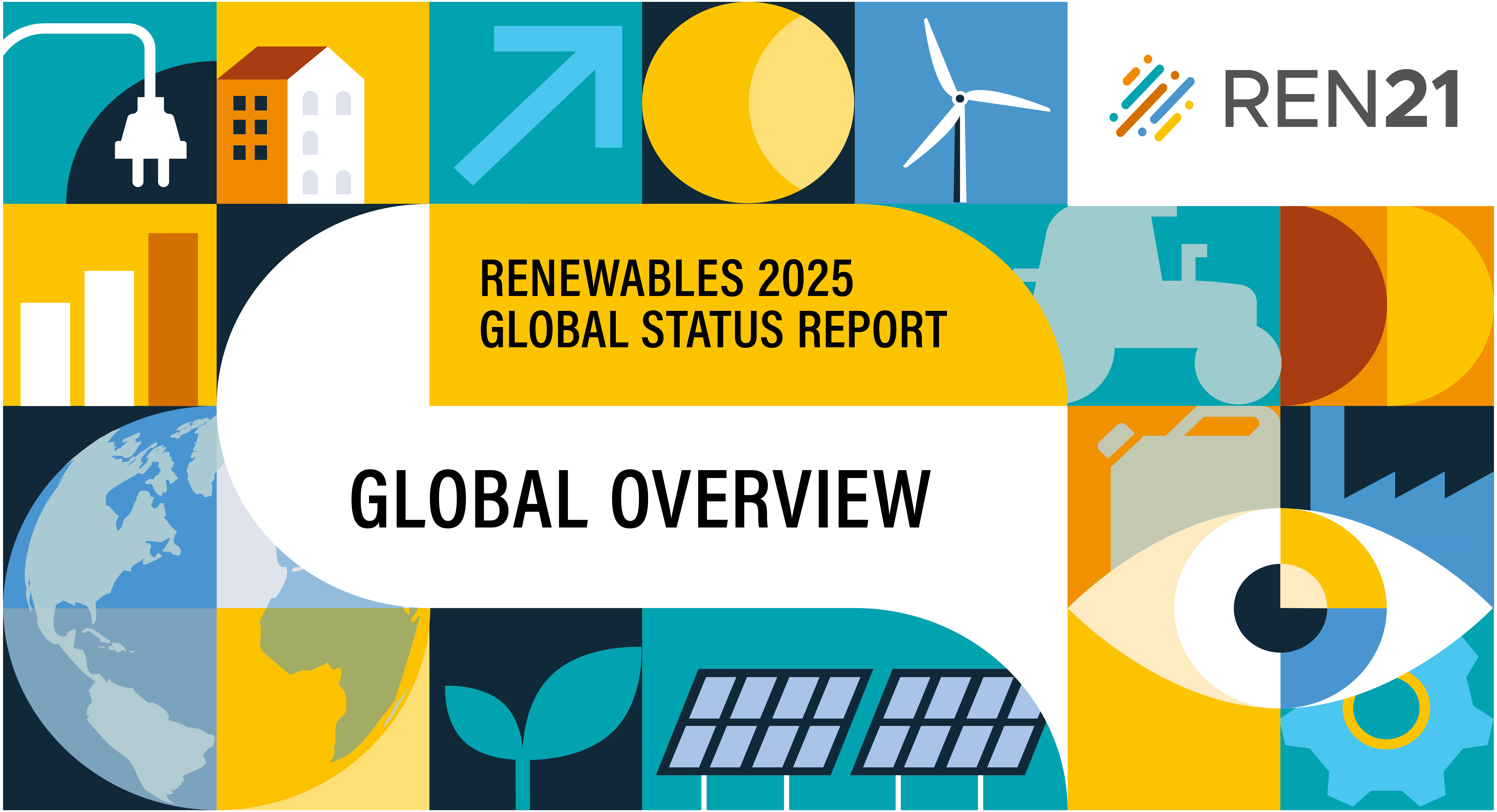


REN21

RENEWABLES 2025 GLOBAL STATUS REPORT

GLOBAL OVERVIEW

REN21 MEMBERS

GOVERNMENTS
Australia
Austria
Brazil
Denmark
Dominican Republic
Georgia
Germany
India
Republic of Korea
Mexico
Morocco
Norway
Panama
Río Negro Province, Argentina
South Africa
South Australia State, Australia
Spain
United Arab Emirates
United States
Zimbabwe

INTER-GOVERNMENTAL ORGANISATIONS
Asia Pacific Energy Research Centre (APERC)
Asian Development Bank (ADB)
ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)
Electric Power Council of the Commonwealth of Independent States (Executive Committee) (EPC)
European Commission (EC)
Global Environment Facility (GEF)
International Energy Agency (IEA)
International Renewable Energy Agency (IRENA)
Islamic Development Bank (IsDB)
Latin American Energy Organization (OLADE)
Regional Center for Renewable Energy and Energy Efficiency (RCREEE)
United Nations Development Programme (UNDP)
United Nations Environment Programme (UNEP)
United Nations Industrial Development Organization (UNIDO)
World Bank (WB)

INDUSTRY ASSOCIATIONS
Africa Minigrid Developers Association (AMDA)
Alliance for Rural Electrification (ARE)
American Council on Renewable Energy (ACORE)
Asia Pacific Urban Energy Association (APUEA)
Associação Lusófona de Energias Renováveis (ALER)
Chinese Renewable Energy Industries Association (CREIA)
Clean Energy Council (CEC)
Euroheat & Power (EHP)
European Heat Pump Association (EHPA)
European Renewable Energies Federation (EREF)
Global Off-Grid Lighting Association (GOGLA)
Global Solar Council (GSC)
Global Wind Energy Council (GWEC)
Green Hydrogen Organisation (GH2)
Indian Renewable Energy Federation (IREF)
International Geothermal Association (IGA)
International Hydropower Association (IHA)
International Union of Railways/Union Internationale des Chemins de Fer (UIC)
Long Duration Energy Storage Council (LDES)
Portuguese Renewable Energy Association (APREN)
RE100/Climate Group (RE100)
RES4Africa Foundation (RES4Africa)
Solar Heat Europe (SHE)
SolarPower Europe (SPE)
Union Internationale des Transports Publics (UITP)
World Bioenergy Association (WBA)
World Biogas Association
World Wind Energy Association (WWEA)

SCIENCE AND ACADEMIA
AEE – Institute for Sustainable Technologies (AEE-INTEC)
Council on Energy, Environment and Water (CEEW)
Fundación Bariloche (FB)
International Institute for Applied Systems Analysis (IIASA)
International Solar Energy Society (ISES)
National Renewable Energy Laboratory (NREL)
National Research University Higher School of Economics Russia (HSE)
South African National Energy Development Institute (SANEDI)
Stockholm Environment Institute (SEI)
The Energy and Resources Institute (TERI)
University of Technology – Institute for Sustainable Futures (UTS)
World Resources Institute (WRI)

MULTI-STAKEHOLDER NETWORK PARTNERSHIP
Hydropower Sustainability Alliance (HSA)
SLOCAT Partnership on Sustainable, Low Carbon Transport (SLOCAT)

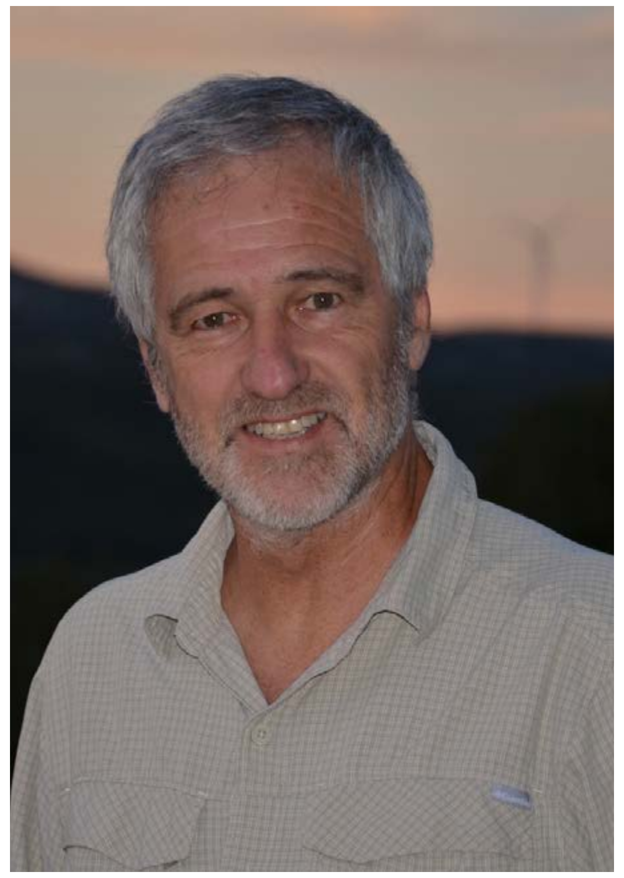
MEMBERS AT LARGE
Michael Eckhart
Rabia Ferroukhi
James Fletcher
David Hales
Kirsty Hamilton
Rosilena Lindo Riggs
Peter Rae

NON-GOVERNMENTAL ORGANISATIONS
350.org
African Association for Rural Electrification (Club-ER)
Asociación Ivy
CDP
Clean Cooking Alliance (CCA)
Climate Action Network International (CAN-I)
Coalition de Ciudades Capitales de las Americas (CC35)
Collaborative Labeling and Appliance Standards Program (CLASP)
Energy Cities
Energy Peace Partners (EPP)
European Youth Energy Network (EYEN)
Fundación Renovables (FER)
Global Forum on Sustainable Energy (GFSE)
Global Women's Network for the Energy Transition (GWNET)
Green Economy Coalition (GEC)
Greenpeace International
ICLEI – Local Governments for Sustainability
Institute for Sustainable Energy Policies (ISEP)
International Electrotechnical Commission (IEC)
International Institute for Sustainable Development (IISD)
Jeune Volontaires pour l'Environnement (JVE)
Mali Folkecenter (MFC)
Power for All
Power Shift Africa
Renewable Energy and Energy Efficiency Partnership (REEEP)
Renewable Energy Institute (REI)
Renewables Grid Initiative (RGI)
Solar Cookers International (SCI)
Solutions for Our Climate (SFOC)
Sustainable Energy Africa (SEA)
Sustainable Energy for All (SEforALL)
The Global 100% Renewable Energy Platform (Global 100%RE)
The Nature Conservancy (TNC)
Women Engage for a Common Future (WECF)
World Council for Renewable Energy (WCRE)
World Future Council (WFC)
World Wide Fund for Nature (WWF)

PRESIDENT
Ramón Méndez Galain

EXECUTIVE DIRECTOR
Rana Adib

FOREWORD | REN21 PRESIDENT



Ramón Méndez Galain

Former Energy Secretary, Uruguay
President, REN21

In Uruguay, we achieved what many thought impossible: we transformed our power system in less than a decade to run on nearly 100% renewables, half of which come from variable renewables sources like wind and solar. This shift didn't just reduce emissions. It cut energy costs, protected us from global fossil fuel/energy price volatility, expanded energy access to 99.9% of households, and created 50,000 new jobs – 3% of our workforce. But it doesn't end there. My country is now making progress in decarbonizing the industrial sector (where we've already reached 65% renewable energy) and, above all, in electrifying the demand for home heating with heat pumps and with electric mobility. Our experience shows that the energy transition is not a burden, but a foundation for resilience and prosperity. A renewables-based economy is not a theory. It is already working, in my country and in many others.

Yet today, we face a paradox. Now that we know a renewables-based electricity system works – and is often the cheapest option – the transition across the broader energy system is slowing, not accelerating. The power sector has proven that the renewable transformation is both technically feasible and economically viable, offering a blueprint for decarbonising heating, transport and industrial processes.

This is not a technical problem. It is a systemic one. Despite clear evidence from the power sector's success, fossil fuels remain favoured by markets, laws and outdated narratives. We are in the middle of a cultural and political battle, a battle of worldviews, and we need every voice at the table to transform our energy system.

That is why the Renewables Global Status Report (GSR) and REN21 are uniquely important. The GSR brings together facts, trends and real-world insights. It shows what is working, what is missing and what is possible. It connects governments, businesses, researchers and communities around a shared understanding. REN21 adds value not by doing what others do, but by enabling what no one can do alone – being a multi-stakeholder catalyst and building a common agenda.

Ensuring reliable, accessible and resilient renewable energy for all is not just about changing fuels. It's about changing the system. This is not a small adjustment; it's a deep transformation. And to make it happen, we need courage, we need collaboration, and above all, we need clarity. That's what this Global Overview offers: a clear picture, built from real experiences, to help all of us move forward together.

Ramón Méndez Galain
President, REN21

FOREWORD | REN21 EXECUTIVE DIRECTOR

Rana Adib

Executive Director, REN21

2024 marked a pivotal moment for renewable energy. The world added over 700 GW of renewable power capacity – the largest annual increase to date. This record growth signals real momentum in the shift to renewables.

But it came against a stark backdrop. For the first full year on record, global temperatures remained above 1.5°C. Wildfires, floods and other climate-driven disasters disrupted lives and energy systems across continents, underscoring the urgent need for systemic change.

Fossil fuels continued to fill part of rising energy demand, pushing CO_2 emissions up by 0.8%. Yet the scale of renewable deployment shows growing capacity to meet global needs, and to shape a different energy future.

Despite policy reversals in some regions, many governments advanced bold renewable strategies. Energy security is now understood as not just fuel supply, but resilience, affordability and infrastructure.

This shift matters. Renewables deliver more than climate benefits: they offer stability, energy sovereignty and economic resilience. The technologies exist. The momentum is here. What's needed now is sustained political will and scaled-up investment.

To unlock the sector's full potential, we must build flexible grids, reform institutions, align sectors and direct finance where it drives real impact. With coordinated structural change, renewables can power resilient, equitable economies.

The *Renewables 2025 Global Status Report* captures insights from across our global network. It provides decision makers with the tools to act – urgently and at scale.

We thank the REN21 network, our global contributors, and the REN21 Secretariat team. Let us move forward together with purpose, determination, and the resolve to turn momentum into lasting change.

Rana Adib
Executive Director, REN21

REN21

RENEWABLE ENERGY POLICY NETWORK
FOR THE 21st CENTURY

REN21 is the only global multi-stakeholder network focused on driving the transition to a renewables-based economy. For over 20 years, we've delivered trusted data, strategic insight, and an impartial platform for debate and collaboration.

Respected for our credibility and convening power, REN21 brings together governments, industry, civil society and academia to bridge silos, spark dialogue and drive informed decisions. We prioritise inclusion – especially of those too often excluded from decision making, including non-traditional actors and those from developing and emerging markets.

With fossil fuel dependence still deeply entrenched and progress too slow and fragmented, REN21 is evolving its approach to tackle the systemic barriers stalling the transition. By leveraging our unique network and launching targeted Change Programmes, we aim to drive the deep structural shifts needed for the energy transition – a shift that underpins resilient, secure and equitable societies, and is essential to realise a world that runs on renewables.

BUILDING THE RENEWABLES-BASED ECONOMY

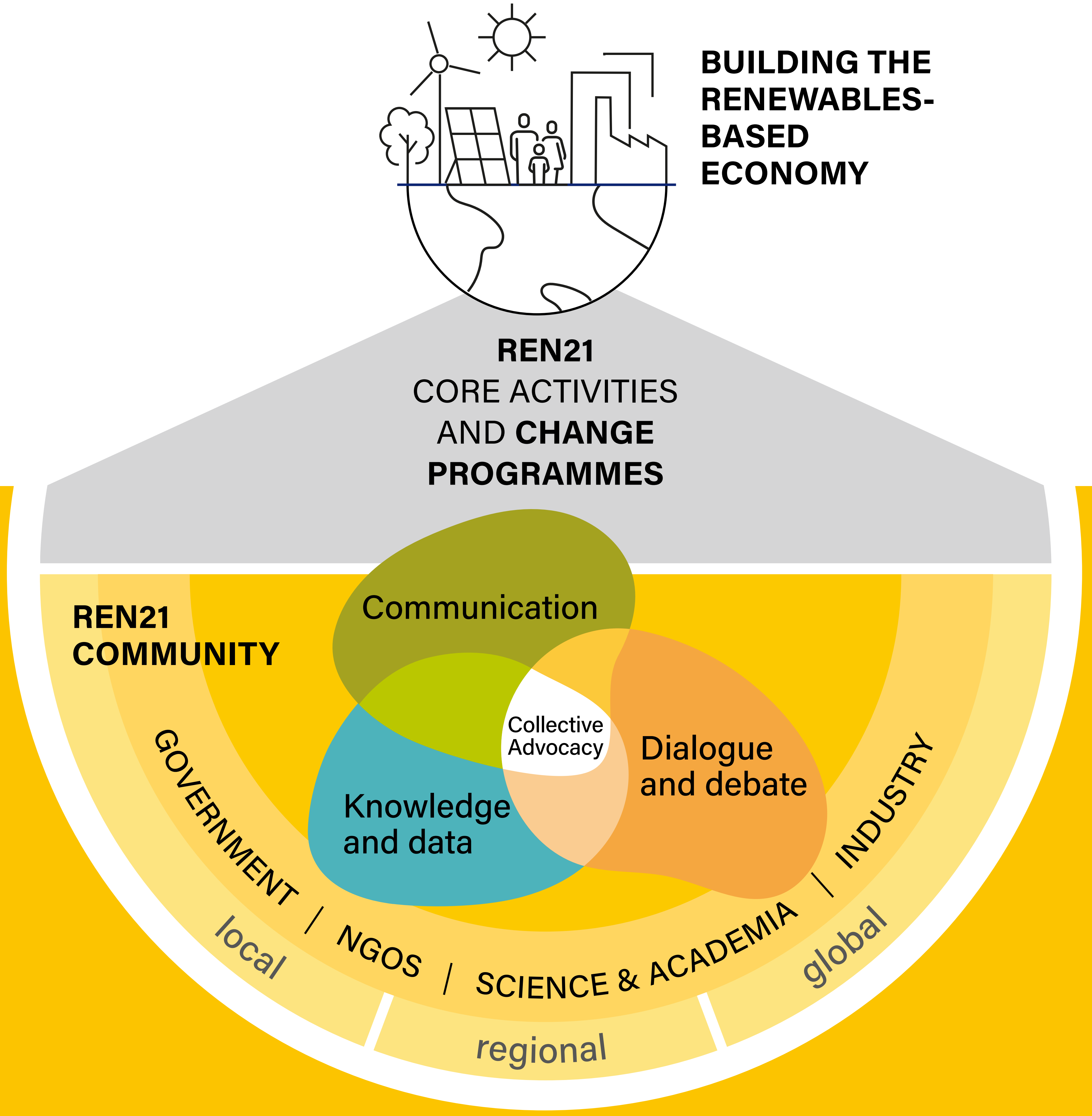
REN21's Approach: ORCHESTRATING SYSTEMIC CHANGE THROUGH A MOBILISED COMMUNITY

REN21 enables the shift to a renewables-based economy by aligning actors, shaping agendas and enabling action at scale.

Our approach is anchored in three core pillars: **trusted data and intelligence, inclusive convening and debate, and strategic communication** — delivered through a dynamic toolbox of high-impact activities such as dialogues, roundtables, campaigns and policy briefings.

At the centre is our diverse global community. **REN21 works with and through this network** — governments, industry, civil society and more — who, collectively, act as the real change agents. As an independent orchestrator, REN21 connects the dots, fosters collaboration and facilitates collective action.

This approach comes to life through our flagship **Change Programmes**: cross-sector initiatives co-created to dismantle the structural barriers, amplify advocacy and drive progress.



Supported by:

Federal Ministry for Economic Affairs and Energy

Federal Ministry for Economic Cooperation and Development

on the basis of a decision by the German Bundestag

This report was commissioned by REN21 and produced in collaboration with a global network of research partners. Financing was provided by the German Federal Ministry for Economic Cooperation and Development (BMZ) and the German Federal Ministry for Economic Affairs and Energy (BMWE).

A large share of the research for this report was conducted on a voluntary basis.

© getty images for unsplash.com

RENEWABLES GLOBAL STATUS REPORT | 2025 COLLECTION

Since 2005, ***REN21's Renewables Global Status Report (GSR)*** has tracked developments and emerging trends shaping the future of renewables through a collaborative process involving hundreds of experts worldwide.

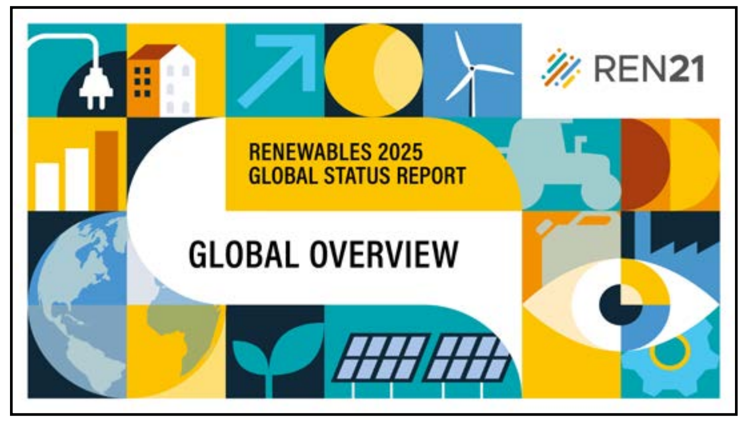
Now in its 20th edition, the 2025 GSR builds on the modular format introduced in recent years, offering an even more accessible and comprehensive view of global renewable energy progress.

This year's edition features an expanded set of factsheets that provide concise, sector-specific insights across both supply and demand, reflecting the latest developments in renewable energy.

Together, these publications offer a systemic and cross-sectoral overview of the uptake, impact, and integration of renewables worldwide.

