA, 2023e). Policy makers should work with the private sector to identify production gaps and supply chain weaknesses on a national and regional basis, and generate strategies to reinforce supply chain security.

Socially responsible procurement is another key issue, where many critical materials and components refined or manufactured in one country are imported by others for use in the renewables sector. It will be vital to ensure supply chains – in the mining and processing segments in particular – are managed with respect to fair trade, and high environmental, social governance (ESG) and sustainability standards. Resilient supply chains are also key to sustaining the cost-value proposition of renewable energy around the world.

As countries usher in large industrial policy packages for the energy transition, there is a risk of increasing barriers in the global exchange of renewable energy knowledge, innovation and technology transfer – all of which will be essential for a cost-effective and fair transition, particularly for emerging markets and developing economies. The need for local value creation and regional supply chain investment must be carefully balanced with reducing trade barriers for goods and services central to the renewables industry. This will be key to avoid intensifying supply chain bottlenecks and making renewables less cost-competitive, while maximising socio-economic benefits.

Multilateral alignment of supply chain, trade and industrial policies for the energy transition will be important in creating unified standards and investment protocols that can channel capital to the renewables sector and nascent green hydrogen sector, and encourage best-in-class development standards. This will require governments to work with industry, civil society and other stakeholders to ensure supply chain planning is conducted through a wider lens that encompasses national interests, cost-effective and socially responsible sourcing, long-term social and environmental sustainability, and climate and renewable energy targets.

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Collaborate with the renewables industry on industrial development reviews and plans for the transition that are sustainable, achievable, and adequately mitigate risk of supply insecurity and price volatility. Approaches include diversifying sources of production, anticipating critical production gaps and localising value chains.
- Ensure socially responsible procurement of renewables by encouraging uptake of sustainable supply chain assurance schemes, such as the Solar Stewardship Initiative.
- Incentivise public-private partnerships and investment in circularity to encourage reuse of materials and a circular economy approach to project development, which can help to reduce concentration risk and supply insecurity of critical materials.
- Co-operate with international fora and financial institutions to safeguard international trade corridors for materials and components for key renewable energy technologies.

Education, training and capacity-building

Building a skilled energy transition workforce requires measures to both expand the talent pipeline and enhance the quality of education and training provisions.

Early exposure to renewable energy topics and careers is vital for sparking interest in pursuing a career in the sector, but also to increase social acceptance by a knowledgeable citizenry. The curricula at higher education and vocational training institutions must reflect the skills and competences required by the transition.

In addition to strengthening the content of education and training programmes, it is also important to enhance the instructional methods used. For example, experiential learning methods where students are encouraged to develop problem-solving strategies can help to prepare learners for jobs in the constantly evolving renewable energy sector, where independent knowledge-seeking will often be necessary.

Facilitating collaboration between government agencies on workforce development, industry and educational institutions will contribute to more co-ordinated skill-matching efforts. It is vital to consider how a just transition can respond to potential labour displacement in the existing energy sector workforce and re-skill or upskill appropriately.

Targeted measures to train, recruit and retain women and other underrepresented or marginalised groups (including older workers, ethnic and religious minorities, people with disabilities and those on a low income) will ensure the dividends of the transition are enjoyed by all. This inclusion can be implemented through early exposure to renewable energy leadership and career pathways, targeted scholarships, government-funded training opportunities, and industry apprenticeship and mentorship schemes.

Outside the renewables industry, it is equally important to ensure sufficiently skilled and trained workers are available in government departments concerned with international trade, supply chains, electric charging infrastructure and land use. Fostering a broader understanding in the public sector of the interconnected nature of the energy transition, and the cascade effect of decarbonisation opportunities brought by a ramp-up of renewable electricity, can help to avoid knowledge silos and create more co-ordinated policy across different pillars of government.