Visit the GSR 2025 microsite for interactive figures and open data sets:
→ **www.ren21.gsr2025.net**

GLOBAL OVERVIEW



ENERGY DEMAND

Factsheets

coming in July 2025

- → Renewables in Industry
- → Renewables in Transport
- → Renewables in Buildings
- → Renewables in Agriculture

ENERGY SUPPLY

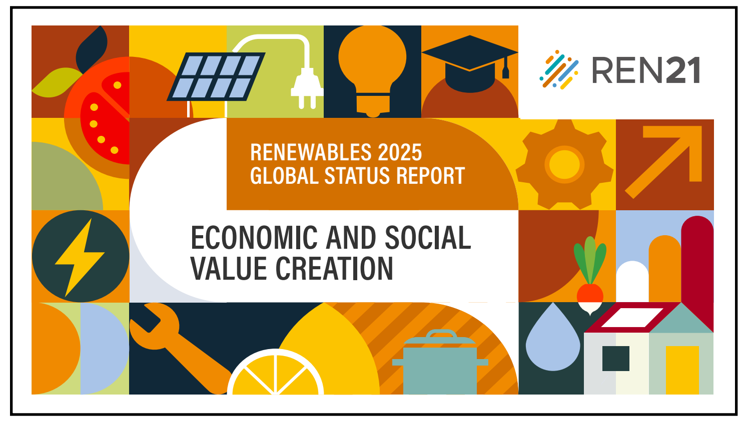
Factsheets

- → Bioenergy
- → Concentrated Solar Thermal Power (CSP)
- → Geothermal Power and Heat
- → Hydropower

coming in September 2025

- → Ocean Power
- → Solar Photovoltaics (PV)
- → Solar Thermal Heating
- → Wind Power

ECONOMIC & SOCIAL VALUE CREATION



coming in October 2025


© fokke baarssen/shutterstock.com

ACKNOWLEDGEMENTS

REN21 DATA AND KNOWLEDGE TEAM
Jad Baba
Janne Luise Piper
Andrea Wainer
Jiayi Wang
Glen Wright

SPECIAL ADVISORS
Janet L. Sawin
Freyr Sverrisson

RESEARCHERS
Siddharth Goel (Lead Researcher)
Pedro Chevez (Buildings and Energy Efficiency)
Hind Couzin (Industry and Transport)
Jonathan Lyons (Industry, Geothermal and Ocean)
Janet Sawin (Solar Thermal and Wind Power)
Kristin Seyboth (Finance and Investment)
Freyr Sverrisson (Geothermal and Hydropower)
Richard Thonig (Concentrated Solar Power)
Gianluca Tonolo (Solar PV)
Maria van Veldhuizen (Agriculture)

DATA AND PROJECT SUPPORT
Nicolas Achury
Noelle Okwedy
Alexandre Roussel
Hend Yaqoob

EDITING, DESIGN AND LAYOUT
Lisa Mastny (Editor)
weeks.de Werbeagentur GmbH (Design)

PRODUCTION AND COMMUNICATION
REN21 Secretariat, Paris, France

DISCLAIMER:

REN21 releases issue papers and reports to emphasise the importance of renewable energy and to generate discussion on issues central to the promotion of renewable energy. While REN21 papers and reports have benefited from the considerations and input from the REN21 community, they do not necessarily represent a consensus among network participants on any given point. Although the information given in this report is the best available to the authors at the time, REN21 and its participants cannot be held liable for its accuracy and correctness.

The designations employed and the presentation of material in the maps in this report do not imply the expression of any opinion whatsoever concerning the legal status of any region, country, territory, city or area or of its authorities, and is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers or boundaries and to the name of any territory, city or area.

The methodology and taxonomy of the REN21 Policy Database were updated for the Renewables 2025 Global Status Report to improve clarity and reflect evolving policy trends. As a result, data presented in this edition may not be fully comparable with figures published in previous Renewables Global Status Reports.

The GSR 2025 builds on data from 2024, where possible, or on the latest data available.

ACKNOWLEDGEMENTS

CONTRIBUTORS

Mohammed Abdalghafoor (Ernst and Young); Hadiza Abdulmumini (SDG7 Youth Constituency/IRENA Youth Council); Mahmoud Abou Elenen (GE Vernova); Hassan Aboughalma (Georenco); Rob Ackril (Nottingham Trent University); Sunday Richardsson Adesuyi (independent researcher); Salem Afeworki (Value Sustainability); Florencia Agatiello (RELP); Gamze Akarsu (Nature Biodiversity Risk); Housam Al Rakouki (Fraunhofer IEG); Sami Al-Nabulsi (independent consultant); Rajia Alhabouby (Innovation Energie Developpement); Nevin Alija (Global Future Energy Leaders); Yavar Anani (Mapna Group); Margalita Arabidze (Ministry of Economy and Sustainable Development of Georgia); Ivana Audia (United Nations Environment Programme Copenhagen Climate Centre); Olurotimi Olakunle Awodiji (University of Jos); Bouramdane Ayat-Allah (independent consultant); Fadeke Ayoola (NET Africa); Mara Braun (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH – GIZ); Nupur Bapuly (The Nature Conservancy); Emma Baz (ArcelorMittal); Franco Borrello (WindSol Consulting); Wemogar Elijah Borweh (University of Liberia); Ayat-Allah Bouramdane (International University of Rabat); Gonzalo Bravo (Bariloche Foundation); Christoph Brunner (AEE-Institute for Sustainable Technologies – AEE INTEC); Bernardo Joel Carrillo Castillo (independent consultant); Chia-Wei Chao (Taiwan Climate Action Network); Bhanu Venkata Krishna Chennapragada (Gayatri Vidya Parishad College of Engineering); Luiz Miranda Ciochetti (Energyc); Suani Coelho (University of São Paulo); Giuseppe Costanzo (WindEurope); Hind Couzin (independent consultant); Nour El Houda Daas (GIZ); Duttatreya Das (Ember Energy); Saikat Das (YOUNGO Energy Working Group); Pedro R. Días (Solar Heat Europe); Ana Díaz Vidal (Sciences Po); Nhat Do (International Institute for Sustainable Development – IISD); Fengli Du (China Solar Thermal Alliance); Julie Dulce (Manila Electric Company); Gordon Edge (International Hydropower Association – IHA); Lydia El Bouazzati (independent consultant); Bärbel Epp (solrico); Oghosa Erhahon (Long Duration Energy Storage Council); A. Ricardo J. Esparta (EQAO/BlockC); Rodrigo Valdovinos Flores (IDMA Institut Chile); Panagiotis Fragkos (E3Modelling); Theophilus Adu Frimpong (Cape Coast Technical University); Shirish S Garud (independent consultant); Duncan Gibb (Regulatory Assistance Project); Pagindhu Yudha Ginting (PT. Indonesia Pomalaa Industry Park); Julien Glaser (Bundesministerium für Wirtschaft und Energie – BMWE); Anastasia Grabco (DVC Partners); Stefan Gsänger (World Wind Energy Association); Elif Gündüzyeli (The Nature Conservancy); Leif Gustavsson (LGT); Andrea Carolina Gutierrez Gomez (University of São Paulo); Siena Hacker (CLASP); Fusun Haklidir (İstanbul Bilgi University); John Hensley (American Clean Power Association); Gabriela Hernández Luna (CIICAp-UAEM); Rainer Hinrichs-Rahlwes (European Renewable Energies Federation); Catharina Horn (NOW GmbH); Abdulwahab Ibrahim (University of Ilorin); Sammy Jamar (Continent Rising); Wim Jonker Klunne (Energy4Africa); Suraj Kanojia (independent consultant); Kamil Kaygusuz (Karadeniz Teknik Üniversitesi); Amin Yahya Khotbehsara (Mapna Group); Shirley Kisuya (independent consultant); Shigeki Kobayashi (Transport Institute of Central Japan); Bharadwaj Kummamuru (World Bioenergy Association); Abigail Kuria (CLASP); Bernard Kwofie (Komfuekuman Foundation); Tara Laan (IISD); Maryse Labriet (Eneris Consultants); Dana Lawrence (independent consultant); Nathalie Ledanois (independent consultant); Alejandra Leon (World Bioenergy Association); Debora Ley (United Nations Economic Commission for Latin America and the Caribbean); Jiang Lin (University of California at Berkeley); Rosilena Lindo (independent consultant); Njoke Mbanda Lionel (Global SDGs and Leadership Development Center); Nkweauseh Reginald Longfor (Sophia University); Juan Roberto Lozano-Maya (Mexico National Energy Control Center); Jonathan Lyons (TheGreenConsult); Abubakar Musa Magaga (Nigerian Institute of Transport Technology); Thailys Campos Magalhães (University of Porto); Kamil Maqsood (REN21); Brandon Marler (IHA); Gaëtan Masson (IEA PVPS); Gabriel Mbangu Simau (University of Zambia); Jonathan Mhango (independent consultant); Doug Miller (Energy Peace Partners); Pradeep Kumar Monga (World Biogas Association); Saurabh Motiwala (Indian Institute of Technology Bombay); Sabatha Mthwecu (Solar Rais); Sumoni Mukherjee (Changescape Consulting); Namiz Musafer (Integrated Development Association – IDeA Kandy); Mussa Abbasi Mussa (Ministry of Energy, Tanzania); Gamuchirai Mutezo (Madam Waste and University of Johannesburg); Amon Mwadime (Africa Minigrid Developers Association); Daya Ram Nhuchhen (City of Edmonton); Onyekachi Nwafor (KatexPower); Brian Nyaware (C40 Cities); Noelle Okwedy (Nextier); Victor Otieno (World Resources Institute – WRI); Josh Oxby (SDG7 Youth Constituency); Ramesh Poluru (The INCLEN Trust International); Ramendra Prasad (University of Fiji); Aleksandra Prodan (United Nations Development Program – UNDP); Liliana Proskuryakova (HSE University); Pallav Purohit (International Institute for Applied Systems Analysis); Mohammad Javad Rahimi (FSTco Center for Renewable Energies); Swasti Raizada (IISD); Munira Raji (University of Plymouth); Nizomiddin Rakhmanov (independent consultant); Bard Rama (independent consultant); Shayan Razaghy (independent consultant); Dave Renne (International Solar Energy Society); Alejandra Romano (Fundación Bariloche); Heather Rosmarin (InterAmerican Clean Energy Institute); Ana Rovzar (Global Renewable Alliance); Bikash Kumar Sahu (Torrent Power Ltd); Khalid Salmi (independent consultant); Miguel Schloss (Surinvest Ltda.); Henning Schuler (Ocean Energy Europe); Cécile Seguineaud (independent consultant); Martina Serao (RES4Africa Foundation); Ali Shahhoseini (Mapna Group); Mweetwa Mundia Sikamikami (TiBE); Kamil Sobczak (RenewStats.com); Laiz Souto (University of Bath); Monika Spörk-Dür (AEE INTEC); Elios Sprung (GIZ); Anneli Stutz (GIZ); Paul H. Suding (independent consultant); Mehdi Tafazoli (Mapna Group); Yael Taranto (SHURA Energy Transition Center); Faruk Telemcioglu (independent consultant); Richard Thonig (CSP.guru); Fabrice Fouodji Toche (Action pour la Formation et la Gestion des Ressources Naturelles – AFOGREN); Gianluca Tonolo (Haki Energy Solutions); Galyna Trypolska (Institute for Economics and Forecasting of the National Academy of Sciences of Ukraine); Prachi Ugle (independent consultant); Rodrigo Valdovinos (IDMA Institut Chile); Kartik Veerakumar (independent consultant); Matías Verdú (Association of Energy Engineers); Julia von Franz (Alliance for Rural Electrification – ARE); Martha Wakoli (CLASP); Marion Walker (Zentrum für Sonnenergie- und Wasserstoff-Forschung Baden-Württemberg – ZSW); Yu Wang (Xuchen Energy); Leianne Wijnhoud (WRI); Shane Wilson (independent consultant); Jeremy Woods (Centre for Environmental Policy, Imperial College London); Peter Yang (Case Western Reserve University); YOUNGO Energy Working Group (United Nations Framework Convention on Climate Change); Hameedullah Zaheb (Kabul University); Feng Zhao (Global Wind Energy Council).

TABLE OF CONTENTS GLOBAL OVERVIEW

INTRODUCTION

POLICY AND COMMITMENTS

INVESTMENT AND FINANCE

RENEWABLES IN ENERGY SUPPLY

ENERGY SYSTEMS AND INFRASTRUCTURE

RENEWABLES IN ENERGY DEMAND

CHALLENGES AND OPPORTUNITIES

FIGURES

SNAPSHOTS

TABLES

SIDEBARS

BOXES

INTRODUCTION

GLOBAL CONTEXT

In 2024, global renewable energy growth was primarily driven by the power sector, where capacity expanded by 741 gigawatts (GW), the largest annual increase ever recorded.[1] Solar photovoltaics (PV) led this growth, supported by rapidly falling costs, large-scale deployments and mature supply chains; however, growth in wind energy installations slowed.[2] Deployment of battery storage hit record levels, driven by falling prices and growing recognition of storage as critical for grid reliability.[3] Despite this momentum, renewable energy growth could not keep pace with rising global electricity demand.[4]

Growth in electricity demand was driven by higher temperatures, industrial expansion and rapid electrification in emerging markets.[5] Data centres consumed large amounts of electricity as use of artificial intelligence (AI) technologies continued to grow.[6] Renewables were deployed to meet some of this demand, and fossil fuels filled the gap.[7] Global energy-related carbon dioxide (CO_2) emissions increased 0.8% compared to 2023.[8]

The year 2024 was the hottest on record, and for the first time the global average temperature exceeded 1.5 degrees Celsius (°C) above pre-industrial levels over a full calendar year.[9] Climate impacts intensified worldwide: Los Angeles (United States) faced severe wildfires, Valencia (Spain) experienced extreme flooding, droughts hit Latin America, and flash floods inundated the Caribbean.[10] These events disrupted communities, economies, and energy systems, with vulnerable regions suffering the most. This series of disasters again emphasises that the climate emergency is not a future threat – it is already disrupting lives and livelihoods across the planet.

Energy security remained in the spotlight in 2024, as geopolitical tensions, trade disruptions and rising economic nationalism influenced national energy strategies.[11] (→ *See Sidebar 1.*) Countries sought to secure supply, reduce external dependencies and control prices. While some countries accelerated their investments in renewables and energy storage to reduce risk and increase resilience, fossil fuel investments also grew, often driven by industrial lobbying and short-term security concerns.[12] As these developments underscore, the energy transition is shaped not only by technical and economic factors, but also by political and governance choices, domestic pressures and competing visions of national interest.

Renewable energy is no longer just a climate solution; it is essential infrastructure. In a world of intersecting crises, renewables support sustainable economic development, public health and energy security.

SIDEBAR 1. ENERGY SECURITY

Energy security is again at the centre of policy agendas worldwide, but the meaning of security and the ways it is pursued are evolving. Once defined as having an uninterrupted fuel supply and strategic reserves, energy security is now viewed through a broader lens. It includes affordability and access to energy, resilience to physical and digital threats, control over energy infrastructure and technologies, and the capacity to withstand climate, economic and geopolitical shocks. Governments, regulators and institutions are adjusting their strategies to confront overlapping crises and deep structural dependencies.

Affordability has emerged as a dominant concern in both high-income and low-income countries. Surging prices for fossil fuels have triggered political and economic instability, prompting governments to introduce subsidies, tax breaks and emergency transfers. These measures offer short-term relief but often entrench fiscal vulnerabilities, delay structural reform and are often poorly distributed. .

In countries with long-standing fuel subsidies, price volatility has led to unrest or service breakdowns. Removing subsidies can deepen poverty – particularly if not paired with measures to make clean alternatives, such as renewable electricity and clean cooking, more affordable. Policy makers increasingly present renewables and electrification as long-term stabilisers of energy markets. Their effectiveness, however, depends on the availability of inclusive financing mechanisms such as pay-as-you-go models, concessional credit and targeted public investment.

In many regions, energy security is still defined by the uninterrupted availability of energy sources at an affordable price. Countries in sub-Saharan Africa and South Asia, as well as many small-island developing states, continue to face chronic energy insecurity due to limited electricity access and underinvestment. As the global energy transition accelerates, the risk of exclusion is growing. Without deliberate efforts to expand distributed systems and to close service gaps, millions will be left behind.

Infrastructure resilience has become a central pillar of energy security. Droughts, floods, wildfires and heatwaves are damaging power generation assets, grid systems and transport infrastructure. System operators are responding with updated reliability standards, climate contingency plans and investments in decentralised, modular systems. These investments not only improve climate resilience but also support domestic industrial capacity and job creation, reinforcing local economies.

The role of renewables in strengthening resilience is increasingly evident. Decentralised systems can maintain energy supply during extreme events. Renewable-powered mini- and microgrids support adaptation to climate impacts and energy system shocks in both remote and urban settings, through technologies such as wind and solar power and geothermal energy. Yet resilience planning remains underfunded in many countries, particularly where infrastructure is centralised or ageing.

As digital risks grow, cybersecurity has become a core element of energy governance. Attacks on wind farms, transmission systems and energy management platforms across Europe, Latin America and Asia have revealed vulnerabilities in highly connected systems. As digitalisation expands, so does the range of potential attacks. Governments are developing national cyber strategies, auditing hardware supply chains and improving co-ordination among energy and security agencies. However, many countries, particularly in the Global South, still lack the regulatory frameworks and institutional capacity to ensure digital resilience.

continued next page

Strategic autonomy is shaping a new wave of industrial policy. Countries are not only seeking to diversify their fuel sources, but also to reduce dependence on imported technologies critical to the energy transition. The United States, European Union, India and others have launched large-scale initiatives to localise manufacturing of solar PV, batteries, wind turbines and hydrogen electrolysers.

In parallel, some governments have doubled down on fossil fuels and nuclear energy. Still, the growth of domestic renewable energy industries is increasingly seen as a pathway to more resilient supply chains and long-term economic gains. In China renewables and enabling technologies contributed to an estimated 10% of gross domestic product (GDP) in 2024. Ensuring secure access to supply chains, innovation ecosystems and intellectual property is now treated as a core energy security priority. As a result, geopolitical focus is shifting from fossil fuel transport corridors to manufacturing hubs and trade rules that govern access to low-carbon technologies.

Security concerns have also spurred greater investment in electric vehicles (EVs), particularly in fossil fuel importing countries such as China, India and Türkiye. However, rising trade restrictions threaten to undermine this progress. In the first half of 2025, tariffs on EVs and lithium-ion batteries from China, imposed by the United States and the EU, increased costs and slowed the deployment. Meanwhile, manufacturing overcapacity in China has helped drive down global prices for solar panels, batteries and EVs. This dynamic has improved affordability but also threatens the commercial viability of new manufacturing projects outside China, raising concerns about long-term competitiveness and resilience.

At the same time, nationalist and populist actors are using energy security narratives to justify protectionist or anti-climate policies. In multiple regions, calls for energy sovereignty have gained political traction. Although national control over energy supply is a legitimate goal, its politicisation brings the risk of undermining co-operation and delaying progress on shared resilience and decarbonisation objectives.

Energy security is no longer a narrow technical issue; it has become a central organising principle of energy policy. But without a systemic and inclusive approach, today's responses could deepen inequality and reinforce fragmentation. Lasting energy security must be built on resilience, equity, and long-term vision, with systems designed to serve both people and the planet.

Source: See endnote 11 for this section.

RENEWABLE ENERGY DEVELOPMENTS AND TRENDS

In 2024, global renewable power capacity increased 18%, adding a record-breaking 741 GW.[13] Solar PV was the primary driver, contributing 602 GW and accounting for 81% of the total capacity increase.[14] Wind energy followed, adding 117 GW globally.[15] Other renewable sources – whether for power, heat or transport fuels – accounted for only small additions to the global energy supply. China was the dominant contributor to new renewable power deployment, responsible for 60% of the global total.[16] The Group of Seven (G7) nations accounted for just around 14%.[17] Even at the record growth levels of 2024, projections indicate that the world will fall 800 GW short of the internationally agreed target calling for a tripling of renewable power by 2030.[18]

Despite its dominant contribution, the annual growth rate of solar PV power capacity additions fell to 32%, down from 82% in 2023 and 35% in 2022.[19] This slowdown reflects growing challenges, including grid saturation, policy shifts and tighter financing in several key markets.[20] Wind power capacity grew 0.2%.[21] China continued to expand its wind energy capacity, adding 79.8 GW in 2024, whereas additions in other regions slowed significantly.[22]

Electricity generation from renewables increased 10% in 2024, doubling the 5% increase seen in 2023.[23] However, this growth was accompanied by a slowing of investment. Total global investment in renewable energy[i] reached USD 728 billion in 2024, up 8% from the previous year.[24] This was well below the growth rates of 19% in 2023 and 23% in 2022.[25] The main reason for this slowdown was a substantial decline in wind power investment.[26]

Electric vehicle sales reached a new record in 2024, with 17 million units sold worldwide.[27] Despite this milestone, the global growth in EV sales slowed to 25%, compared with 34% in 2023 and 55% in 2022.[28] Strong demand in China and other emerging economies was in contrast to modest gains in the United States and a clear slowdown in the European Union (EU).[29] In Europe, the withdrawal of EV purchase subsidies in Germany, combined with the anticipated roll-out of EU-wide CO_2 standards in 2025, led to a cooling of consumer demand.[30] Meanwhile, investment in road transport infrastructure increased 20% to reach USD 757 billion in 2024, exceeding investment in renewables[ii].[31] Global investment in heat pumps fell from USD 81.4 billion in 2023 to USD 77.1 billion in 2024, with a slowdown in sales in key markets (especially Europe) due to economic conditions, subsidised fossil fuels and reduced incentives.[32]

i Data from BloombergNEF classify the following technologies as renewables: biofuels; biomass and waste; geothermal; ocean; small hydropower (between 1-50 MW); solar; and wind.

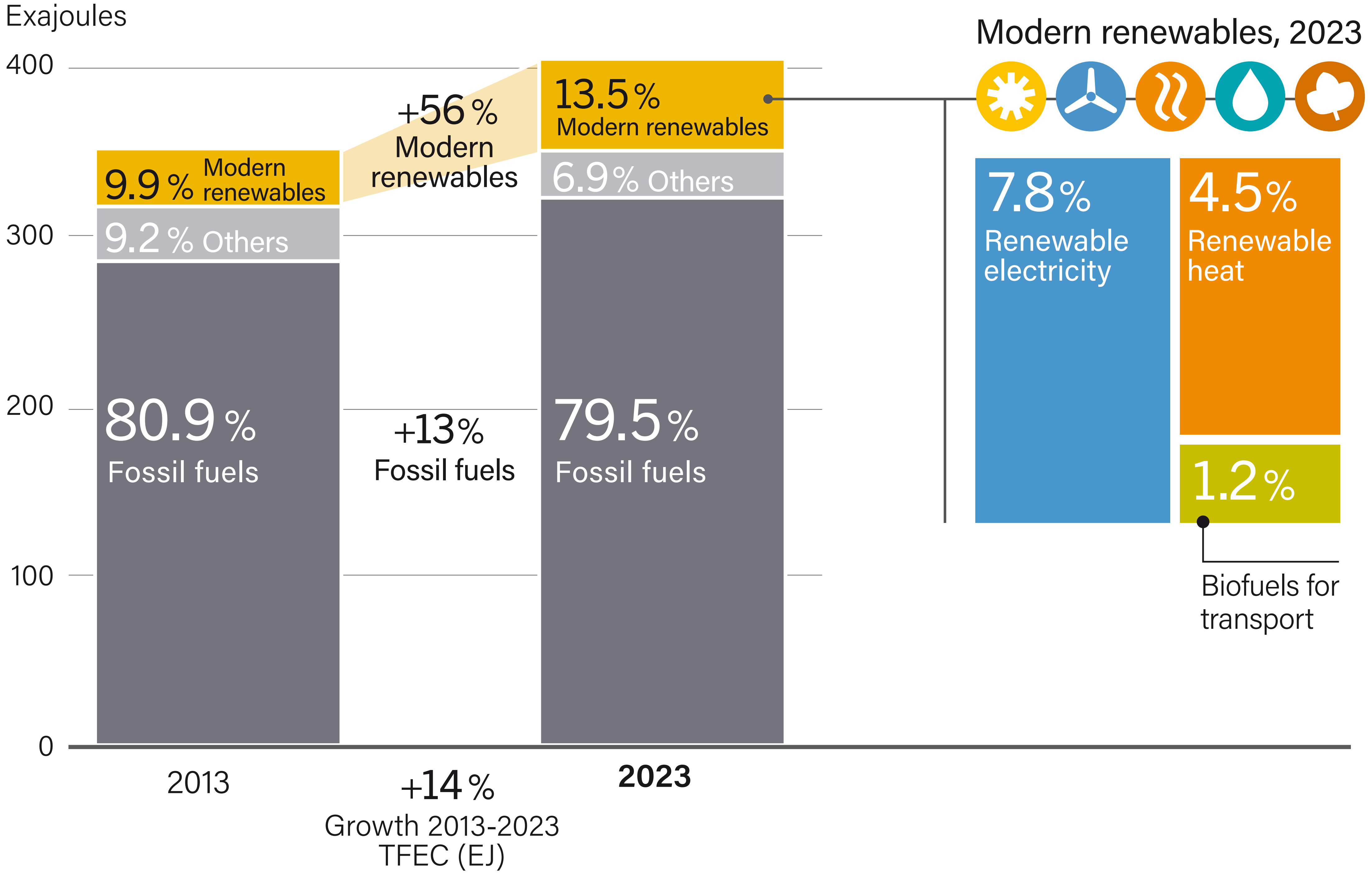
ii Including EV and fuel-cell vehicle sales and charging infrastructure.

RENEWABLES IN THE GLOBAL ENERGY SYSTEM

Global energy demand continued to rise in 2023.[33] The increase was reflected across all end-use sectors, as total final energy consumption (TFEC) grew 2.2%.[34] The estimated share of renewable energy in TFEC in 2023 was 13.5%.[35] (→ *See Figure 1.*) Industry remained the largest end-use sector, accounting for 34% of total consumption, followed by buildings (31%), transport (31%) and agriculture (2.5%) and other energy uses (1.5%).[36] In 2023, Iceland remained the country with the highest share of renewable energy in TFEC at 83%, owing to hydropower and geothermal; Lao People's Democratic Republic (PDR) (73%) and Gabon (66%) followed, both of which rely heavily on hydropower.[37] (→ *See Figure 2.*)

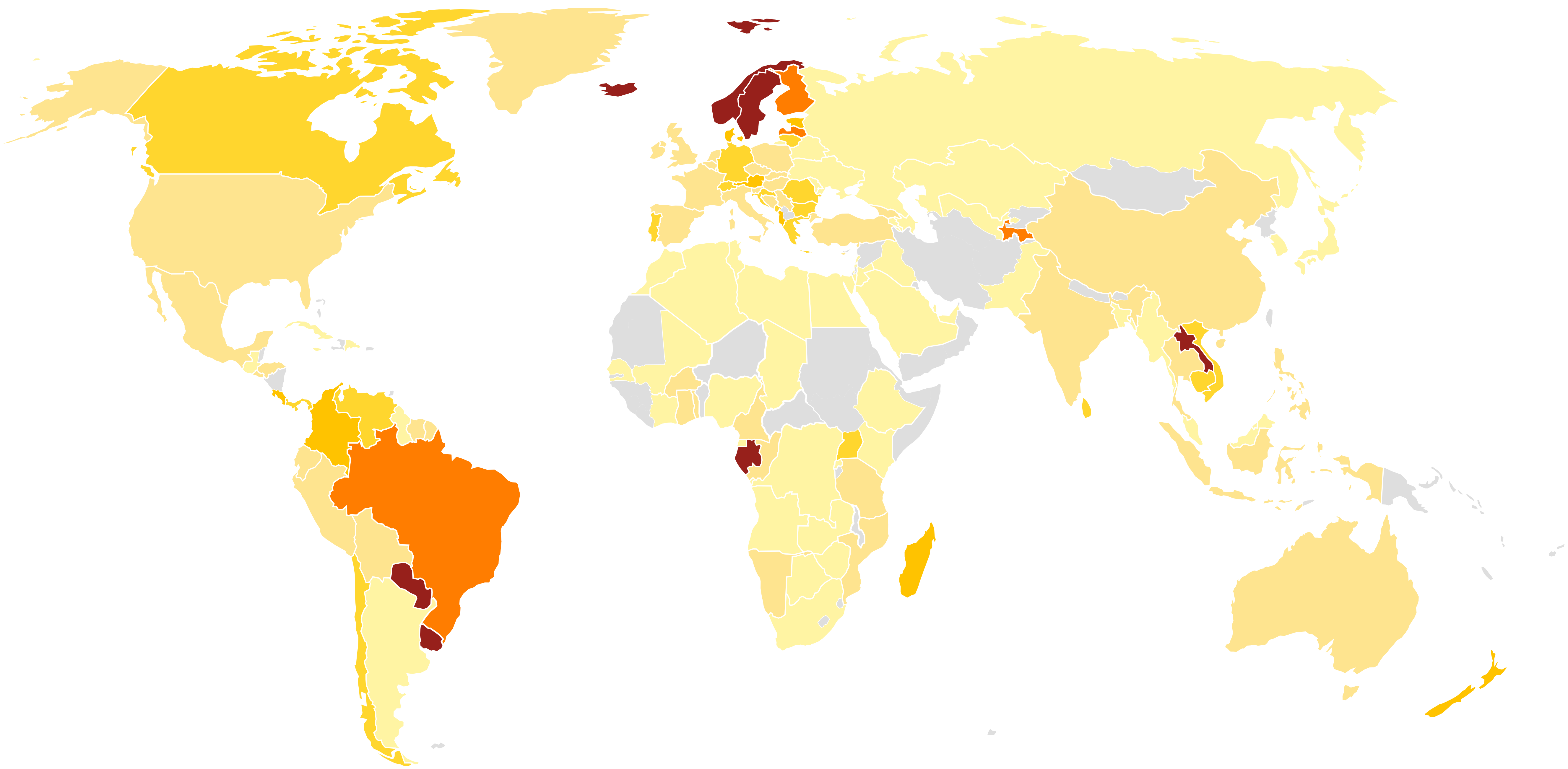
Sets of cooling towers in the data center

FIGURE 1.
Total Final Energy Consumption by Source, 2013 and 2023



Source: Based on IEA World Energy Balance, 2025, processed by REN21. See endnote 35 for this section.
Note: The 2023 data is a projection. The category "others" includes traditional biomass and nuclear.

FIGURE 2.
Renewable Share of Total Final Energy Consumption, by Country, 2022



Renewable share of TFEC

No data | 0-9% | 10-19% | 20-29% | 30-39% | 40-49% | >50%

Number of countries

Source: See endnote 37 for this section.

Electricity demand increased 4.3% in 2024, up from growth of 2.5% in 2023 and well above the annual average growth of 2.7% between 2010 and 2023.[38] This increase was driven primarily by rising cooling needs and rapid industrial development in emerging economies.[39] Energy demand also rose in advanced economies, notably in the United States, where the proliferation of infrastructure for data centres created substantial new electricity loads.[40]

Renewable capacity additions met two-thirds of the increase in global power demand, while the use of fossil fuels, particularly coal and natural gas, also increased.[41] Electricity from coal reached a global all-time high in 2024, although the growth rate slowed to 0.88% (1.7% in 2023).[42] In total, 44 GW of new coal-fired power capacity was commissioned in 2024, surpassing the 25.2 GW of coal capacity that was retired in the same period.[43]

The number of people without access to electricity declined by more than 8 million from over 745 million in 2023 to around 737 million in 2024.[44] Sub-Saharan Africa accounted for the vast majority of the global electricity access gap, with 80% of those without access residing in the region.[45] Achieving Sustainable Development Goal 7.1 – universal electricity access by 2030 – would require the number of people without access to decline at a rate roughly ten times faster than the current pace.[46]

Meanwhile, global progress on energy efficiency remained weak at around 1% in 2024.[47] This was unchanged from 2023 and well below the average annual gains of the previous decade.[48] This stagnation is particularly concerning in light of the commitment made at the 2023 United Nations Climate Change Conference in Dubai, United Arab Emirates (COP 28) to double the annual rate of energy efficiency improvement from 2% to 4% by 2030.[49] Gains were led primarily by the United States and the EU, where regulatory frameworks and market incentives helped reduce energy waste across sectors.[50]

The insufficient deployment of renewables and slow progress on energy efficiency meant that emissions again increased in 2024, albeit at the slowest rate since the easing of the COVID-19 pandemic in 2021.[51]


© i viewfinder, shutterstock.com

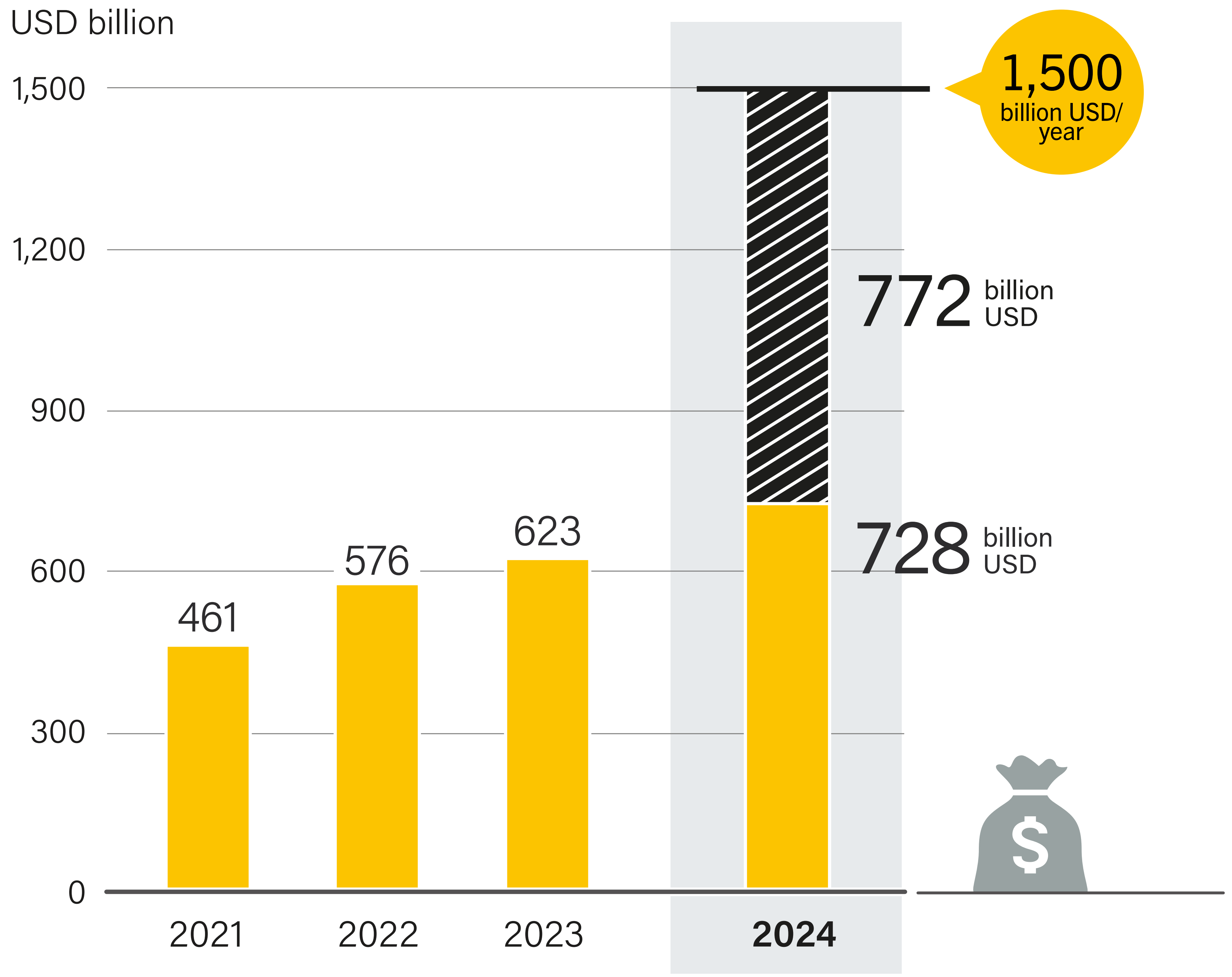
Several governments and private actors showed evidence of backsliding on climate and energy commitments amid rising trade barriers, grid-related constraints, political shifts and policy changes.[52] In early 2025, the new United States administration announced plans to withdraw once again from the Paris Agreement, promote fossil fuels, and roll back domestic and international support for renewables and climate-related projects.[53] The EU postponed its implementation of stricter CO_2 emission standards that had been scheduled for 2025.[54] New Zealand reversed its ban on offshore oil and fossil gas exploration and withdrew incentives for EVs, although the government also took measures to speed up consenting processes for renewable energy installations.[55]

The underlying economics of renewable energy have nonetheless continued to improve, and renewables increasingly outcompete fossil fuel technologies on cost grounds alone.[56] To achieve the internationally agreed target to triple renewable energy power capacity by 2030, an additional USD 772 billion investment will be needed between 2025 and 2030.[57] (→ *See Figure 3.*)

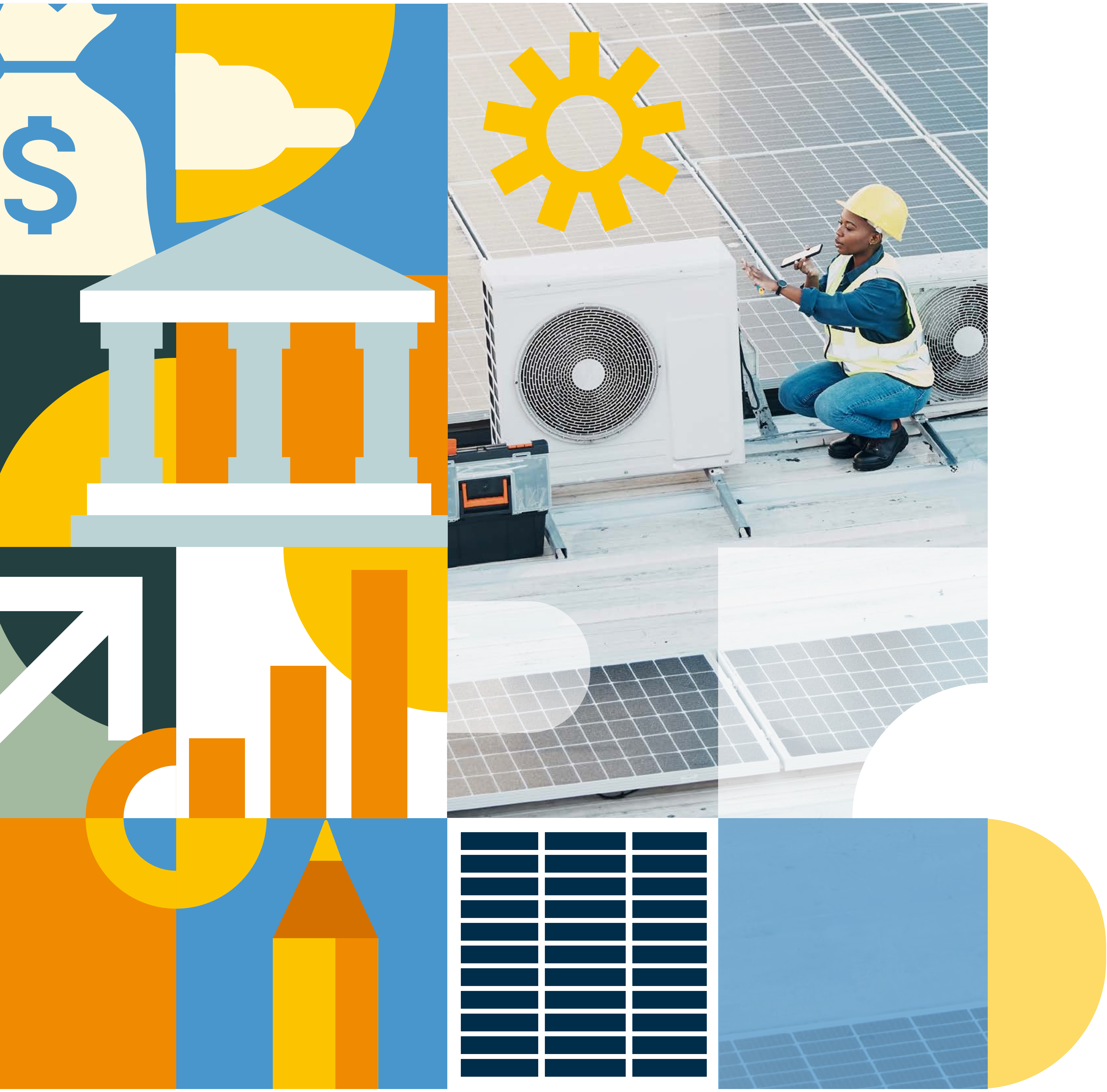

© Andrew F. Kazmierski, shutterstock.com

More than **2x** investment needed to reach COP28 tripling target.

FIGURE 3.
Investment Gap to Reach the COP 28 Tripling Power Target by 2030



Source: See endnote 57 for this section.



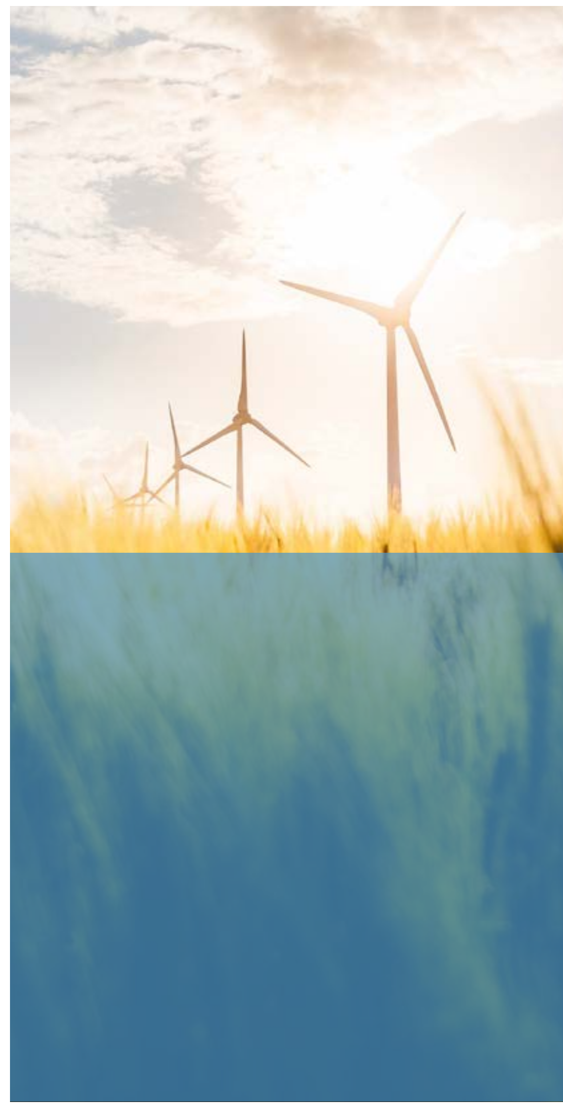
POLICY AND COMMITMENTS

In 2024, policies and commitments on renewables showed uneven progress. Some governments raised ambition through updated targets and supporting policy mechanisms, while others stalled or backtracked. Most policy attention continued to centre on the renewable power sector, with less focus on renewable heating, cooling and renewable fuels[i].[1]

CLIMATE AND ENERGY COMMITMENTS

Several new **international climate and energy commitments** were announced in 2024, yet their implementation remained vague. At the 2024 United Nations Climate Change Conference in Baku, Azerbaijan (COP 29), developed countries agreed to triple climate finance for developing nations.[2] The new target is for developed countries to provide USD 300 billion annually, with combined public and private flows expected to reach USD 1.3 trillion per year by 2035.[3] However, this outcome drew criticism from civil society organisations and climate-vulnerable countries — including least developed countries and members of the Alliance of Small Island States (AOSIS) — which argued that the pledges fall short of what is needed in light of escalating climate impacts and the urgent need for adaptation finance.[4] The agreement also lacked clarity on how the funds would be mobilised and allocated.[5]

The final outcome document of COP 29 did not call for "transitioning away from fossil fuels", reflecting a step backwards compared to the stronger language adopted a year earlier at COP 28.[6] This omission was seen by many as a setback for global climate policy, and an indication of the ongoing resistance from fossil fuel interests that is weakening the push for co-ordinated phase-out strategies.[7]



i The data in this section draw from the REN21 Policy Database. Developed and regularly updated by REN21, the database tracks renewable energy targets and policies across sectors and policy types, primarily at the national level, to support the analysis of ambition and implementation. The REN21 Policy Database is currently being expanded to enhance coverage across governance levels (including sub-national levels) and end-use sectors.


© metamorworks, shutterstock.com

Global subsidies for fossil fuels remained high at

1.1 USD trillion

in 2023.

Only

22 countries

submitted updated NDCs by May 2025.

COP 29 delivered three notable energy pledges:

- A pledge on Green Energy Zones and Corridors – backed by 57 countries, including Belgium, Türkiye, and the United Kingdom, along with non-governmental actors – aims to connect renewable-rich areas with demand centres through large-scale inter-regional grids.[8]
- The Global Energy Storage and Grids Pledge, which included commitments from 65 countries, sets collective goals to deploy 1,500 gigawatts (GW) of energy storage, double global grid investment and build 25 million kilometres of new grid infrastructure by 2030.[9]
- The Hydrogen Declaration committed 62 countries to scale up green hydrogen production and reduce their reliance on fossil-based hydrogen.[10] Green hydrogen output was less than 1 million tonnes in 2024, compared to 96 million tonnes for fossil-derived hydrogen.[11]

The Group of Seven (G7) countries announced a pledge to phase out "unabated" coal power plants between 2030 and 2035.[12] The language left room for interpretation, allowing countries to align with their own pathways towards net zero greenhouse gas emissions, seen as a concession to coal-dependent G7 members such as Germany and Japan.[13] The G7 also remains unlikely to meet its earlier target of eliminating "inefficient" fossil fuel subsidies by 2025.[14] Global subsidies for fossil fuels remained high at USD 1.1 trillion in 2023[i,15] Although this was down from the record USD 1.7 trillion in 2022, it remains a major barrier to the energy transition.[16]

Whereas international-level pledges help set the tone for global ambition, **national commitments** determine whether this ambition translates into tangible progress. This is particularly evident in the case of energy access. An estimated 737 million people worldwide still lacked access to electricity as of 2024.[17] Current improvement rates remain far below what is needed to meet the target for universal electricity access by 2030, set in Sustainable Development Goal (SDG) 7.1.[18] While some governments have adopted national energy access targets in line with SDG 7, underpinned by renewable energy strategies, many fall short on implementation and financing.[19] (→ *See Sidebar 2.*).

As of May 2025, of the 195 Parties that had signed the Paris Agreement, 180 had submitted at least one set of **Nationally Determined Contributions (NDCs)** in the decade since 2015.[20] However, only 22 countries (together contributing just 21% of global greenhouse gas emissions) had submitted their updated NDCs[ii], which include climate targets for 2025-2035.[21]

Changes in government, leadership or political priorities led several countries to reverse or delay overall climate measures in 2024.[22] Just 13 countries met the NDC submission deadline of 10 February 2025, and several major emitters missed the deadline.[23] However, all 22 of the updated NDCs submitted by May 2025 referred to renewable energy as a means to support climate mitigation and/or adaptation.[24]

i Global subsidies for fossil fuels include the fiscal cost of support for fossil fuels through three support mechanisms: direct transfers, tax expenditures, and price support, based on combined data from the Organisation for Economic Co-operation and Development (OECD) and the International Energy Agency.

ii To qualify as a new submission in the 2025 round, an NDC must define its contribution with a 2035 time frame. Countries that submitted their 2025 NDC updates by May 2025 were: Andorra, Brazil, Canada, Cuba, Ecuador, Japan, Kenya, Maldives, Marshall Islands, Montenegro, Nepal, New Zealand, the Republic of Moldova, Saint Lucia, Singapore, Switzerland, the United Kingdom, the United Arab Emirates, Uruguay, the United States, Zambia and Zimbabwe.