Carefully designed public-private partnerships (PPPs) can also play a crucial role in improving overall training quality while meeting sectoral labour requirements, promoting national skill standards and matchmaking communities with workplace training opportunities. In addition to improving training content, PPPs can also play a role in shifting the financing of training provisions to a more integrated approach that incorporates multiple funding mechanisms including payroll-based training levies, tax incentives, scholarships and donations, vouchers and student loans (Dunbar, 2013).

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Align workforce planning among all stakeholders, including labour agencies, labour unions, the wider energy industry and educational institutions, to identify critical skill gaps and workforce needs in advance, and to design skill-building strategies accordingly.
- Provide capacity-building opportunities to a broad range of public sector departments – from energy to transport and industry – to foster a more comprehensive policy and technical understanding of different elements of the energy transition.
- Ensure energy transition goals are reflected in educational programmes and resources, such as university curricula, vocational training institutions, occupational health and safety training institutions, and professional education programmes.
- Build the talent pipeline by ensuring young people are exposed to renewable energy and transition career opportunities early in their education; and foster increased participation of women in the energy sector workforce.
- Invest in reskilling and upskilling measures for vulnerable communities and those in fossil fuel industries to ensure the employment benefits of the transition are extended to a wide subset of the population. Such measures need to be embedded in broader regional economic revitalisation programmes and investments.

PATHWAY TO +1.5°



SCALING-UP PUBLIC AND PRIVATE FINANCE⁸

Global investment in energy transition technologies reached USD 1.3 trillion in 2022⁹ – a new record high (IRENA and CPI, 2023). However, investments remain focused on a few technologies and concentrated in a limited number of countries. For instance, around 85% of global renewable energy investment benefitted less than 50% of the world’s population and Sub-Saharan Africa received less than 1% of the global total in the past two years (IRENA and CPI, 2023). This trend is reflected in renewable power capacity additions, as all of Africa accounted for less than 2% of additional capacity in 2022 (IRENA, 2023a; IRENA and CPI, 2023).

To achieve a tripling of renewable power capacity by 2030, the annual average investment in renewable power generation in the 2023-2030 period would need to reach USD 1 300 billion, compared to 486 billion in 2022. It is equally important that investments to modernise power grids and enhance operational flexibility increase from the annual average investment of USD 274 billion in 2022 to USD 605 billion by 2030.¹⁰

This presents a dual challenge: 1) how to scale existing investment flows in countries and technologies; and 2) how to ensure these investment flows reach countries that are currently underserved by the energy transition. Efforts to address the much higher cost of capital faced by developing economies – as much as three to five times more than in most OECD countries – are also needed (IRENA, 2023f). A substantial increase in public funding (especially in developing countries), along with interventions and innovations across fiscal, financial and regulatory policy are needed to drive cross-sector investment and ensure a sufficiently large pipeline of bankable renewable energy and storage projects.

Repurposing public capital from the fossil fuel sector, including both direct investments and financial support in the form of subsidies, can help accelerate progress towards unlocking the capital required. This public money can then catalyse private capital flows, amplifying investment efforts towards the USD 35 trillion required (for the energy transition as a whole) in the remainder of this decade.



8) This section draws on the content of the *World Energy Transitions Outlook 2023* (IRENA, 2023a).

9) This is as measured by financial investment decisions, actual spend in any year will differ.

10) Clean hydrogen here refers to green hydrogen (produced using renewable power) and blue hydrogen (produced using natural gas and complemented by carbon capture and storage [CCS] technologies).

For example, public financial flows to fossil fuels in the G20 countries alone reached USD 1.4 trillion in 2022 – more than double 2019 levels. Moreover, G20 governments supported the global fossil fuel industry through international aid, export credit support and concessional financing (such as equity, grants, loans and loan guarantees) at an average of USD 50 billion per year from 2019 to 2021 (IISD, 2023).

Public funding is urgently needed for basic energy infrastructure in the developing world, as well as to drive deployment in less mature technologies (especially in end uses such as industry and transport, or synthetic fuel production) and in areas where private investment is scarce. Without this, the gap in investment between the Global North and the Global South could continue to widen, to the detriment of billions of people and the success of a just and inclusive global energy transition.