SIDEBAR 2. THE ROLE OF RENEWABLES IN UNIVERSAL ACCESS TO ELECTRICITY

Despite continued progress, 737 million people remained without access to electricity in 2024, the vast majority of them in sub-Saharan Africa. Addressing this gap requires a combination of grid expansion and the deployment of decentralised renewable energy solutions. In recent years, a growing number of countries have adopted more ambitious targets and policy frameworks for electricity access, many of which highlight the role of renewables in achieving universal access.

Several countries have set targets for universal electricity access by 2030 or earlier, backed by detailed implementation plans. Chad aims to increase access from only 11% in 2023 to 90% by 2030, targeting 14 million additional people. Côte d'Ivoire plans to raise its access rate from 64% to 100% by 2030, and the Democratic Republic of the Congo aims to provide universal access to electricity by 2030, increasing the access share from 21.5% in 2024.

Similar targets have been announced in Niger, Nigeria, Senegal and Zambia and include a mix of grid and off-grid strategies, including the deployment of mini-grids and solar home systems, particularly in rural and underserved areas. Zambia plans to double its annual grid connections from 60,000 to 120,000 by 2030 while also scaling up off-grid access. These efforts reflect a broader trend of integrated electrification strategies that combine infrastructure development with decentralised renewable energy deployment.

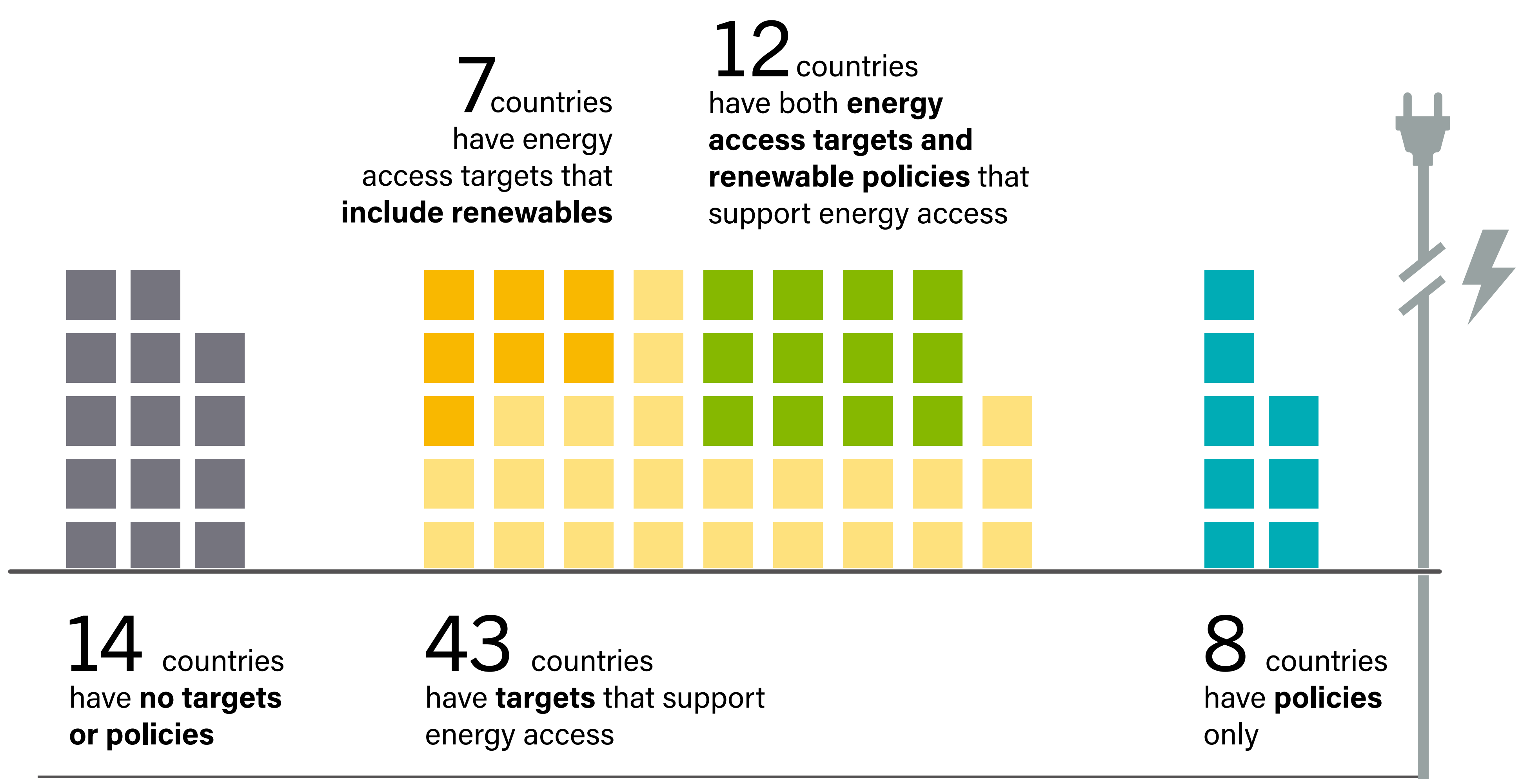
Several African countries – including Cameroon, Ethiopia, Rwanda, Senegal and Uganda – have adopted relatively comprehensive policy frameworks, with multiple policy types in place and clear links to renewable energy. Ethiopia has four energy access policy types, three of which directly support renewables. The country targets 96% grid connectivity by 2030 and 100% electrification by 2025, with 35% of the population served through off-grid solutions and 65% via grid extension.

These national efforts are increasingly supported by regional initiatives. In 2024, the World Bank, in partnership with the African Development Bank, launched Mission 300, an initiative to connect 300 million people in sub-Saharan Africa to electricity by 2030 (including 250 million through World Bank-supported programmes). Approaches include both grid expansion and decentralised solutions such as solar home systems and mini-grids. The ASCENT programme, targeting eastern and southern Africa, and the Regional Energy Access Financing Platform (REAF) further channel direct finance and performance-based grants to clean energy enterprises, helping to scale up access across the region.

Despite this, many countries remain in the early stages of policy development. Nearly half of countries surveyed (with less than 98% electricity access rates as of 2024) had only one energy access policy type in place (or none at all) and often lacked explicit references to renewables. Burundi, Chad and Liberia all report relatively low electricity access rates and weak policy frameworks, but recent developments suggest a shift towards greater commitment.

While momentum is building, the alignment between electrification plans and renewable energy strategies remains uneven. (→ *See Figure 4*.) Ensuring that the expansion of electricity access is both inclusive and sustainable will require greater policy coherence and the integration of renewables in national access frameworks.

FIGURE 4.
Electricity Access Targets and Policies with Renewables in Countries with No Universal Access to Electricity, as of End-2024



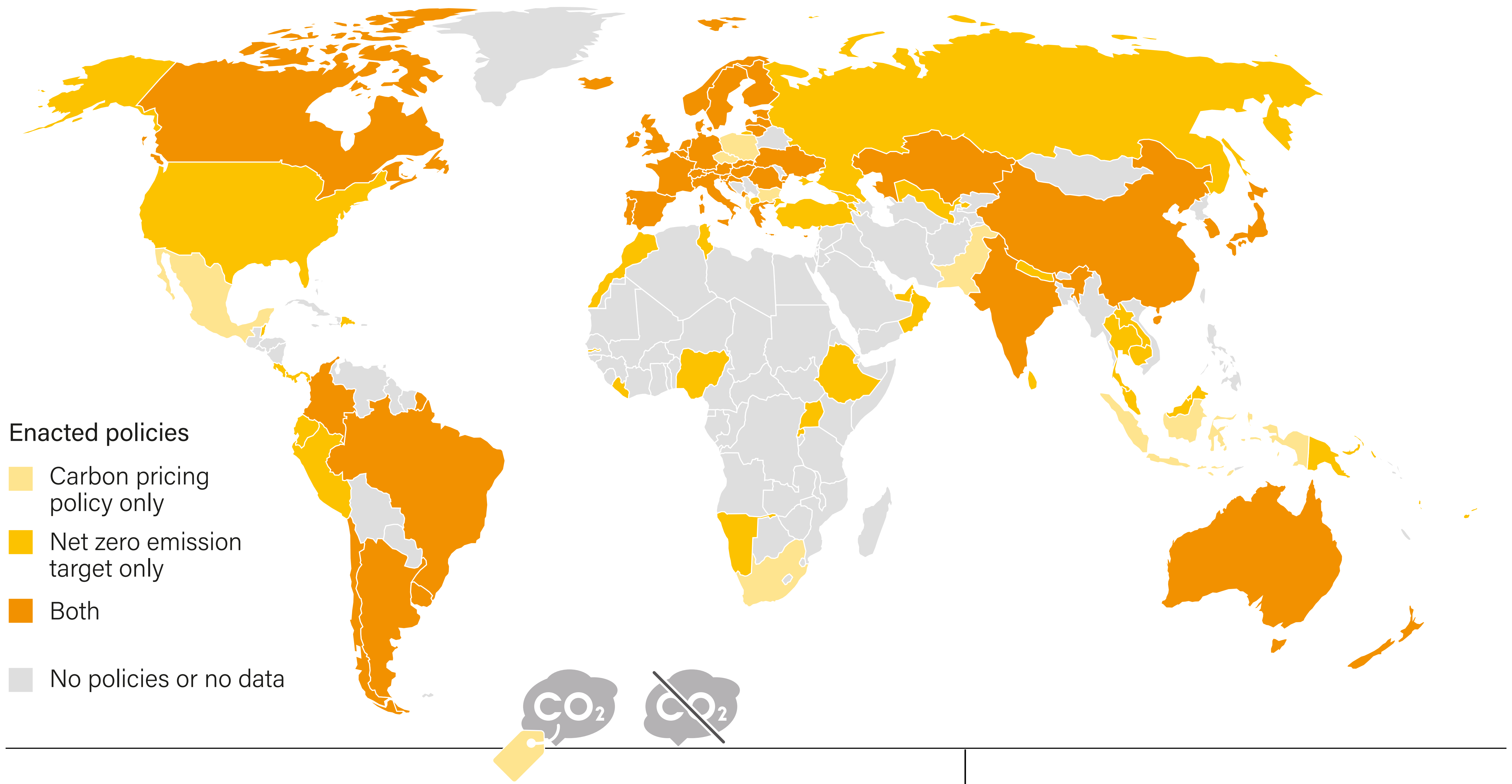
Note: "No universal access to electricity" refers to countries where 98% or less of the population had access to electricity as of end-2024.
Source: See endnote 19 for this section.

As of 2024, 53 countries had carbon pricing policies in place and 45 countries had both **net zero emission targets** and **carbon pricing policies** – including carbon taxes and emission trading systems (ETS).[25] (→ *See Figure 5.*) However, many of the existing carbon pricing policies cover only a small share of national emissions, or just one end-use sector: 51 countries covered emissions from industry, and 45 countries covered emissions from transport (including aviation), yet only 23 countries covered emissions from buildings and only 17 countries covered emissions from the agricultural sector.[26]

As of 2024, 44 countries, including all EU Member States, had established emission trading systems.[27] Only two new countries initiated national carbon pricing frameworks during the year: Pakistan, through the adoption of its National Carbon Market Policy, and Brazil, where the Congress approved a framework law to establish a national ETS.[28] A total of 31 countries had carbon taxes in place in 2024, with no new policies enacted during the year; carbon tax rates ranged from less than USD 1 to USD 167 per tonne of CO_2 or CO_2 equivalent.[29] Uruguay had the highest carbon tax rate at USD 167 per tonne of CO_2 equivalent, followed by Switzerland and Liechtenstein (both with USD 132 per tonne of CO_2[i]).[30]

i Other countries with relatively high carbon tax rates in 2024 included Sweden (USD 127 per tonne of CO_2), Norway (USD 108 per tonne of CO_2 equivalent) and Finland (USD 100 per tonne of CO_2). The lowest carbon tax rates in 2024 were in Japan (USD 1.91 per tonne of CO_2), Argentina (USD 0.81 per tonne of CO_2 equivalent) and Ukraine (0.77 per tonne of CO_2). See endnote 30 for this section.

FIGURE 5.
Countries with Enacted Climate Change Policies, by Type of Measure, as of 2024



Note: Enacted climate change policies include policies that have been officially passed into legislation or an official policy strategy (including NDCs). They also include net zero emission targets that have already been achieved. Carbon pricing policies include emission trading systems and carbon taxes. Carbon pricing policies of sub-national jurisdictions are not included in this figure. The EU ETS applies in all EU Member States, the European Free Trade Association countries (Iceland, Liechtenstein and Norway) as well as Northern Ireland for electricity generation (under the Protocol of Ireland and Northern Ireland); some countries (Austria, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Latvia, Liechtenstein, Luxembourg, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, Slovenia and Hungary) have an additional national scheme in place to complement the EU ETS.

Source: REN21 Policy Database. See endnote 25 for this section.

As many as 90 countries had in place targets for net zero greenhouse gas emissions as of 2024, and 68 of these countries set 2050 as the target year.[31] Cabo Verde had the most ambitious target, with 2025 as the target year, followed by Dominica, Liechtenstein, Maldives and Uzbekistan (all with 2030 as the target year).[32] Uganda and Thailand had among the longest timelines for reaching net zero emissions, targeting 2065, and India set its target year to 2070.[33] Additionally, 43 further countries had a net zero target that was proposed or declared only by 2024, but not yet fully enacted.[34] Most policies outlining net zero emission targets include renewable energy as a core feature.[35]

Meanwhile, as of 2024, 89 countries had enacted economy-wide renewable energy targets, and 64 countries had both net zero emission and economy-wide renewable energy targets.[36] (→ *See Figure 6.*)

Only two countries had both net zero emission and 100% economy-wide renewable energy targets.[37] These two countries were Fiji and Nauru, both developing countries that are particularly vulnerable to climate impacts.[38]

Despite continued global commitment and the growing number of net zero emission targets, setbacks have become apparent. Scotland, for example, eliminated its 2030 climate targets because they were considered unachievable, but kept in place targets for 2045.[39] Such **revisions to near-term climate targets and delays in updating targets**, combined with political and regulatory uncertainties, have continued to undermine implementation, increasingly affecting investor confidence.[40] Relatedly, the private sector sent mixed signals in 2024, with some new initiatives but also signs of backtracking among key actors.[41] (→ *See Sidebar 3*).

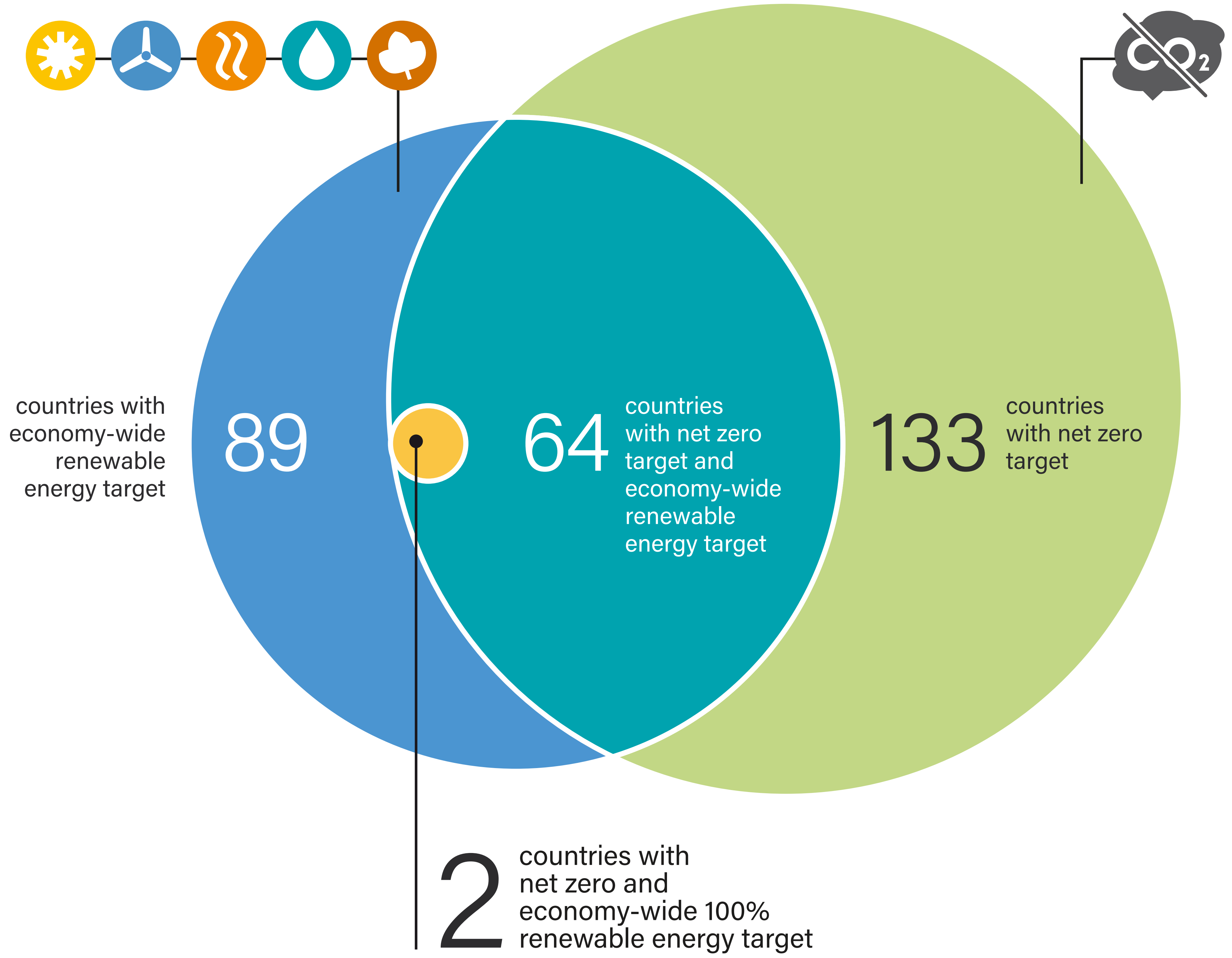
Solar PV in Fiji

89

countries

had economy-wide renewable energy targets in 2024, while 133 countries had net-zero targets.

FIGURE 6.
Countries with Net Zero Emission Targets and Renewable Energy Targets, as of 2024



Note: Of the 133 net zero emission targets (including both proposed and declared), 90 were in place in 2024. All 89 economy-wide renewable energy targets were fully enacted in 2024.

Source: REN21 Policy Database. See endnote 36 for this section.

SIDEBAR 3. PRIVATE SECTOR COMMITMENTS

Private sector engagement on climate and renewable energy showed mixed progress in 2024. Although new alliances and targets were announced, **backsliding by key actors** in energy, finance and manufacturing raised concerns about the credibility and durability of private climate and renewable energy leadership.

Several major **banks** withdrew from the Net Zero Banking Alliance during the year, highlighting growing tensions between fiduciary obligations and net zero commitments. Their departure undermined a key framework designed to align financial flows with the goals of the Paris Agreement.

The **fossil fuel sector** also rolled back commitments to renewable energy and climate alignment. Equinor, Shell and BP all scaled down their renewable energy strategies in 2024. Investor pressure to prioritise short-term returns, combined with shifting regulatory landscapes, pushed firms to reassert their focus on core fossil fuel operations.

Vehicle electrification is considered one of the key drivers of renewable energy uptake; however, several incumbent automakers in the **transport sector** have re-evaluated their timelines for this shift. Despite an overall increase in electric vehicle sales in 2024, the share of plug-in hybrid vehicles among these sales also grew, indicating a shift towards transitional technologies rather than full electrification. Slower-than-expected consumer uptake in some markets, coupled with regulatory uncertainty, led some firms to delay the phase-out of internal combustion engine models.

Despite these setbacks, some **utilities and industrial companies** reaffirmed renewable energy commitments. Several fossil fuel-dependent countries and companies launched the Climate Finance Action Fund to provide off-take agreement guarantees for small and medium-sized renewable energy producers, alongside first-loss capital for green industrial projects. The Utilities for Net Zero Alliance, launched at COP 28, updated its goals in April 2024. The alliance – led by the United Arab Emirates' grid operator TAQA, and also including UK-based National Grid, Italy's Enel, France's EDF and US-based groups such as Edison International – committed to increasing their "green energy" capacity to at least 749 GW by 2030 (a 250% increase from their renewables capacity in 2023).


© Massimo Parisi; shutterstock.com

However, other major utilities continued to invest in new coal and fossil gas infrastructure or to keep existing plants operating beyond scheduled retirements, indicating a lack of alignment with climate and energy transition objectives.

Source: See endnote 41 for this section.

RENEWABLE ENERGY TARGETS

Renewable energy targets are formal commitments that define clear goals to increase renewable energy within a set time frame, guiding policies and investments to drive uptake.[42] Showing little growth since 2023, 89 **economy-wide renewable energy targets** were in place in 2024, ranging from a 10.6% renewables share in Malta's energy supply to 100% renewable shares planned in Barbados, Comoros and Fiji by 2030.[43] Economy-wide renewable energy targets for 2050 ranged from 31% in Indonesia to 100% in the Philippines.[44]

Six countries had targets for 100% renewables as of 2024: Barbados, Comoros, Fiji, Guyana, Nauru, and the Philippines, most of which are small island developing states (SIDS).[45] This reflects the high ambition on renewable energy among some of the countries that are most exposed to the impacts of climate change.[46]

Indonesia, however, lowered its 2025 renewable energy target from 23% to between 17% and 19%.[47] In early 2025, the EU announced that it is far behind its 2030 renewable energy target of at least 42.5% and highlighted the need for accelerated efforts, with renewables making up only 24.5% of the EU energy mix in 2023.[48]

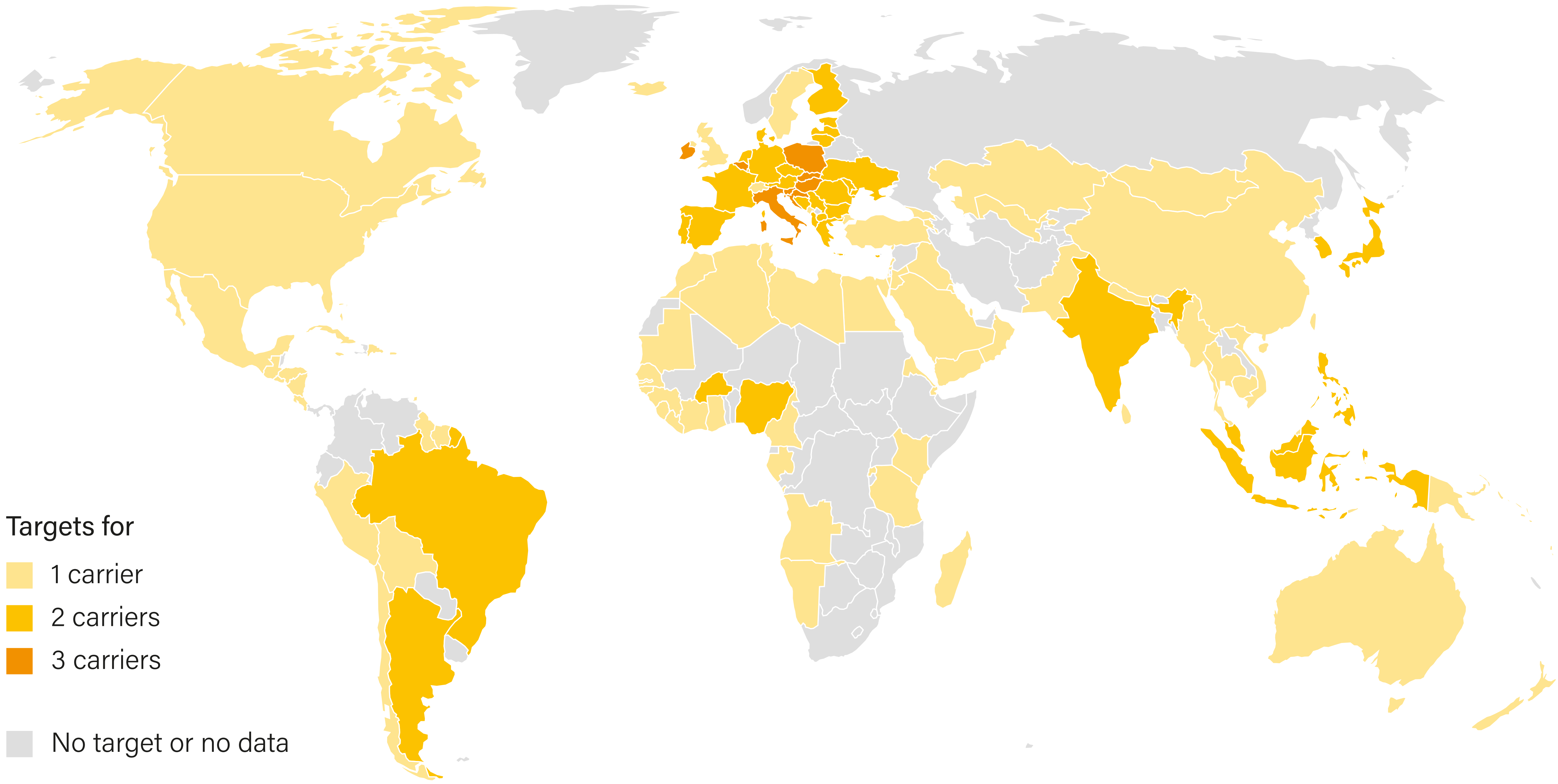
Moreover, several specific targets were in place to support an increase in **renewable energy supply** across electricity, direct thermal energy (heat) and fuels in 2024. By year's end, 287 renewable energy targets across energy carriers were in place in 162 countries.[49] (→ *See Figure 7.*)

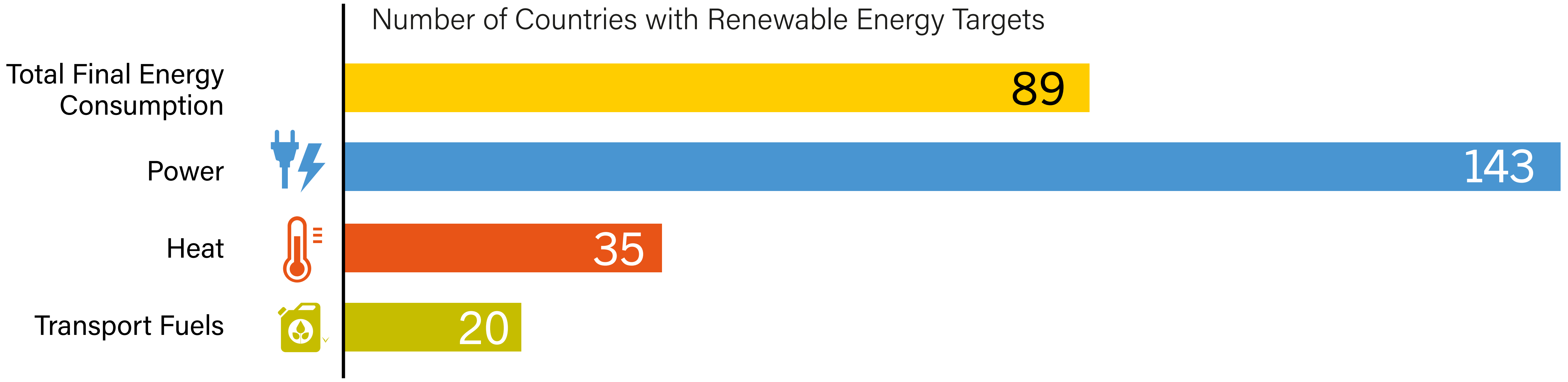
Additionally, 143 countries had in place renewable electricity targets as of 2024, ranging from a 10% target for 2030 in Ghana to 100% targets for 2030 in Barbados, Denmark, Kenya, and Tuvalu, among other countries.[50]
A total of 35 countries had targets for direct renewable heat (thermal energy), ranging from 7% by 2030 in Georgia to 67.5% by 2030 in Lithuania.[51] Twenty countries had in place renewable fuel targets in 2024, mostly biofuel blending mandates, ranging from 7% by 2030 in the Netherlands to 34% by 2030 in Finland.[52] The uneven distribution across renewable power, heat and fuel targets shows that renewable energy policy attention remains concentrated on the power sector, with limited focus on renewable heat and fuels.

As of 2024, only nine countries had targets for all mentioned renewable energy carriers, all in the EU.[53] Most countries (83) had a target in place for only one renewable energy carrier.[54] Only Romania enacted a new economy-wide renewable energy target during

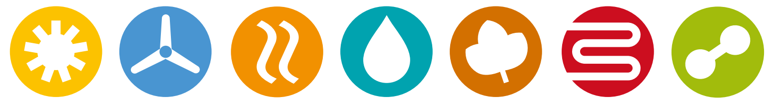
FIGURE 7. | Renewable Energy Targets, by Country and by Energy Carrier and in Total Final Energy Consumption, as of 2024

Renewable Energy Targets, by Country and by Energy Carrier, as of 2024

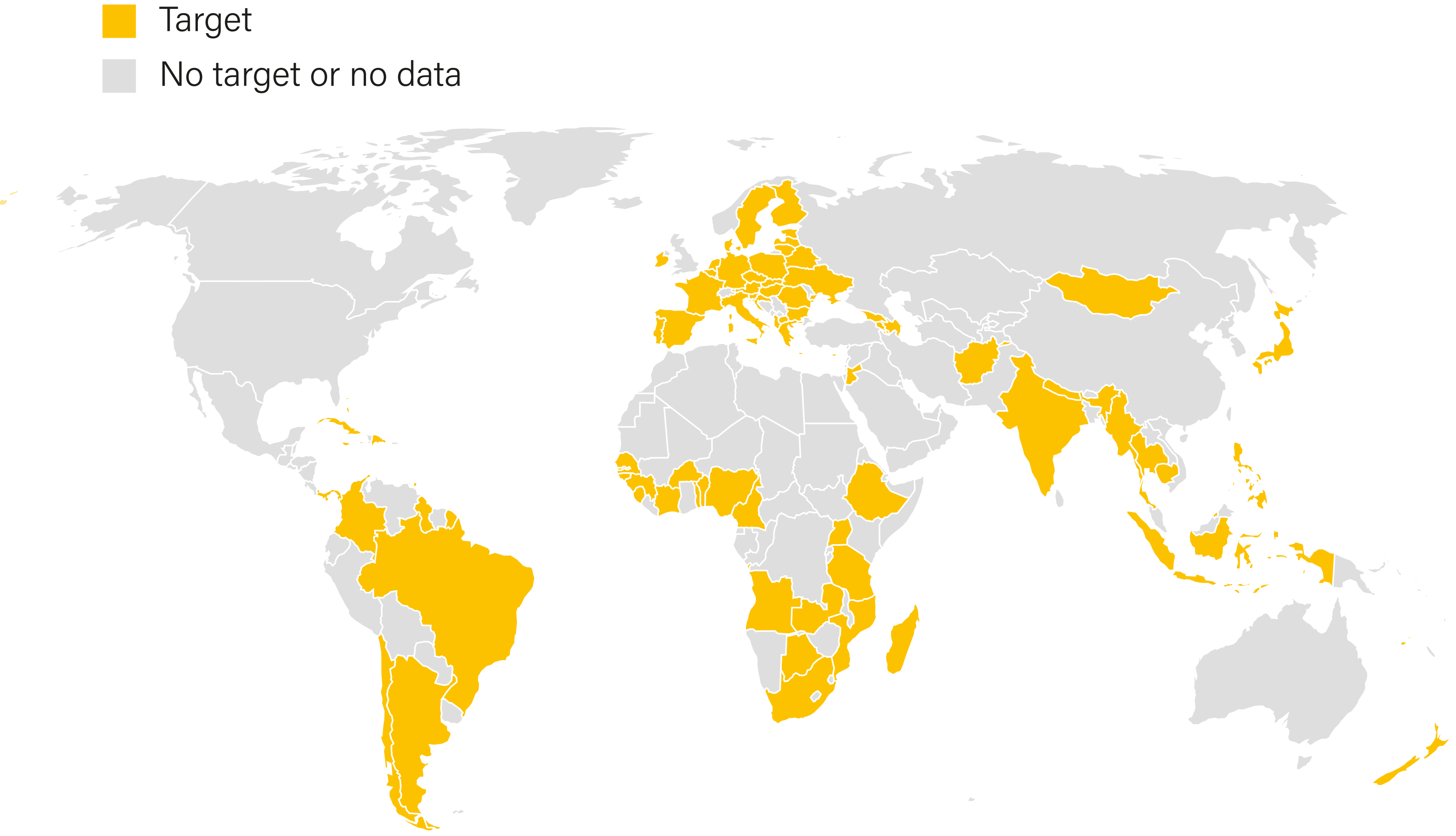




89 countries have renewable energy targets for TFEC

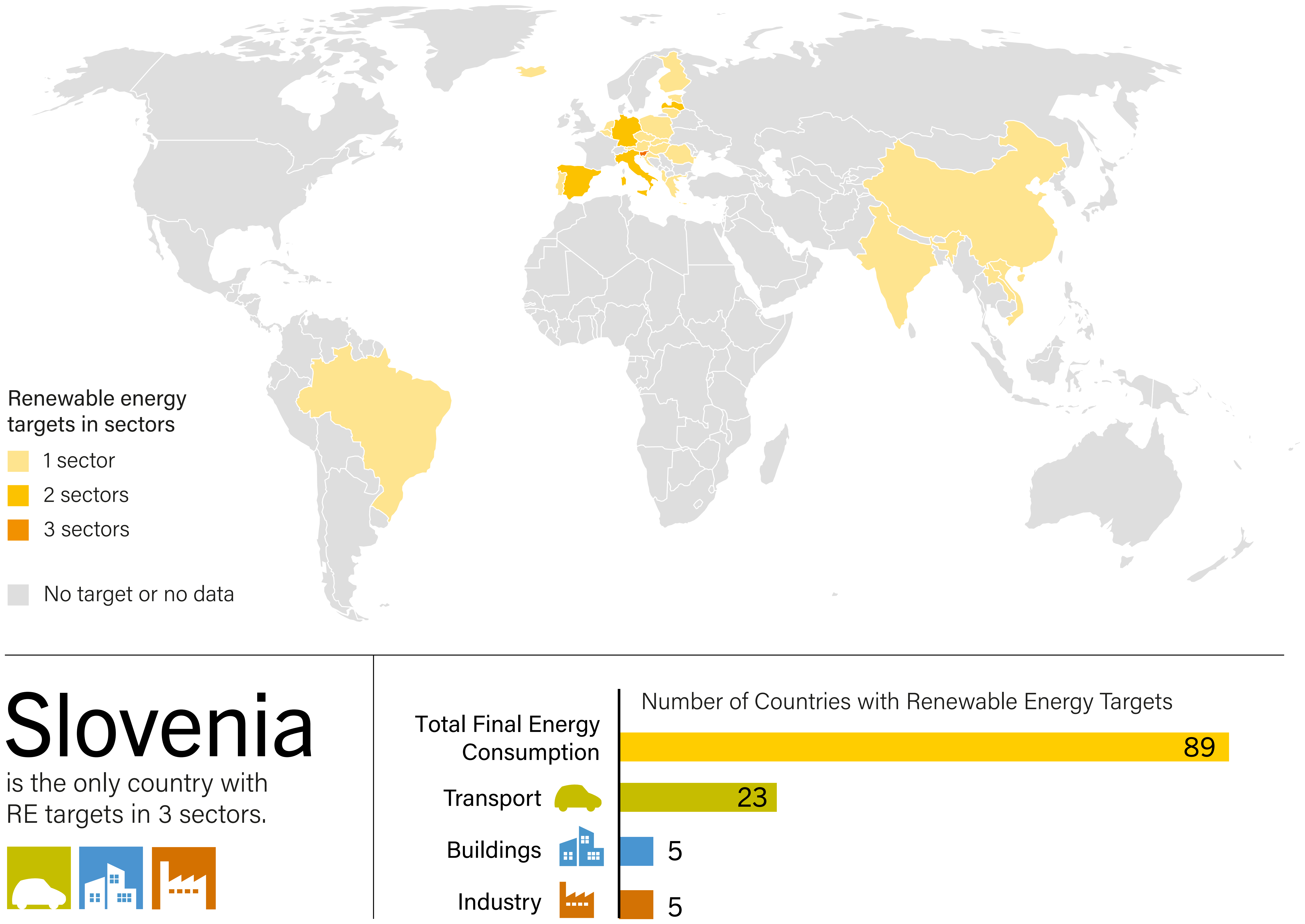


Renewable Energy Target for Total Final Energy Consumption (TFEC), by Country, as of 2024



Note: An energy carrier is a transmitter of energy. Energy carriers include electricity, heat and fuels. They occupy intermediate steps in the energy-supply chain between primary sources and end-use applications.
Source: REN21 Policy Database. See endnote 49 for this section.

FIGURE 8.
Renewable Energy Targets, by Country and Sector, as of 2024



Source: REN21 Policy Database. See endnote 62 for this section.

the year; only the Czech Republic, Ukraine and Uzbekistan enacted new renewable power targets; and only Cambodia and Poland announced new renewable power targets.[55] Both Montenegro and Ukraine enacted renewable heat targets, while Slovenia announced a renewable heat target.[56] Revised, more ambitious biofuel targets were announced and/or enacted in Japan, the Philippines and Poland in 2024.[57]

Despite the global goal set at COP 28 to triple the world's renewable power capacity by 2030, existing national plans and targets are projected to deliver only half of the necessary expansion.[58] This translates to a projected shortfall of 3.8 terawatts, or 34%, based on existing policy trajectories.[59] Of the major renewable energy technologies, only solar PV is on track to meet the required levels of growth.[60] Supported by more robust policy implementation, deployment of all other renewable technologies will need to accelerate substantially to contribute meaningfully to global goals.[61]

In 2024, targets continued to play a central role in driving **renewable energy consumption in end-use sectors**. However, whereas 89 countries had economy-wide renewable energy targets in 2024, only 27 countries had sectoral targets for renewables during the year.[62] (→ *See Figure 8.*) This included 23 countries with targets for renewable energy shares in the transport sector, with 2030 targets ranging from 13.4% in Greece and 14% in Estonia and Hungary to 40% in China and Iceland.[63] Five countries had renewable energy targets for buildings in 2024, ranging from 50% in Viet Nam to 68% in Latvia, both set for 2030.[64] Equally, five countries had targets for industry, ranging from 27% by 2030 in Italy to 64.9% by 2030 in Latvia.[65] No renewable energy targets were in place in the agricultural sector in 2024, indicating uneven policy attention across sectors.[66]

Only a few new **sectoral targets** were enacted in 2024, including Latvia's target for nearly 65% renewables in industrial energy consumption by 2030.[67] In the buildings sector, Germany enacted a new renewable energy target based on its Building Energy Act, which requires newly installed heating systems to use 65% renewables.[68] Meanwhile, seven countries enacted new renewable energy targets in the transport sector in 2024 (ranging from 15% to 30% renewable shares); all of these countries were EU Member States, which enacted the targets as part of the 2024 updates to their 10-year national energy and climate plans for 2021-2030.[69]

POLICY MECHANISMS

Beyond setting national targets, governments use various policy tools to stimulate renewable energy demand and guide progress towards achieving ambitions. These include feed-in tariffs (FITs), net metering and net billing, auctions and tenders, mandates such as renewable portfolio standards (RPS), and hybrid system incentives.[70]

Policies such as **feed-in tariffs, net metering and net billing**[i], which create incentives for renewable energy producers and help facilitate their participation in the energy system, received continued policy attention in 2024. During the year, 116 of these policies were in place across 93 countries.[71] (→ *See Figure 9.*) This included 44 countries with feed-in tariffs, 61 countries with net metering policies, and 11 countries with net billing policies.[72] 23 countries implemented feed-in tariffs alongside other support mechanisms; among them, 19 combined feed-in tariffs with net metering, while four (France, Greece, Moldova, and Poland) combined feed-in tariffs with net billing policies.[73]

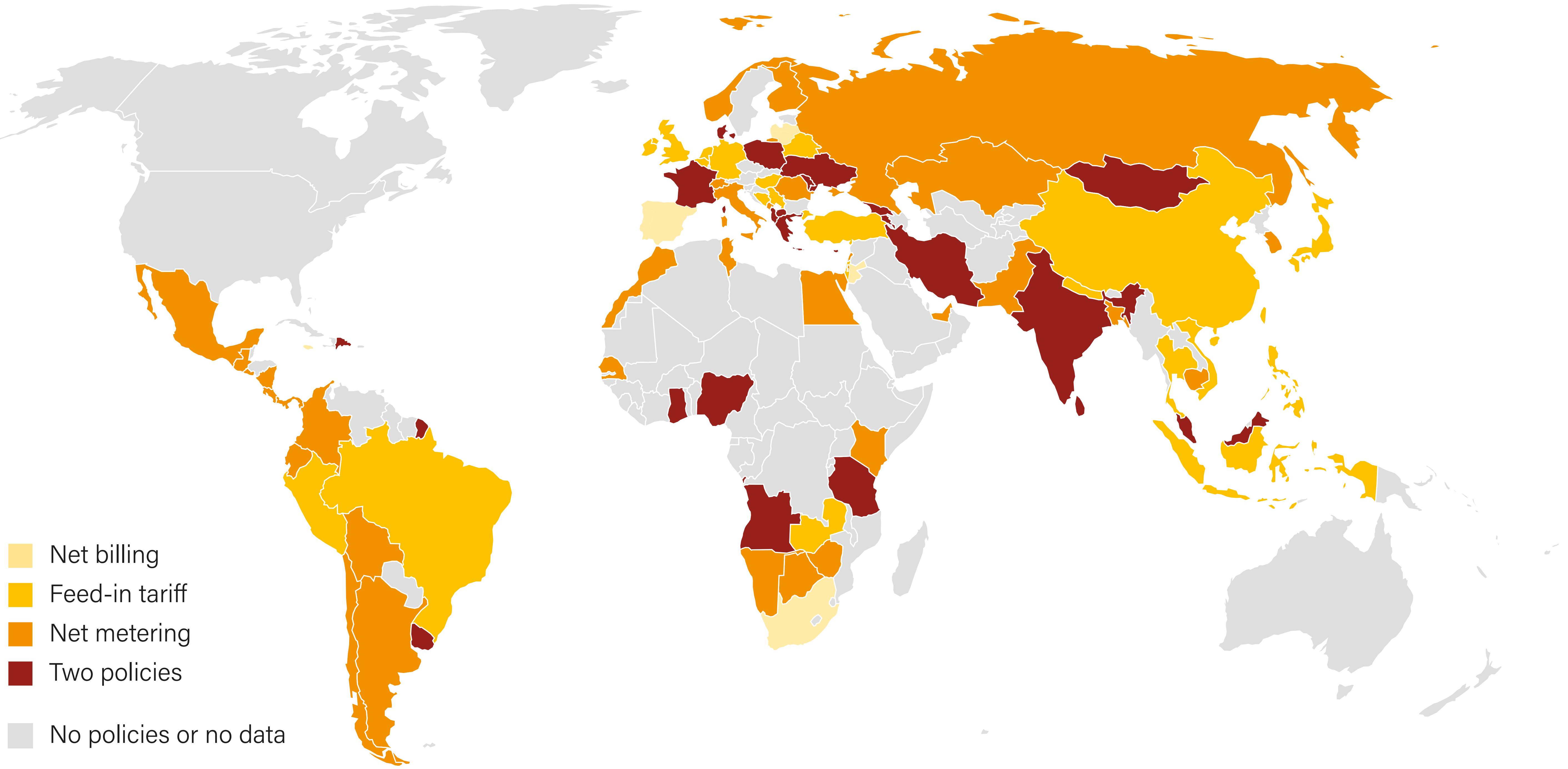
i Net metering typically credits surplus electricity at the full retail rate, offsetting consumption on a one-to-one basis, whereas net billing compensates exports at a lower rate – such as the wholesale or avoided cost – and separates billing for consumption and generation.

© Marcin Rogozinski; shutterstock.com

Net metering

was the leading policy tool in 2024, in place in 61 countries, including 19 that combined it with feed-in tariffs.

FIGURE 9.
Renewable Energy Feed-In Tariffs, Net Metering and Net Billing Policies by Country, as of 2024



Number of countries with policies

61 Net metering | 44 Feed-in tariff | 11 Net billing

23 countries implement two types of support mechanisms

116 policies are in place across 93 countries

Source: REN21 Policy Database. See endnote 71 for this section.

Several new incentive policies were announced and enacted in 2024, with five countries – Greece, Japan, the Netherlands, Poland and Ukraine – announcing and enacting new feed-in tariffs.[74] In a further five countries – Bosnia and Herzegovina, Cyprus, Denmark, North Macedonia and the United Kingdom – feed-in tariff schemes were closed to new applicants, but existing contracts remained in force.[75] Four countries – Greece, Jamaica, South Africa and Spain – enacted new net billing schemes, and Lithuania shifted from net metering to net billing in 2024.[76] In total, six countries have transitioned from net metering to net billing in recent years: Jamaica, Latvia, Lithuania, Portugal, South Africa and Spain.[77] Cambodia and Malaysia enacted new net metering schemes in 2024.[78]

Policy efforts in 2024 increasingly focused on accelerating project permitting and enhancing renewable electricity integration into the electric grid, reflecting the growing global ambition to improve grid and storage infrastructure, a key barrier to the deployment of renewable power capacity in recent years.[79] (→ *See Energy Systems and Infrastructure section.*) The increase in hybrid solar-wind systems in India provides a clear example of how **hybrid system incentives** can drive the uptake of renewables while enhancing grid integration.[80] (→ *See Snapshot India*).