A more comprehensive definition of risk around investing in energy assets is needed. A narrow focus on the return risk to investors must expand to encompass environmental and social risks. This approach, which should be exercised through rigorous international benchmarks and protocols for investment, can also help to shift funding from fossil fuel assets to the renewables sector. With limited public funds available in the developing world, the international community must step up.

Public funds (domestic or through international collaboration) must flow through intermediaries (e.g. governments, development finance institutions and global funds such as the Green Climate Fund). Such instruments should channel public funds towards policies that support structural change and a just transition. Furthermore, these instruments should be designed progressively to ensure economic benefits are shared in an equitable way.

Finally, public investments are needed for economic interventions to support a more equitable distribution of benefits from large-scale renewables growth. National carbon pricing revenues, for example, could be redirected to support clean, affordable electricity access for lower-income households on a progressive basis.

It is also important to actively engage the private sector, given that public financing alone will not be anywhere near sufficient to address the huge investment needs for the global energy transition. The public sector can play a catalysing role by providing a conducive and predictable enabling environment for the long-term investment decisions made in the private sector. Also, governments can set the right conditions for private sector actors to build and finance a viable pipeline of energy transition-oriented projects.

For example, blended finance structures would allow concessional public finance, and even philanthropic grant-based finance, to improve the risk-return profile of an investment, so that private capital is attracted at lower cost and/or better terms (IRENA, 2023g). Banks can also pool loans to relatively small renewables projects into a securitised product aimed at impact-minded investors, including retail investors who otherwise have few avenues to earn returns while funding renewables deployment (GFMA and BCG, 2020). The resulting financial portfolio of projects would reduce the perceived risk associated with its individual components. Such an approach would require a level of contract standardisation to enable the bundling of small projects (IRENA, 2021b).

While there is no shortage of capital to meet current rates of renewable energy deployment, it is clear that both public and private finance must expand significantly to support a 1.5°C-compliant pipeline of projects by 2030. In addition to the measures described above, capital mobilisation schemes like green bonds for renewables, as well as international coalition-building to guide distribution of renewables investment between the Global North and Global South, will be crucial to ensure renewables can equitably scale this decade.

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Redirect public capital flows from the fossil fuels sector – including direct investments, subsidies, export credit guarantees and concessional financing – to renewable energy and supportive infrastructure (including grid and transmission modernisation).
- Promote the adoption of a comprehensive definition of investment risk within public and private institutions that encompasses environmental and social externalities, thereby aligning financial decision-making with broader public and social goals.
- Collaborate with public and private sector actors to develop innovative, context-specific financing and business models that address renewable energy financing gaps in underinvested countries. This involves utilising blended finance, green bonds, financial aggregation, and innovative risk mitigation tools tailored to each country's unique needs.
- Direct the proceeds of fossil fuel taxation and carbon pricing mechanisms towards initiatives that support a just and inclusive energy transition, such as targeted support for lower income households and the provision of energy access.
- For Global North countries, actively engage in international climate finance frameworks that support the equitable distribution of renewable energy investment and technologies across the Global South.



Enhancing international collaboration

International collaboration is essential in the effort to reach global targets for renewable energy and energy efficiency by 2030. A fractured and unaligned approach to renewables deployment will lead to missed opportunities for countries to accelerate growth and enjoy the benefits of clean electricity, particularly in the Global South. Public and private stakeholders alike are responsible for enhancing participation in multilateral initiatives that can facilitate knowledge-sharing and capacity-building to deliver a just transition via a 1.5°C pathway.

With the lion's share of renewables investment benefiting developed economies, it will be important to strengthen North-South and South-South collaboration to maximise the social and economic benefits from clean industrialisation. Country blocs such as the G20 can be powerful coalitions to mobilise support and investment around the global renewable energy target and its key enablers.