Besides policies that support the increase of renewable energy supply, 69 countries had **regulations and fiscal or financial incentives targeting end-use sectors** in place in 2024.[81] Out of these, only five countries addressed all four major end-use sectors, reflecting a lack of cross-sectoral approaches to the uptake of renewables.[82] Policies mandating biofuel blending in transport, as well as subsidies, rebates and tax exemptions that encouraged the integration of renewable energy systems in buildings, continued to be primary drivers for increasing renewable energy use in end-use sectors.[83] Agriculture and industry garnered less policy attention.[84] (→ *See Renewables in Energy Demand section.*)

Eight countries adopted new policy measures to support renewables in the buildings sector in 2024, and most of them were subsidies for rooftop solar PV.[85] Six countries – Austria, Belgium, Brazil, France, Norway and Poland– introduced new transport sector policies, primarily implementing new biofuel blending mandates or tax exemptions.[86] Canada, China, France, India and Slovenia implemented mechanisms to encourage renewable energy uptake in the industrial sector, including subsidies and tenders.[87] Italy, Morocco and Portugal launched subsidy schemes for the agricultural sector in 2024, supporting agrivoltaics and solar pumping kits.[88]

In 2024 and early 2025, some policies promoting renewable energy adoption were rolled back, including the incoming US administration's reversal of a 2024 rule that had reduced fees by approximately 80% for wind and solar projects on federal lands.[89] At the same time, **fossil fuel bans** were repealed or relaxed across different sectors, indicating a retreat from climate and renewable energy commitments. New Zealand lifted its ban on offshore oil and fossil gas exploration and removed incentives for electric vehicles.[90] In early 2025, the United Kingdom announced it would abandon its plan to ban the sale of new gas boilers by 2035, a policy initially introduced by the previous Conservative administration to reduce carbon emissions from home heating.[91] Few governments have enacted their announced bans on internal combustion engine (ICE) vehicle sales, and several have scaled back or delayed these plans, such as the EU allowing ICE cars with CO_2-neutral fuels beyond 2035.[92]

Trade policies related to renewable energy and enabling technologies have increased sharply in recent years.[93] In 2015, only nine formal trade measures related to renewables and enabling technologies were in place; by 2024, this number had surged to 212, doubling from 2022 and including measures related to solar PV (more than 50 policies), battery components (more than 50), electric vehicles (47), wind turbines (32) and heat pumps (16).[94] Nearly 40% of new trade policies since 2020 involved tariff changes, anti-dumping measures and countervailing duties, while half of energy-related critical minerals are regulated by export controls.[95] Over the same period, around 50 new free trade agreements were signed, most of them maintaining preferential tariffs for renewables and enabling technologies.[96]

Although only

27 countries

had sectoral targets for renewables in 2024, 68 countries had regulations or incentives for renewables in end-use sectors.

Hybrid solar-wind systems represented **40%** of the total awarded renewables capacity in India in the first half of 2024.

SNAPSHOT INDIA

HYBRID SOLAR AND WIND ENERGY SYSTEMS SURGING

In the first half of 2024, hybrid solar PV and onshore wind energy systems represented 40% of the total awarded renewable energy capacity in India. These systems involve the co-location of solar PV, onshore wind and often battery storage technologies. They are attractive for electricity utilities and corporate buyers of power purchase agreements because they help reduce the variability in electricity generation and facilitate the integration of renewables into the grid.

According to the International Energy Agency, India is a pioneer in promoting hybrid renewable power plants and can provide useful lessons for other countries seeking to minimise the impacts of variable renewable energy on their electricity network infrastructure. The overall awarded capacity for hybrid systems in India more than doubled from around 5 GW in 2023 to around 12 GW in just the first half of 2024. This represents a significant acceleration in annual growth following the launch of a solar-wind hybrid policy in 2018 by India's Ministry of New and Renewable Energy.

The goal of the policy was to establish a framework to promote large-scale, grid-connected wind-solar PV hybrid systems and to provide incentives to developers. Solar-wind hybrid systems have numerous benefits, including:

- efficient use of transmission infrastructure and land;
- increased capacity utilisation factors (CUF) compared to stand-alone solar PV and onshore wind plants;
- lower variability in generation due to complementary generation profiles (i.e., generating electricity from solar during the day and from wind at night); and
- cost-competitive tariffs compared to stand-alone wind power systems.

India's solar-wind hybrid policy also permits the use of battery storage to provide more reliable and balanced power output. Several state governments in India have announced their own policies and incentives to promote hybrid projects. A study from Ember found that the tariff rates for hybrid projects in India range in between those for solar and wind projects.

- For a 1,350 megawatt (MW) auctioned wind capacity (closed bidding), tariffs were in the range of INR 3.60-3.70 (USD 0.042-0.043) per kilowatt-hour (kWh), with a minimum CUF requirement of 22%.
- For a 1,200 MW auctioned wind-solar hybrid capacity, discovered tariffs were in the range of INR 3.43-3.46 (USD 0.040-0.041) per kWh, with a minimum CUF requirement of 30%.
- For a 1,200 MW auctioned solar capacity, discovered tariffs were INR 2.48 (USD 0.029) per kWh, with a minimum CUF requirement of 17%.

In India, hybrid projects with battery storage or with firm and dispatchable renewable energy commitments have higher tariffs in the range of INR 3.5-5.6 (USD 0.041-0.066) per kWh. The falling prices of batteries are expected to drive down the cost of these hybrid systems. Meanwhile, higher tariffs through the integration of battery storage will need to be weighed against the benefits of more reliable and balanced output.

Key challenges faced in installing hybrid systems include land constraints (given that many of India's high-potential wind sites have been saturated), grid integration challenges and the lack of a skilled workforce to execute the systems. Despite these constraints, hybrid systems are expected to grow further, with estimates of 30 GW of projects in the pipeline in India as of September 2024.

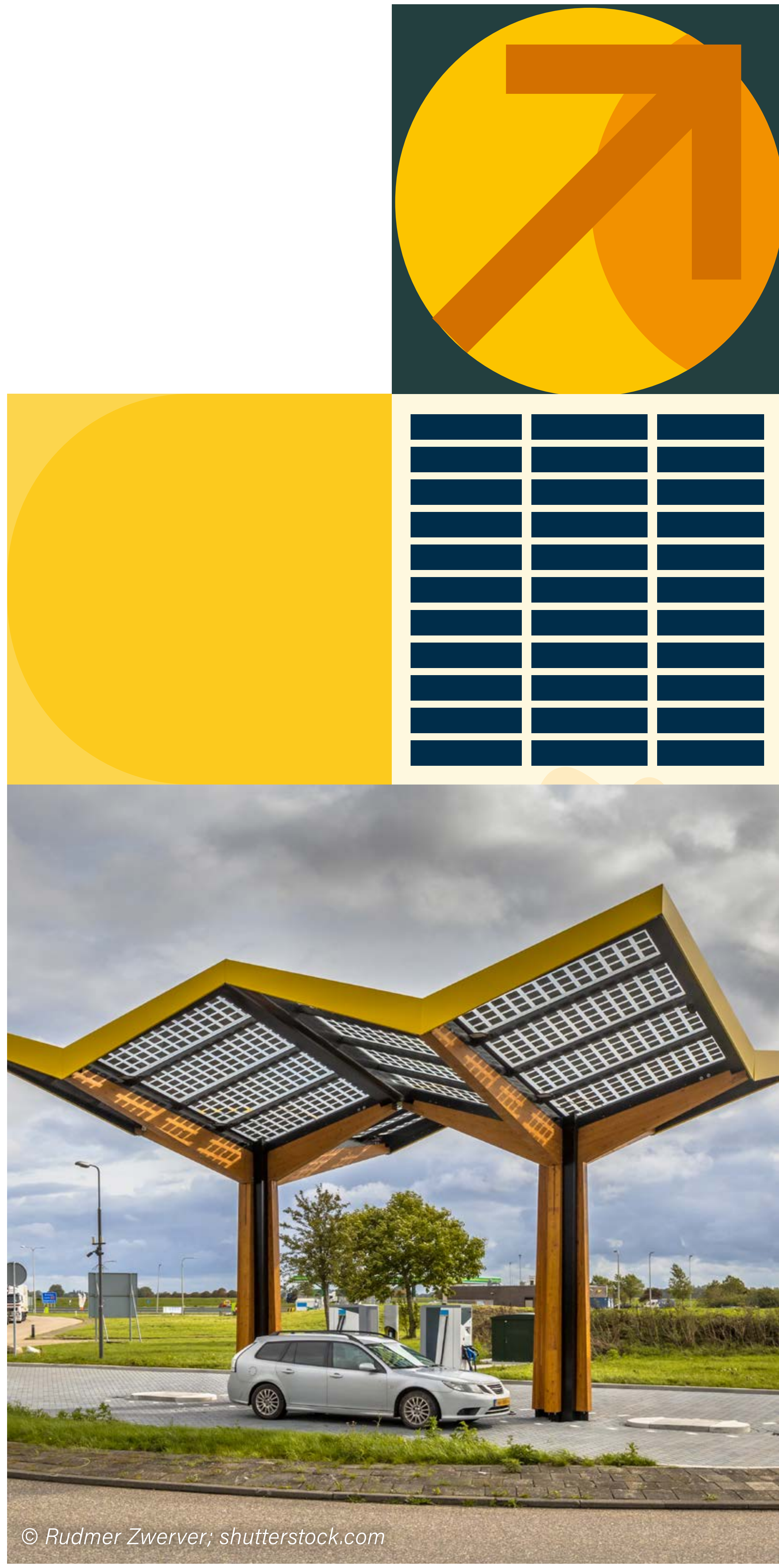
Source: See endnote 80 for this section.

INVESTMENT AND FINANCE

RENEWABLE ENERGY

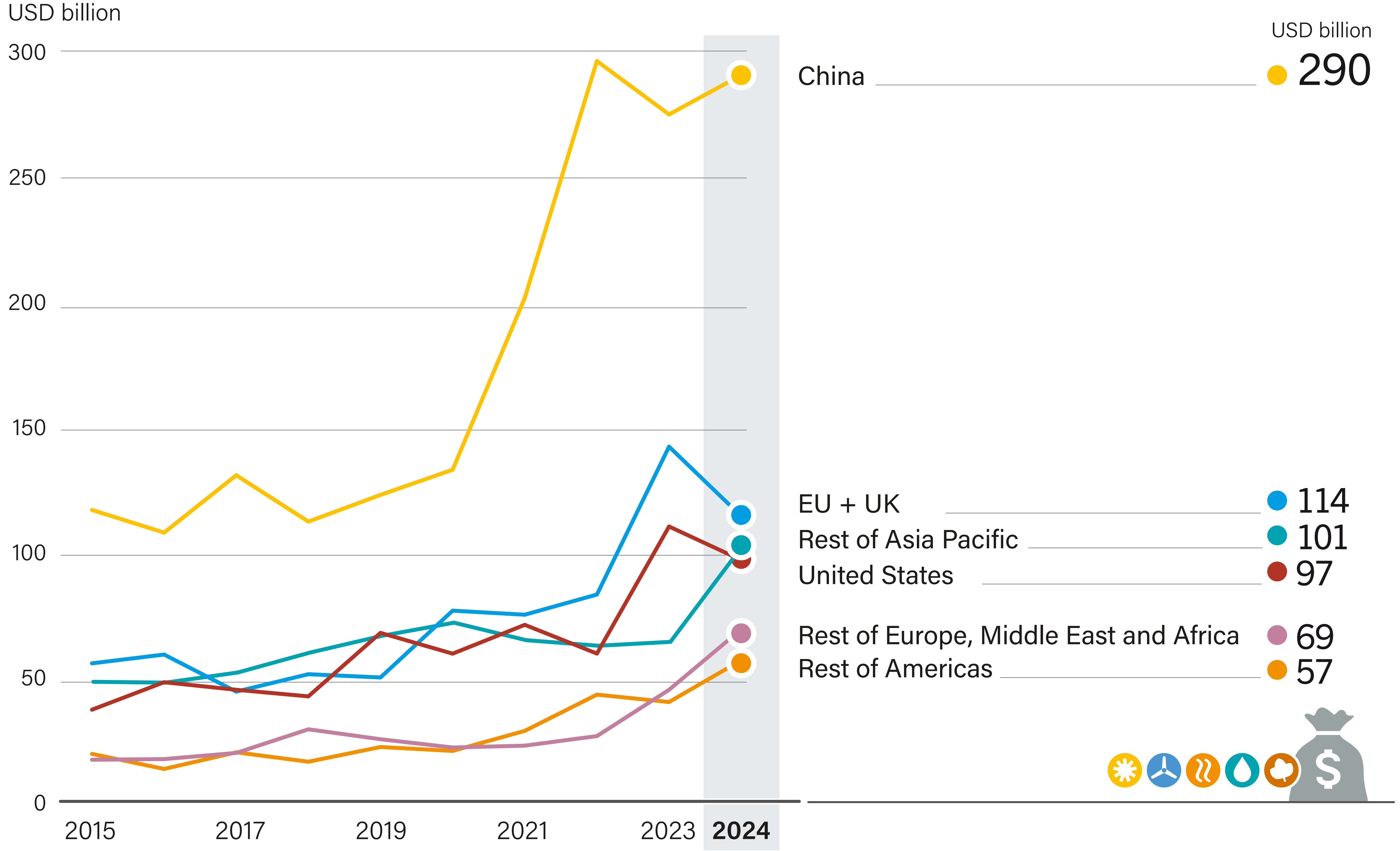
In 2024, global investment in renewable energy and enabling technologies reached a record USD 2.1 trillion, an 13% increase from the previous year.[1] Of this, **renewable energy investment** amounted to USD 728 billion, up 8% for the year but below the double-digit growth rates of 2023 (19%) and 2022 (23%).[2] Much of the overall investment continued to be in **solar power and electric vehicles**, highlighting a funding imbalance across the technologies. Global investment in renewables remains well short of what is needed. At just 48% of the annual investment level required through 2030, the world remains off track to reach net zero greenhouse gas emissions by 2050.[3]

Regional trends in renewable energy investment reveal significant disparities.[4] (→ *See Figure 10.*) Between 2015 and 2024, **China** consistently led global renewable energy investment, peaking at over USD 290 billion in 2024 and accounting for the largest share each year.[5] Investment in the **European Union (EU)** and the **United Kingdom** surged in 2023 but dropped significantly in 2024, falling from USD 142 billion to USD 114 billion.[6] Similarly, US investment peaked at USD 110 billion in 2023 before declining to around USD 97 billion in 2024, while growth in the rest of **Asia, Africa** and the **Middle East** continued to accelerate.[7]



© Rudmer Zwerver; shutterstock.com

FIGURE 10.
Global Investment in Renewable Power and Fuels, by Country and Region, 2015-2024



Source: See endnote 4 for this section.

728 USD billion

total investment in renewable power and fuels in 2024.

Despite the strong emphasis on industrial policy support, spending on renewable energy and enabling technologies supply chains fell slightly from USD 145 billion in 2023 to USD 140 billion in 2024.[8] This decline reflects growing caution in the market, particularly within the solar photovoltaic (PV) sector, where oversupply has become a critical issue.[9] **Global solar PV manufacturing** capacity was expected to surpass 1,100 gigawatts (GW) by the end of 2024 – more than double the current demand.[10] As a result, module prices have more than halved since early 2023, pushing many solar PV manufacturers into negative net margins.[11] These challenging conditions have led to the cancellation of around 300 GW of planned polysilicon manufacturing capacity and 200 GW of wafer manufacturing projects, representing an estimated USD 25 billion in lost investment.[12]

A significant barrier to accelerating renewable energy deployment in emerging and developing economies is the persistently high **cost of capital**.[13] For utility-scale solar PV and wind energy projects, the weighted average cost of capital in these regions is often more than twice that in advanced economies.[14] (→ *See Figure 11.*) This disparity arises from factors including political and economic instability, currency risks, and underdeveloped financial markets, which collectively elevate the perceived investment risk.[15] Consequently, financing costs constitute a substantial portion of the levelised cost of electricity in these countries, making renewable energy projects less financially viable and hindering their implementation.[16]

Reducing the cost of capital in emerging and developing economies can greatly lower the overall financing costs of renewable energy projects.[17] A one percentage point reduction in the cost of capital could reduce the financing cost of achieving net zero by USD 150 billion per year.[18] In countries such as Kenya and Senegal, high interest rates and currency risks make financing renewable energy much more expensive than in advanced economies.[19] Without targeted policy and financial interventions, such regions risk being left behind in the global energy transition.[20]

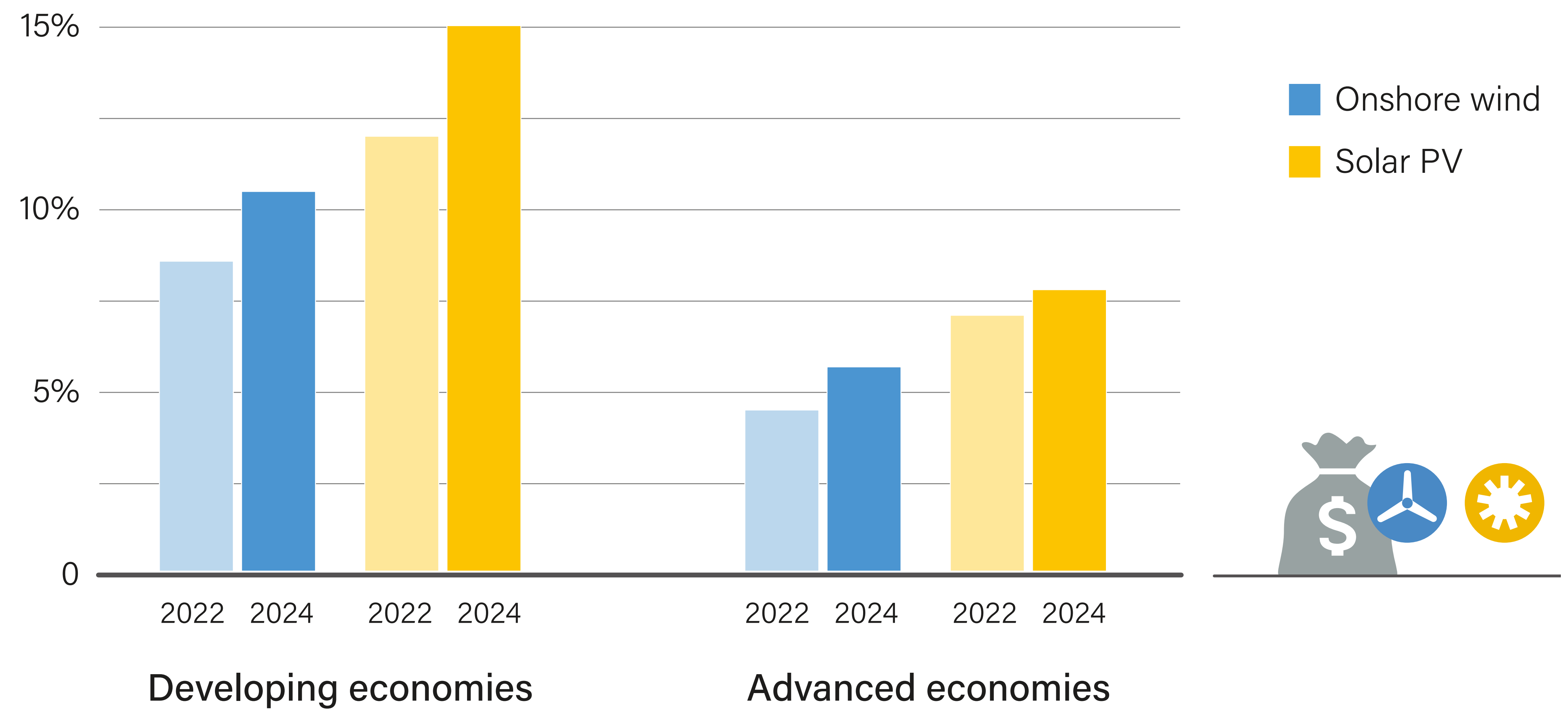
Technology-specific trends reveal a mixed picture.[21] Annual investment in **solar PV** surged 22% in 2024 to reach USD 521 billion, outpacing the 20% growth in 2023 and underscoring solar's continued dominance in the energy transition.[22] (→ *See Figure 12.*) A major shift in 2024 was the expansion of small-scale PV, which accounted for more than half of total solar PV investment.[23] Pakistan alone installed 12.5 GW of unsubsidised rooftop solar, reflecting a growing trend towards decentralised generation.[24] In Brazil and the United States, despite record capacity additions, solar investment fell due to declining module costs.[25] The falling cost per installed unit meant that even though more solar capacity was added, the total capital expenditure was lower.[26] In the EU, solar investment stagnated as lower electricity prices made residential solar less attractive, limiting adoption in Germany, France and other major European markets.[27]

In contrast to solar PV, **wind energy investment** dropped around 15% in 2024 to its lowest level since 2021.[28] This decline reflects persistent permitting challenges, supply chain constraints and uncertain policy signals in several major markets. During 2023 and 2024, several **offshore wind** projects in the United States and Europe defaulted due to unhedged costs and revenue-support schemes that were not adapted rapidly to external market conditions.[29] Renegotiations of offtake deals put projects at risk of further delays.[30]

The cost of wind energy materials, labour and logistics has increased due to strong demand and constrained supply in the wake of the COVID-19 pandemic.[31] The global economic fallout from the Russian Federation's invasion of Ukraine in 2022 raised overall project capital expenditures for most developers globally.[32] The rising costs of raw materials and components required for turbine production have increased both the manufacturing and upkeep costs that manufacturers need to bear.[33] These price increases have put additional pressure on developers who are already operating with narrow profit margins and are constrained by wider project economics.

The US offshore wind industry has faced a perfect storm of rising costs, permitting delays and grid connection hurdles – all leading to low returns.[34] Inflation and supply chain challenges have driven up capital expenditures, and financing costs have spiralled due to rising interest rates.[35] Some developers have sought to renegotiate their previously agreed offtake deals, which are no longer profitable, while others have tried to cancel their contracts altogether.[36]

FIGURE 11.
Weighted Average Cost of Capital for Onshore Wind Power and Solar PV, by Country Income Level, 2022-2024

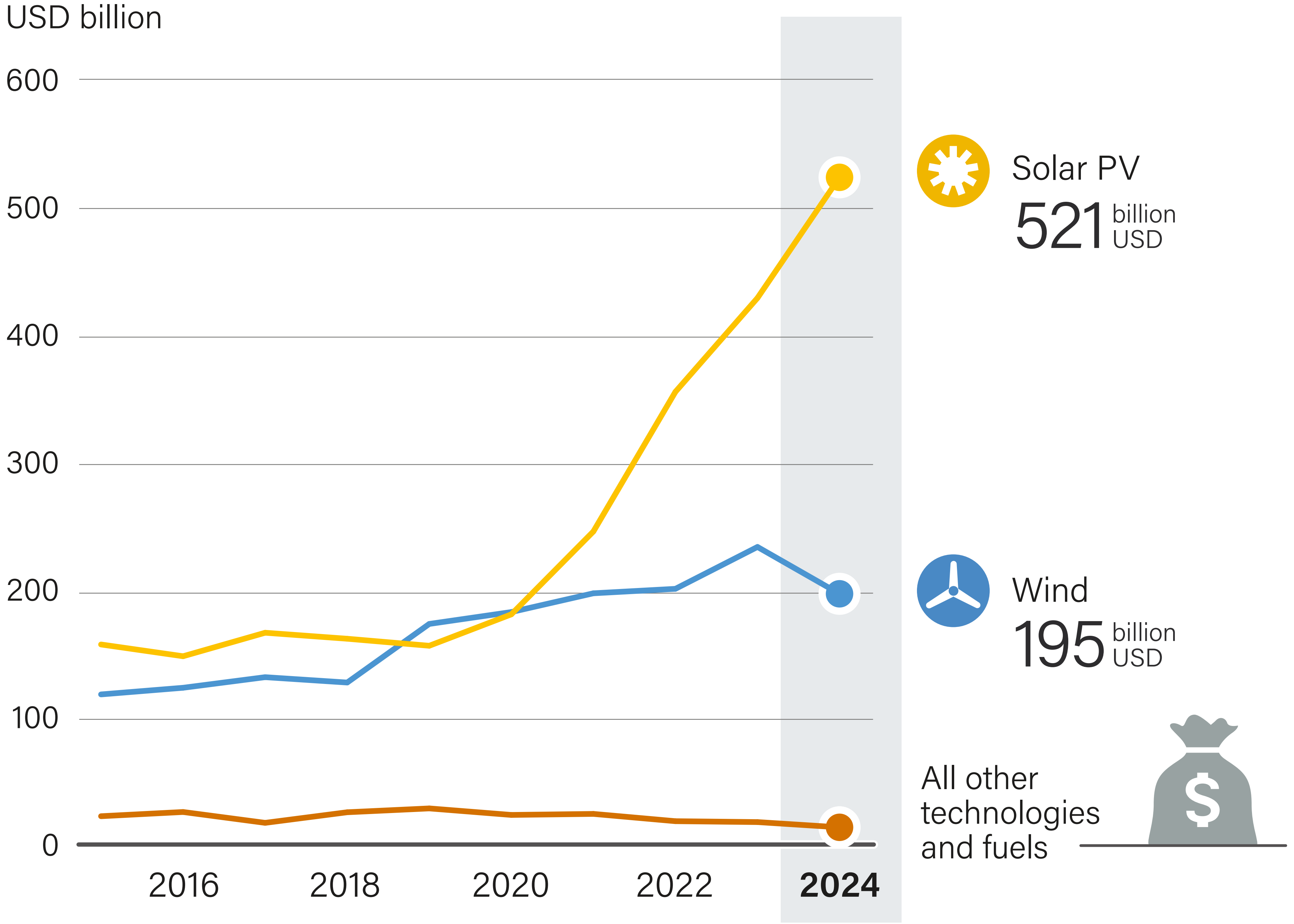


Source: See endnote 14 for this section.

x2

cost of capital in emerging and developing economies compared to advanced economies.

FIGURE 12.
Global Investment in Renewable Power and Fuels, by Technology, 2015-2024



Source: See endnote 22 for this section.

72%

was the share of solar PV of global renewable investment in 2024.

22%

was the growth in solar PV related investment in 2024.

After a period of relative stagnation, global investment in **liquid biofuels** increased in both 2023 and 2024.[37] Most of this investment was in hydrotreated vegetable oil (HVO) production capacity, as well as conventional ethanol in Brazil and India.[38] In addition to ethanol for road fuel, investments gained momentum in the use of ethanol as aviation fuel (alcohol-to-jet), mainly in the United States.[39] Among the leading companies, BP had the largest announced production capacity in its pipeline – a combined 130,000 barrels per day of ethanol and HVO and sustainable aviation fuel (SAF) capacity – positioning BP as a global frontrunner in bioenergy.[40] Other oil majors, including Chevron, Eni, ExxonMobil, Shell, and TotalEnergies, also made large strides, particularly with advanced biofuels, although many projects are still in development.[41]

Despite a 7% overall decline in the global **solar thermal** market in 2023, due mainly to a 7.7% drop in China, notable growth occurred in some areas.[42] In India, also a solar thermal leader, the market grew 27%.[43] Interest has risen as well in southern Africa and Latin America, with solar thermal growth reported in Mozambique (40%), South Africa (12%), Mexico (5%) and Brazil (3%).[44]

The rising prominence of **nuclear energy** presents another shift in the energy investment landscape. This risks diverting capital from renewable energy efforts, potentially crowding out the broader renewables agenda.

Despite broader market gains, renewable energy companies experienced plummeting stock values in late 2024 amid fears that the incoming US administration could enact policies eroding the competitiveness of renewables.[45] Market dynamics have added to the uncertainty.[46] The demand outlook for renewable energy technologies is clouded by volatile pricing, supply chain overcapacity and investor scepticism.[47] Large energy companies, including BP, have contributed to this trend by scaling back their renewable energy strategies and redirecting investment towards fossil fuels.[48] (→ *See Sidebar 4*). Meanwhile, private investors, including major hedge funds, have expressed waning interest in clean energy due to concerns about profitability and political risk, with some declaring that "clean is dead for now".[49]

In addition, there has been growing uncertainty about the future availability of international climate finance. Policy shifts – such as the loss or redirection of financing for the US Agency for International Development and various climate-related funds – pose a serious threat to renewable energy initiatives in developing countries.[50] A lack of clarity on the future of tariffs and tax credits triggered steep declines in funding and investment for renewables in early 2025.[51]

ENERGY EFFICIENCY AND ENABLING TECHNOLOGIES

Investment in **energy efficiency and enabling technologies** was an estimated USD 871 billion in 2024, a 12% increase from 2023.[52] This was driven mainly by a 20% increase in investment in electrified transport[i], which reached USD 747 billion and surpassed investment in renewables.[53] Markets for other technologies slowed, with heat pump investments declining 5%, hydrogen falling 42% and clean industry[ii] plummeting 50%.[54] However, between 2020 and 2024, electrification of end-uses experienced the fastest growth.[55] During the same period, investments in fossil fuels and nuclear energy also grew but at a slower rate; their relative share in total energy investment declined, reflecting a broader trend towards renewable energy and enabling technologies.[56] (→ *See Figure 14.*)

i Electrified transport investment is based on preliminary sales data and estimated prices of electric vehicles, fuel cell vehicles, and electric charging infrastructure and hydrogen refuelling stations. Private charging investment for commercial vehicles is not included.

ii Clean industry investments include investments in bioplastics, circular economy, clean ammonia and clean steel.

SIDEBAR 4. OIL AND GAS PROFITS TAKE PRIORITY OVER CLIMATE COMMITMENTS

Over the past decade, oil and gas companies have faced growing financial as well as social, legal and political pressure to reduce their greenhouse gas emissions. In the financial sphere, shareholder activism and stricter lending policies by European and US banks have had a measurable impact on the investments of publicly traded oil and gas companies, which comprise roughly one-third of the total equity value of the industry (the remainder being state-owned and private companies).

In response to this pressure, some oil and gas companies began investing in areas outside their core businesses, although this share of total investment has remained small. As of 2024, around 20% of oil and gas production came from companies that aimed to diversify their activities into "clean energy", which may include renewable energy, carbon capture and storage, low-emission fuels and electric vehicle charging.

TotalEnergies, Equinor, Shell and BP led the charge, together accounting for more than 60% of such investment by oil companies. Between 2020 and 2024, these companies consistently invested 5-15% of their total capital in low-carbon options (→ *see Figure 13*), including renewables, with TotalEnergies investing nearly a third of its capital expenditure in this sector in 2023. Companies that invested smaller shares in low-carbon activities included CNPC, ConocoPhillips and Qatar Energy.

Since early 2024, many oil and gas companies that had been pro-active in the energy transition began to slow and even reverse their commitments. In February 2025, Norway's Equinor announced that it was dropping its renewable energy spending targets and halving its investments in renewables. Similarly, BP announced in 2025 that it would cut its annual investment in renewable energy businesses to between USD 1.5 and USD 2 billion per year.

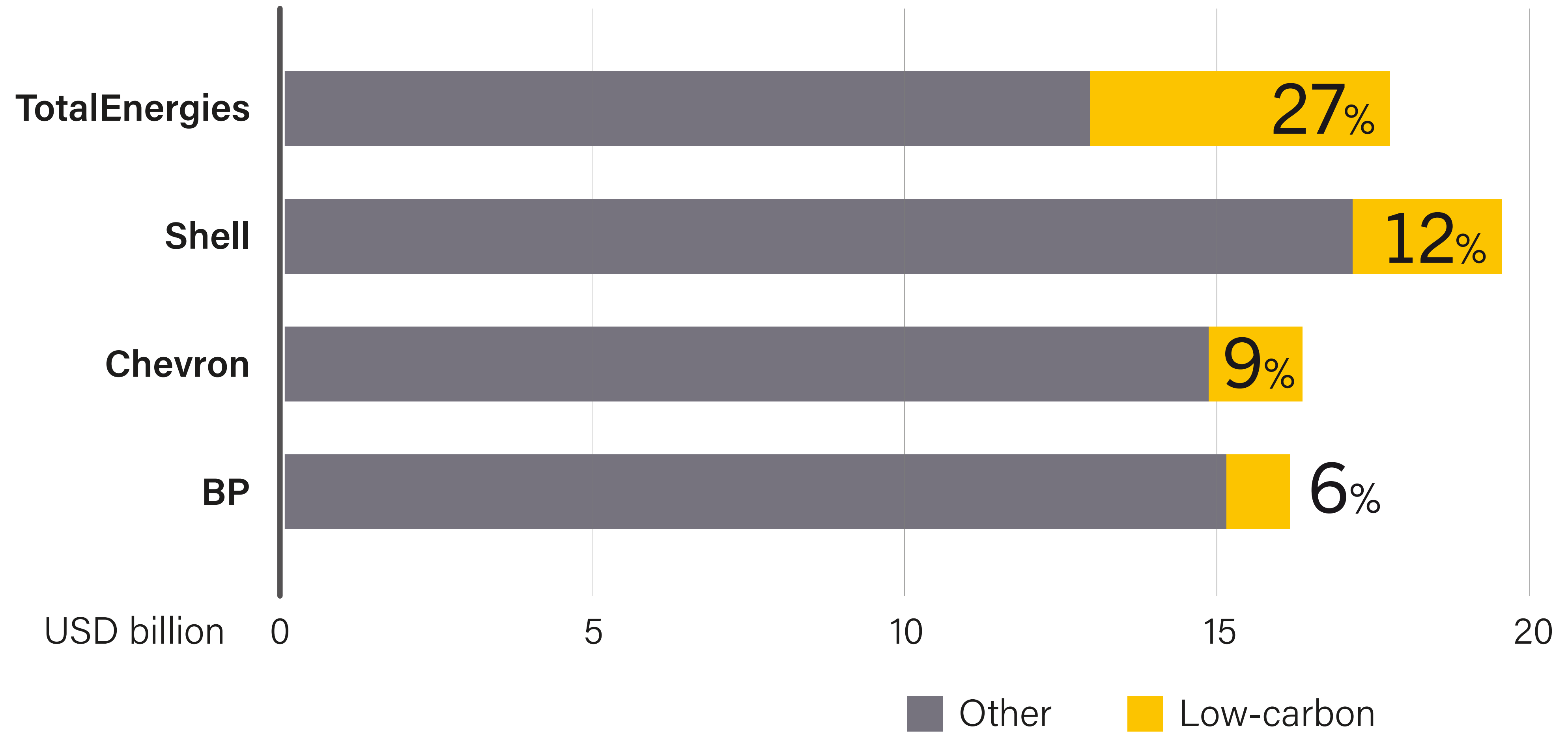
Profitability is a key consideration, as fossil fuels have continued to produce a higher return than renewables. The internal rate of return[i] for investment in oil and gas projects is expected to be around 20% (depending on the price of oil), whereas renewable energy projects provide single-digit returns of closer to 6-8%. Stock values have also underperformed for oil and gas companies that invested more heavily in renewables. For example, BP's stock value fell 10% after the company's preliminary investment in the energy transition, whereas companies that did not make the shift saw thriving stock prices in the same period (with Chevron and ExxonMobil up 46% and 57%, respectively). Geopolitical disruptions (such as the Russian Federation's invasion of Ukraine and a slowing of clean energy policies) further weakened company incentives to prioritise the energy transition.

i The internal rate of return describes the money a company will make off of the capital it invests in a project.

Source: See endnote 48 for this section.

Despite the backsliding trend, a few oil giants spurred new movement in the renewables sphere in 2024. Saudi Aramco, the world's biggest oil company, allocated 10% of its annual USD 50 billion capital expenditure to renewable energy projects that year. Chevron, the world's third largest oil and gas company, announced a new USD 500 million fund for low-carbon solutions including industrial decarbonisation, emerging mobility and energy decentralisation. The second biggest oil company globally, ExxonMobil, has consistently avoided investments in renewable energy, although it has placed some focus on carbon capture and storage, hydrogen and lithium.

FIGURE 13.
Low-Carbon and Total Capital Expenditures by Major Energy Companies, 2024



Note: Low-carbon options are defined differently by company and may include renewable energy, carbon capture and storage, low-emission fuels and electric vehicle charging.

Global demand for **heat pumps** weakened in early 2024, although some regions may have reached a turning point.[57] Sales in China grew 13% in the first few months of 2024 – the second consecutive year of double-digit growth – consolidating its position as the largest domestic heat pump market (30% of the global total).[58] In the United States, the second largest market, sales fell 1% in the first half of the year, and in the EU they fell nearly 50%.[59] Factors contributing to the decline in European heat pump sales included falling natural gas prices, a slowdown in the construction sector (with a large share of heat pumps installed in new buildings) and an uncertain political and regulatory landscape.[60]

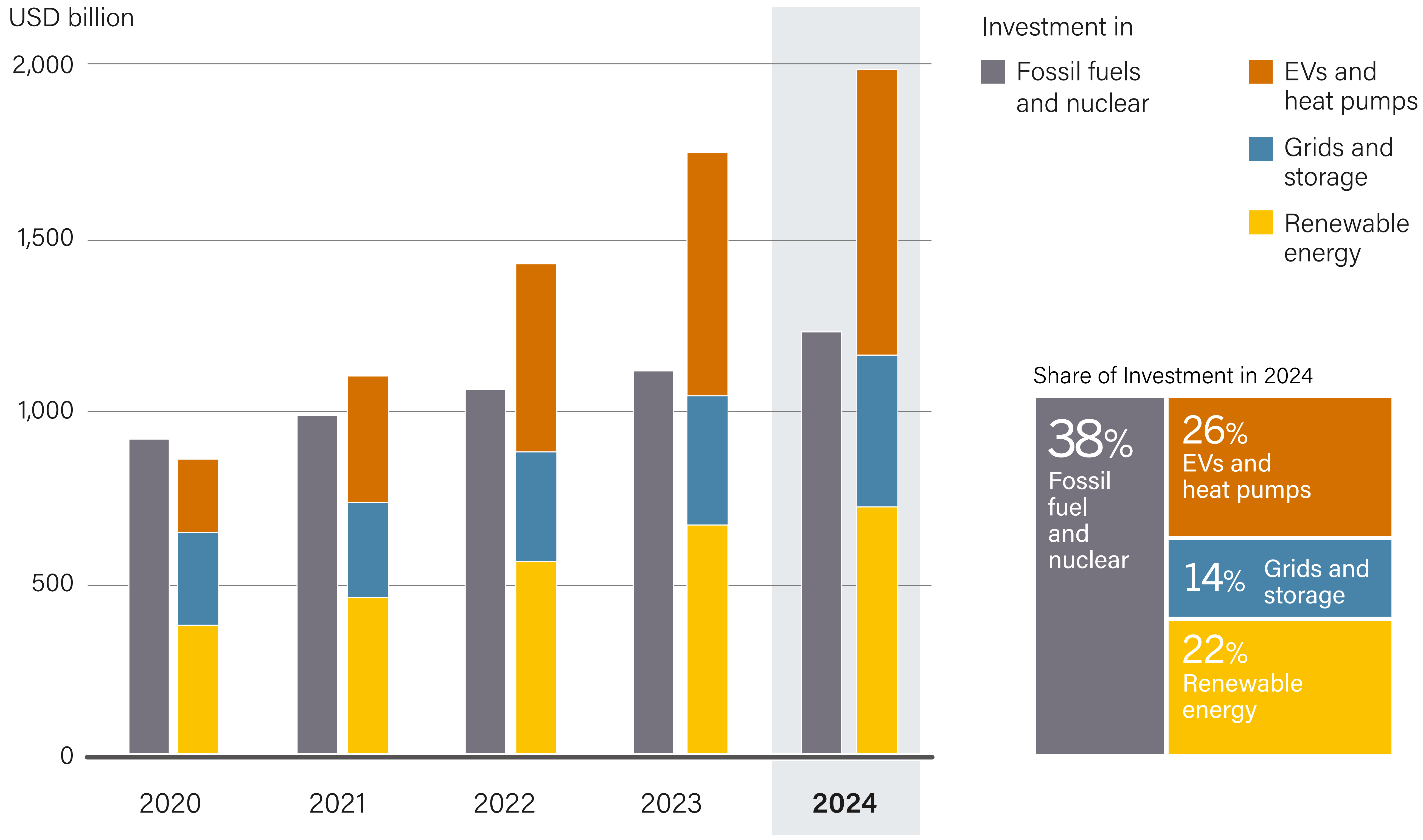
Investment in **clean industry projects**[i] fell nearly 50% in 2024.[61] Clean steel projects took the biggest hit in financial commitments, with investment falling to around USD 17.3 billion, down from USD 40.2 billion in 2023.[62] Green hydrogen made from renewables remained costly and in scarce supply, and some producers (such as Europe's ArcelorMittal) delayed planned investments in hydrogen-based projects.[63] Unlike in 2023, few developers of new clean steel and ammonia facilities allocated capital for "co-located" hydrogen plants and renewable energy installations.[64]

Despite these setbacks, clean **hydrogen** projects – encompassing both renewable and low-carbon sources – reached a major milestone, with final investment decisions (FIDs) rising sharply from 102 projects in 2020 (worth around USD 10 billion) to 434 projects in 2024 (worth around USD 75 billion).[65] The share of total hydrogen investment dedicated to clean hydrogen supply projects also increased, from more than 60% in 2020 to 75% in 2024.[66]

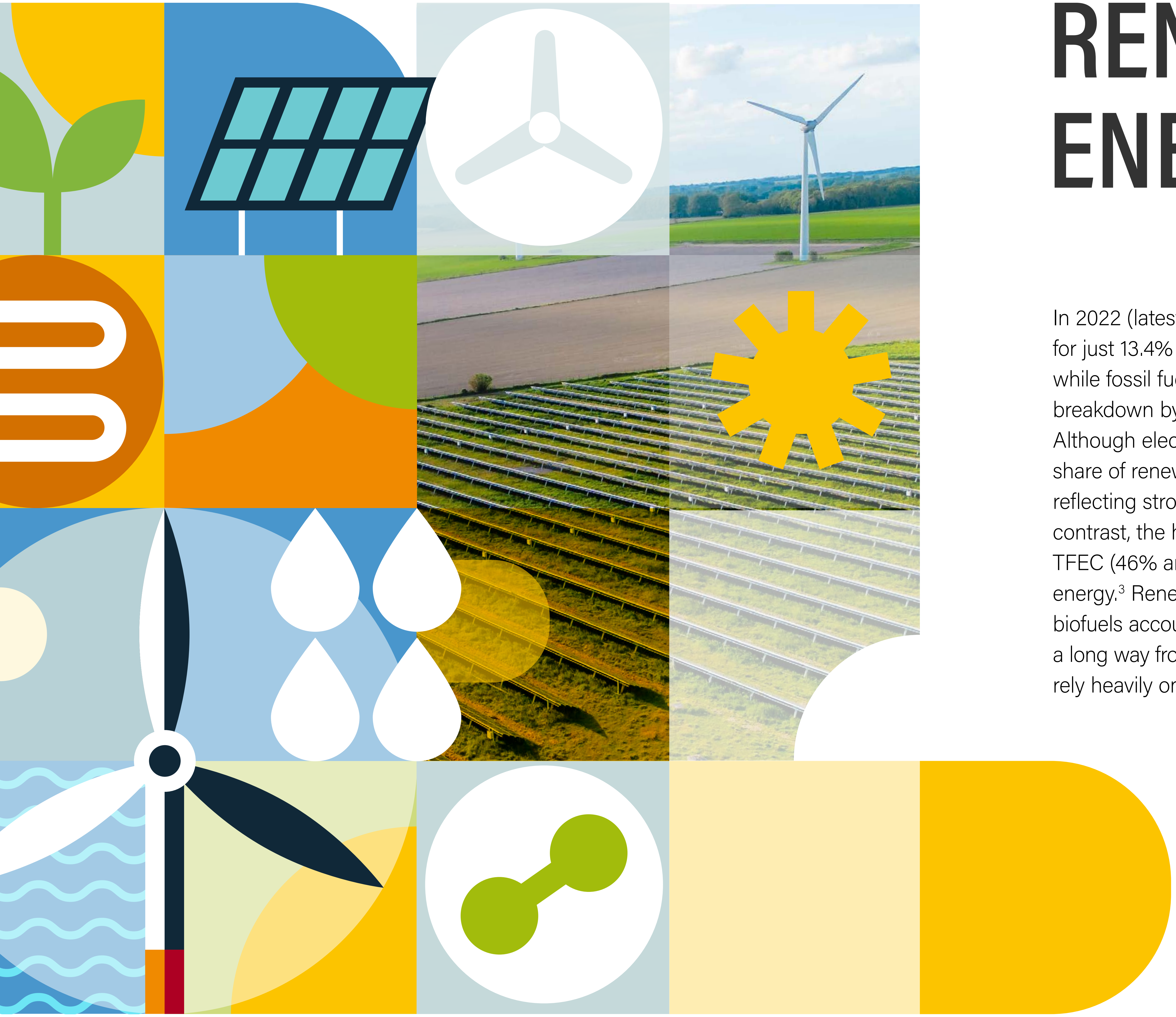
Global investment in **power grids** and **energy storage** reached a record high in 2024. Grid spending rose 15% to USD 390 billion, with growth across all regions, notably in Europe.[67] Investment in energy storage increased 36% to USD 54 billion, driven largely by developments in Asia and the United States.[68] Despite this progress, investment in grid infrastructure still needs to increase significantly to support the expansion of renewable generation required to achieve net zero greenhouse gas emissions targets by 2050.[69]

i Clean industry projects include, bioplastics, circular economy, clean ammonia and clean steel.

FIGURE 14.
Global Investment in Selected Energy Technologies, 2020-2024



Source: See endnote 56 for this section.