Mobilising capital through enhanced energy and climate finance mechanisms – from green bonds to existing multilateral development banks – will be vital to meeting the investment needs of the global renewable power and energy efficiency targets. Public and private sector actors should work together through schemes and organisations like the Climate Bonds Initiative to improve blended finance initiatives and credibility in renewable energy and climate finance flows, while multilateral development banks and development finance institutions can co-operate on risk mitigation instruments and innovative financing that can drive a phase-down of fossil fuels in parallel with accelerating renewables.

Advanced economies are better positioned to mobilise public financing, but global policy frameworks are necessary to secure affordable funding to underpin the energy transition at the national level elsewhere. In emerging economies, just transition funds need to be established to support plant closures, communities in transition, repurposing/rehabilitation, and retraining and skilling, among other priorities. The way in which just energy transition funds – such as the Just Energy Transition Partnerships (JETPs) or other such initiatives – are structured is critical. A high proportion of the public funding mobilised will need to be grant-based, avoiding the danger of adding to already high debt burdens faced by many countries.

International climate finance has a key role to play in providing the public financing necessary for a just and fair energy transition. Its function will vary depending on the context; fossil fuel-dependent communities and countries will require targeted efforts to unwind lock-ins to the fossil fuel economy and plan an alternative development trajectory based on renewable power generation and economic activities (CPR, 2021). Countries where mitigation requirements consistent with climate targets go beyond their fair share of the global mitigation burden will require support to trigger the needed collaborative framework, leapfrog to renewables-based energy systems and reap their share of the transition benefits.

It will be important to ensure definitions, standards, governance and investment protocols for the energy transition are fairly aligned to effectively funnel capital to renewables development that meets high social and environmental standards. From green taxonomy to emissions reduction standards, the need for common ground in the renewables and green hydrogen sectors will be increasingly helpful for multinational investors, companies and civil society actors to navigate the transition.

International collaboration on renewable energy research and innovation will also be important to ensure that best-in-class technology and practices are being deployed not only in mature markets for renewable energy, but also frontier markets. There are many areas for continued innovation and learning, from DSM to LDES to green hydrogen derivatives – all of which will have a positive impact on decarbonisation. Platforms for knowledge-sharing and imparting lessons learnt, such as the IRENA Collaborative

Frameworks or the Global Offshore Wind Alliance (GOWA), are important vehicles to ensure ambition can be transformed into effective action at country level. This is particularly important for those countries that are most vulnerable to the severe impacts of climate change, and so face more significant challenges to protect communities without adequate support for adaptation measures (UNCTAD, 2022).

Finally, the development of regional power grids remains fertile ground for multilateral co-operation, as grid access planning can support the growth and integration of large volumes of renewable energy. The ASEAN regional power grid project provides an example of how countries with a surplus of clean electricity are exploring opportunities to trade with neighbouring countries that lack renewable energy resources (IRENA, 2022b; SEADS, 2023). Scaling up grid planning will support a more economic and sustainable approach to the transition, enabling better system balancing and resilience.

URGENT RECOMMENDATIONS FOR POLICY MAKERS

- Encourage multi-stakeholder collaboration on climate finance and renewable energy investment, resilient global supply chains for renewable energy, and grid connectivity. This requires public-private platforms that bring governments together with financial institutions, renewable energy developers and supply chain actors, civil society and other relevant stakeholders.
- Ensure just transition funds and programmes that crowd in international finance are well structured to support communities in the transition and contribute to virtuous cycles of renewable energy deployment and climate-resilient industrial growth.
- Encourage robust standards and investment protocols for the transition that can allocate capital to high-impact solutions in the renewables sector. This includes strict emissions standards as part of green taxonomies to guide a capital shift away from fossil fuels and accelerate the development of a green hydrogen sector.
- Participate in platforms for knowledge-sharing and exchange on renewable energy research, innovation and best practices across policy areas including auction design and corporate procurement. Technology exchange and harmonised standards can also build the resilience of the global renewable energy supply chain by achieving cost efficiencies, supporting best-in-class asset development and lowering barriers to market.
- Intensify co-operation with neighbouring governments and grid authorities on regional grid planning and opportunities for building interconnections, cross-border power trading, regional power pools and innovative approaches like meshed grids.





CONCLUSION

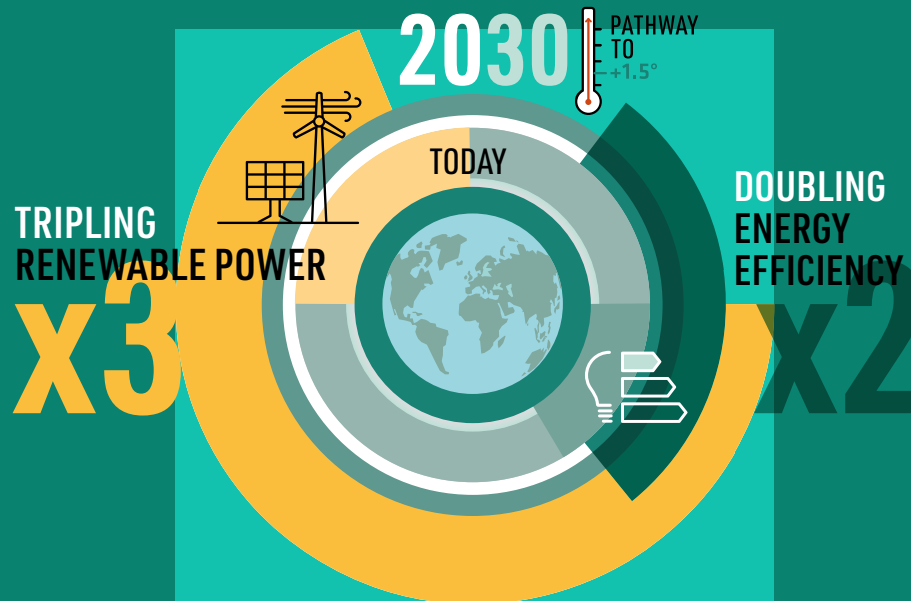
FROM AMBITION TO ACTION

As IRENA's 1.5°C Scenario in the *World Energy Transitions Outlook 2023* shows, global energy-related CO₂ emissions will need to be reduced significantly by 2030 to keep the Paris Agreement climate target within reach. This reduction will require a step change in action on both the supply and demand sides across the entire energy system.

Total global renewable power generation capacity – a key energy transition driver on the supply side – will need to more than triple from the 2022 level under the 1.5°C Scenario, with solar PV and wind power accounting for about 90% of the renewable energy capacity additions between now and 2030. This will need to be complemented by a phase-down in fossil fuel generation, physical infrastructure upgrades, modernisation and expansion, as well as enhanced grid flexibility.

On the demand side, energy efficiency improvements will be key. The global annual rate of energy intensity improvement would need to double by 2030 from the current level under the IRENA 1.5°C Scenario, helping to curb the growth of global final energy consumption without compromising the provision of energy services. This will not only require technological solutions but also behavioural changes, necessitating greater awareness and broad support from communities and individuals for the energy transition.

The twin goals of tripling renewable power and doubling energy efficiency by the end of this decade are undoubtedly challenging; but they are achievable. Their realisation requires urgent action by all stakeholders – governments (national, regional and local), international organisations, industry, finance institutions and energy end-users (from big industrial users to individual households). The sooner we act, the sooner we will unlock the net economic, environmental and socio-economic benefits of an energy transition pathway that is consistent with the Paris Agreement goals.



This report has identified five key enablers for the required scale up in renewable power and energy efficiency, with concrete and urgent recommendations for policy makers in each area:

- INFRASTRUCTURE AND SYSTEM OPERATION
- POLICY AND REGULATION
- SUPPLY CHAINS, SKILLS AND CAPACITIES
- FINANCE
- INTERNATIONAL COLLABORATION

To establish a more effective enabling environment for both the private sector and individuals to act, policy makers need to lead by setting ambitious and concrete targets, implementing cross-sector planning across the economy, providing fiscal incentives/disincentives and improving regulatory frameworks and efficiency. They also need to make sure that the energy transition fosters socio-economic benefits and minimises adverse environmental impacts. Public funding will need to be redirected from fossil fuels to energy transition technologies and infrastructure, whilst ensuring a more equitable distribution of investments and renewable energy installations between the Global North and the Global South. Enhanced international collaboration can help facilitate knowledge-sharing and capacity-building, as well as mobilise additional funding.

The current pace of action falls far short of that required to meet the 1.5°C target. COP28 provides a clear opportunity for world leaders to step up and agree new targets in two key areas: we must commit to tripling renewable power capacity and doubling energy efficiency to reach the 1.5°C target. Now is the time for an ambitious new pledge that safeguards the wellbeing of our planet and enables the equitable distribution of the benefits of the energy transition among all peoples, nations and regions of the world.

REFERENCES

- CPR (2021)**, *Managing a fair transition away from coal in India*, Centre for Policy Research, New Delhi, www.cprindia.org/managing-fair-transition-away-coal-india
- Dunbar, M. (2013)**, *Engaging the Private Sector in Skills Development*, Oxford Policy Management, Health & Education Advice and Resource Team, Oxford, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/213937/engagingprivate-sector-skills-development.pdf
- ETC (2023)**, *Streamlining planning and permitting to accelerate wind and solar deployment*, Energy Transitions Commission, www.energy-transitions.org/publications/planning-and-permitting/
- European Commission (2022)**, *Digitalising the energy system – EU action plan*, European Commission, Strasbourg, https://ec.europa.eu/commission/presscorner/api/files/document/print/en/qanda_22_6229/QANDA_22_6229_EN.pdf
- European Commission (2023)**, *Technical support for RES policy development and implementation – simplification of permission and administrative procedures for RES installations (RES Simplify)*, European Commission, Directorate-General for Energy, Strasbourg, <https://op.europa.eu/en/publication-detail/-/publication/0e9db9fa-d653-11ec-a95f-01aa75ed71a1/language-en>
- Fyson, C., et al. (2023)**, *2030 targets aligned to 1.5°C: evidence from the latest global pathways*, Climate Analytics, <https://climateanalytics.org/publications/2023/2030-targets-aligned-to-15c-evidence-from-the-latest-global-pathways/>
- GFMA and BCG (2020)**, *Climate Finance Markets and the Real Economy*, Global Financial Markets Association and Boston Consulting Group, Washington, D.C., www.gfma.org/policiesresources/gfma-and-bcg-report-on-climate-finance-markets-and-the-real-economy/
- GHO (2023)**, *Tackling climate change through fast and fair permitting for renewable energy and hydrogen: Recommendations from the Planning for Climate Commission*, Green Hydrogen Organisation, <https://gh2.org/planning-climate>
- GWEC (2023)**, *Global Wind Report 2023*, Global Wind Energy Council, Brussels, <https://gwec.net/globalwindreport2023/>
- Haegel, et al. (2023)**, "Photovoltaics at multi-terawatt scale: Waiting is not an option", *Science*, Vol. 380, Issue 6640, pp. 39-42, 6 April 2023, DOI: 10.1126/science.adf6957
- Hotmaps (2021)**, "Hotmaps Project - The open source mapping and planning tool for heating and cooling", www.hotmaps-project.eu (accessed 21 May 2021).
- 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 (2023)**, *Energy Efficiency: The Decade for Action*, International Energy Agency, Geneva, www.iea.org/reports/energy-efficiency-the-decade-for-action
- IHA (2023)**, *World Hydropower Outlook 2023*, International Hydropower Association, London, www.hydropower.org/publications/2023-world-hydropower-outlook
- IISD (2023)**, *Fanning the flames*, International Institute for Sustainable Development, Winnipeg, www.iisd.org/publications/report/fanning-flames-g20-support-of-fossil-fuels
- 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 (2019)**, *Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2019/Feb/Innovation-landscape-for-a-renewable-powered-future
- IRENA (2021a)**, *Sector coupling in facilitating integration of variable renewable energy in cities*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2021/Oct/Sector-Coupling-in-Cities
- IRENA (2021b)**, *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 (2022a)**, *RE-organising power systems for the transition*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jun/IRENA_Organising_Power_Systems_2022.pdf
- IRENA (2022b)**, *Renewable energy outlook for ASEAN: Towards a regional energy transition (2nd Edition)*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2022/Sep/Renewable-Energy-Outlook-for-ASEAN-2nd-edition (accessed 16 December 2022).
- IRENA (2023a)**, *World Energy Transitions Outlook 2023: 1.5°C Pathway*, Vol. 1, International Renewable Energy Agency, Abu Dhabi, <https://www.irena.org/Publications/2023/Jun/World-Energy-Transitions-Outlook-2023>
- IRENA (2023b)**, *Renewable power generation costs in 2022*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Aug/Renewable-Power-Generation-Costs-in-2022
- IRENA (2023c)**, *Renewable energy statistics 2023*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jul/Renewable-energy-statistics-2023
- IRENA (2023d)**, *Innovation landscape for smart electrification: Decarbonising end-use sectors with renewable power*, International Renewable Energy Agency, Abu Dhabi
- IRENA (2023e)**, *Geopolitics of the energy transition: Critical materials*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jul/Geopolitics-of-the-Energy-Transition-Critical-Materials
- IRENA (2023f)**, *The cost of financing for renewable power*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/May/The-cost-of-financing-forrenewable-power
- IRENA (2023g)**, *Low-cost finance for the energy transition*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/May/Low-cost-finance-for-the-energytransition

IRENA (2023h), *Enabling frameworks for offshore wind scale up: Innovations in permitting*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Sep/Enabling-frameworks-for-offshore-wind-scale-up

IRENA and AfDB (2022), *Renewable energy market analysis: Africa and its regions*, International Renewable Energy Agency and African Development Bank, Abu Dhabi and Abidjan, https://irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Market_Africa_2022.pdf

IRENA Coalition for Action (2020), *Stimulating investment in community energy: Broadening the ownership of renewables*, International Renewable Energy Agency, Abu Dhabi, https://coalition.irena.org/-/media/Files/IRENA/Coalition-for-Action/IRENA_Coalition_Stimulating_Investment_in_Community_Energy_2020.pdf

IRENA Coalition for Action (2022), *Sector coupling: A key concept for accelerating the energy transformation*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2022/Dec/Sector-coupling-A-key-concept-for-accelerating-the-energy-transformation

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 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 IEA (2016), *End-of-life management: Solar photovoltaic panels*, International Renewable Energy Agency and International Energy Agency, www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_IEAPVPS_End-of-Life_Solar_PV_Panels_2016.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).

LBNL (2022), *Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2021*, Lawrence Berkeley National Laboratory, Berkeley, CA, https://emp.lbl.gov/sites/default/files/queued_up_2021_04-13-2022.pdf (accessed 27 September 2023).

LDES Council and McKinsey & Co. (2021), *Net-zero power long duration energy storage for a renewable grid*, Long Duration Energy Storage Council, www.mckinsey.com/capabilities/sustainability/our-insights/net-zero-power-long-duration-energy-storage-for-a-renewable-grid

SEADS (2023), "Building the ASEAN Power Grid: Opportunities and Challenges", *Asian Development Bank, South East Asia Development Solutions*, <https://seads.adb.org/solutions/buildingasean-power-grid-opportunities-and-challenges>

UNCTAD (2022), *Least Developed Countries Report 2022: Daunting implications for structural transformation*, United Nations Conference on Trade and Development, Geneva, https://unctad.org/system/files/official-document/ldc2022_en.pdf





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2030