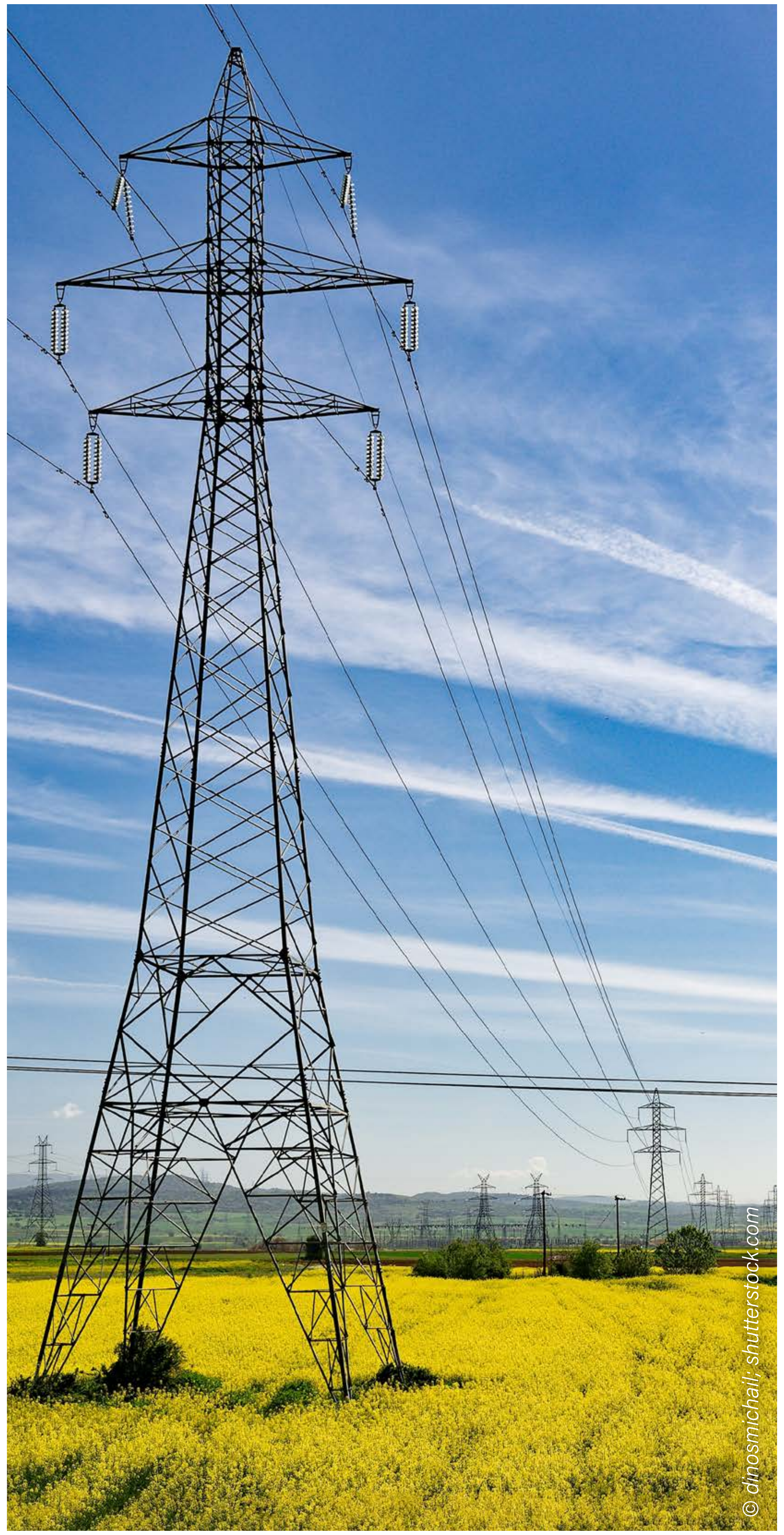


RENEWABLES IN ENERGY SUPPLY

In 2022 (latest data available), modern renewable energy accounted for just 13.4% of global **total final energy consumption** (TFEC), while fossil fuels continued to dominate across end-use sectors.[1] The breakdown by sector reveals disparities in renewable energy uptake. Although electricity represented only 23% of TFEC, it had the highest share of renewables at around 30% in 2022, up from 23% in 2015, reflecting strong progress in the power sector.[2] (→ *See Figure 15.*) In contrast, the heat and transport sectors together accounted for 77% of TFEC (46% and 31% respectively) but lagged in the use of renewable energy.[3] Renewables supplied only 10.6% of the world's heat, and biofuels accounted for just 3.6% of transport fuel use.[4] The world remains a long way from decarbonising heat and transport, which continue to rely heavily on fossil fuels.[5]

13.4%

share of renewables in TFEC in 2022.



RENEWABLE POWER

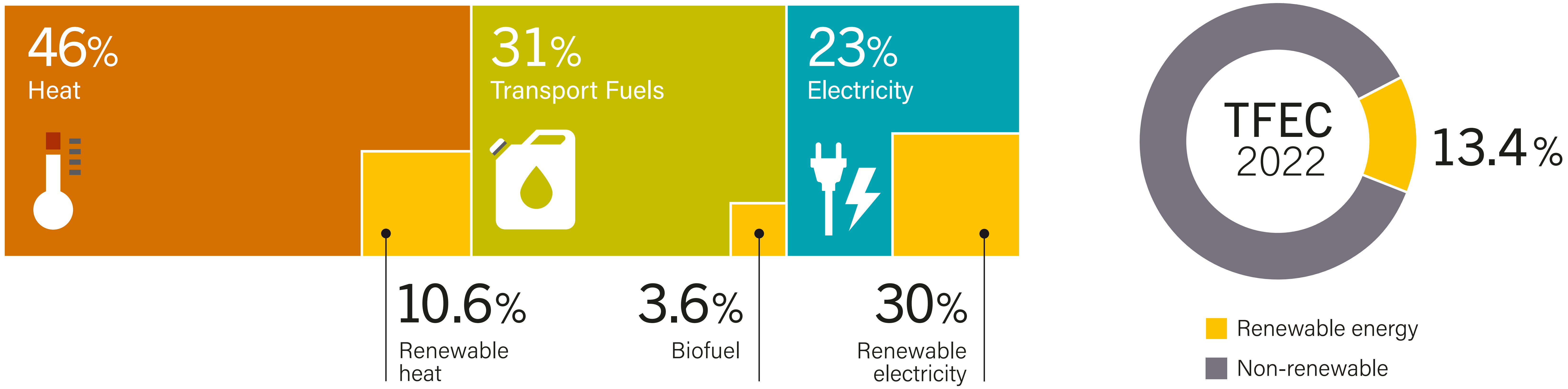
In 2024, **global electricity generation** reached a record high of around 30.9 thousand terawatt-hours (TWh), with renewables accounting for nearly one-third (31.9%) of the total.[6] (→ *See Figure 16.*) Fossil fuels remained the dominant electricity source, generating 18.2 thousand TWh and representing 59.1% of the total, although this share has been declining; nuclear power accounted for the remainder (9%).[7]

Hydropower remained the largest source of renewable electricity (14.3% of the total), while wind and solar power saw the most dynamic growth.[8] Between 2015 and 2024, solar power generation increased 16-fold, reaching 2,132 TWh (6.9%), while wind generation rose nearly 4-fold to 2,494 TWh (8.1%).[9] Bioenergy and geothermal power together contributed 800 TWh (2.6%).[10] Thanks to the steady rise in wind and solar generation renewables are helping to meet rising electricity demand while increasingly displacing fossil fuels in the power sector.[11]

23%

of total final energy consumption is met by electricity.

FIGURE 15.
Total Final Energy Consumption (TFEC) and Share of Modern Renewable Energy, by Energy Carrier, 2022

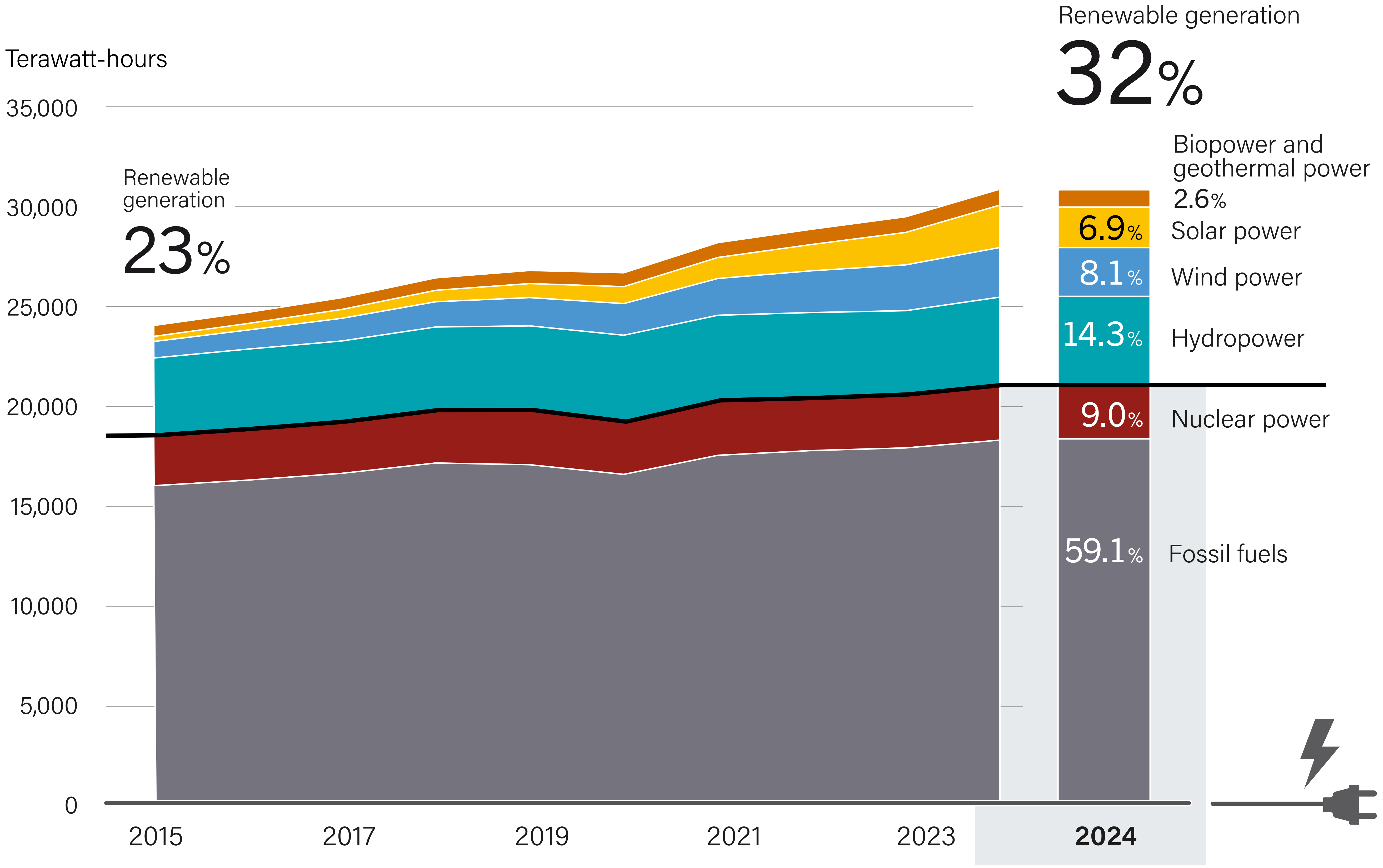


Source: See endnote 2 for this section.

Global renewable power capacity additions totalled 741 gigawatts (GW) in 2024, with China alone accounting for 60.2% (445 GW).[12] (→ *See Figure 17.*) Europe contributed 12.4% (92 GW), followed by Asia and Oceania (excluding India and China) with 9.8% (73 GW) and North America with 7.6% (56 GW).[13] India added 36 GW (4.8%) in 2024, while Brazil added 2.4% (18 GW), and the rest of Latin America and the Caribbean added just 1.0% (8 GW).[14] Africa and the Middle East collectively accounted for only 1.7% (13 GW) of renewable power capacity additions.[15] Most growth continued to be concentrated in a few key markets (particularly China), while many regions remain greatly under-represented in the global energy transition.

Solar PV was the clear driver of this growth, accounting for 81% of new capacity additions in 2024, followed by wind power at 16%.[16] (→ *See Figure 18.*) Hydropower contributed just 2%, and other renewables – bioenergy, geothermal, concentrated solar thermal power (CSP) and ocean power – accounted for only 1% of newly installed capacity.[17] Solar PV holds a dominant position not only as the most rapidly expanding renewable energy technology, but also as the largest overall source of renewable power capacity.

FIGURE 16.
Electricity Generation by Energy Source, 2015-2024



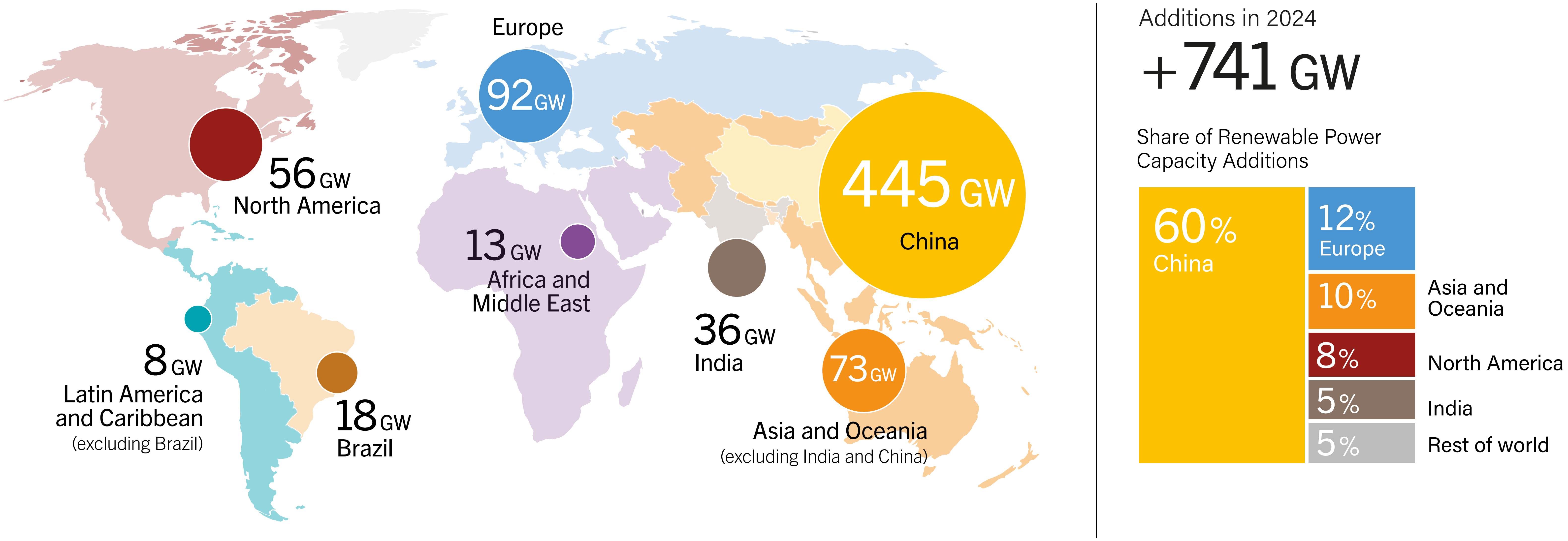
Source: See endnote 6 for this section.

Total cumulative installed **solar PV** capacity passed the 2 terawatt (TW) mark in 2024, reaching 2.25 TW nearly double the global total in 2022.[18] In 2024 an estimated 602 GW of new capacity was added – up 32% over 2023 – comparable to the cumulative capacity installed globally by 2019.[19] This continued growth was driven by historically important markets such as China (around 60% of the growth), the United States (8%), and India (5%); however, some new entrants were also significant. For example, in Pakistan (3%) solar PV combined with battery systems has become an attractive option for achieving energy autonomy.[20] Pakistan alone installed more solar PV capacity in 2024 than Italy, France and Australia combined.[21]

An estimated 116.8 GW[i] of new **wind power** capacity was connected to the world's grids in 2024, a record high despite marginal growth (0.2%).[22] **Onshore** wind installations rose 3.1%, to 109 GW, whereas **offshore** additions fell 27.5%.[23] China again dominated global wind power additions, accounting for 68.3%; not including China, global additions fell 9.6%.[24] The cumulative wind power capacity in operation grew 11.2% to 1,135.4 GW during 2024.[25] The wind industry had another challenging year, and deployment was slowed by several factors, including political and policy instability, increasing costs and risks, permitting and grid-related challenges, and rising opposition in some key countries.[26] However, installations picked up in some emerging markets, and several countries saw positive policy developments.[27]

i The data in this section reflect wind power capacity that was newly grid-connected during 2024 and in operation by the end of 2024. Accounting for decommissioning, net additions were an estimated 114.9 GW in 2024. Including more than 9 GW of capacity that was mechanically installed in China, India and the United States, but not necessarily grid-connected, global wind power additions in 2024 were closer to 127 GW. "Mechanically installed" refers to capacity that is in place and ready to produce electricity but not officially connected to the grid. See endnote 22 for this section.

FIGURE 17.
Renewable Power Capacity Additions, by Region/Country, 2024



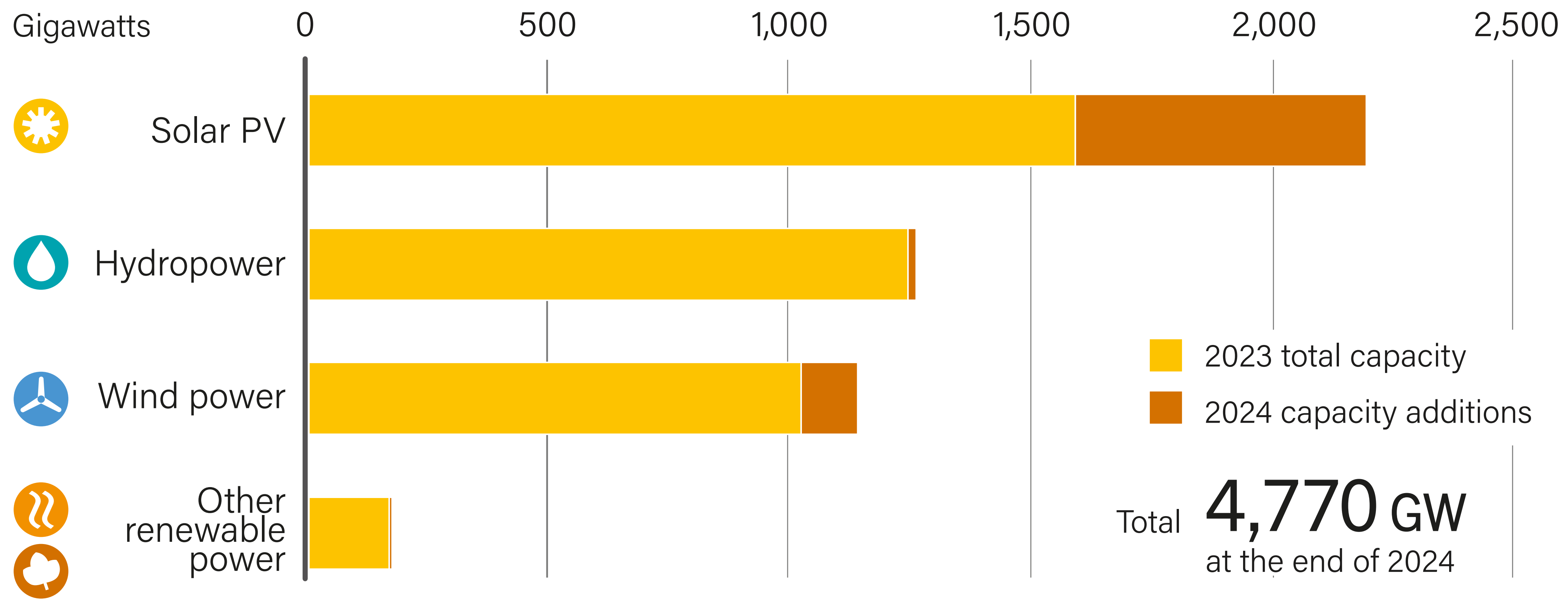
Source: See endnote 12 for this section.

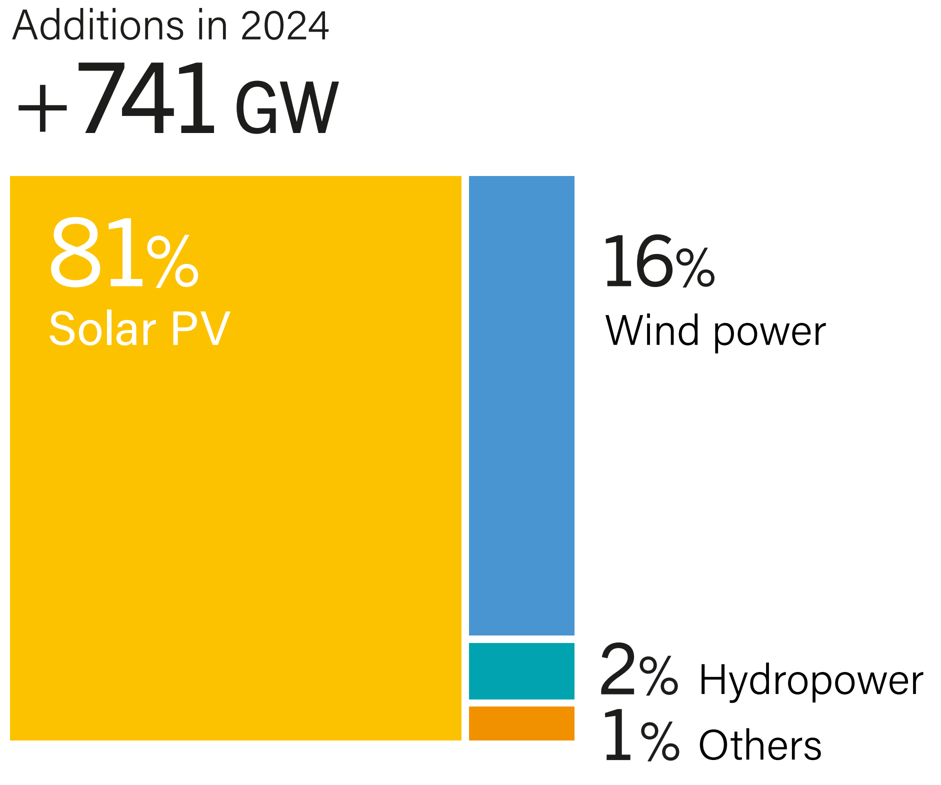
In 2024, **hydropower** continued to play a central role in renewable electricity generation, with total output reaching an estimated 4,578 TWh.[28] Globally 16.2 GW capacity was added in 2024.[29] China remained the dominant player, adding 6.7 GW of new conventional capacity and maintaining its position as the top hydropower producer, generating more than 1,400 TWh.[30] Other countries that contributed to new capacity additions included Tanzania (added 1.9 GW), Ethiopia (1.2 GW), Bhutan (1.1 GW) and Pakistan (0.9 GW).[31]

Capacity in bioenergy, geothermal, ocean power and CSP remained relatively flat, collectively totalling 177 GW.[32] **Biopower** capacity increased 4.6 GW in 2024, due mainly to new installations in China and France, reaching a global total of 155 GW.[33] Electricity generation from solid biomass power facilities increased globally to 711 TWh, although it fell in Europe with major producers such as Sweden, Finland, Denmark, and the Netherlands seeing reductions, driven by shifts in energy policy, market competitiveness and lower pellet imports.[34]

Global **geothermal** electricity generation reached an estimated 99 TWh in 2024.[35] At least 400 megawatts (MW) of new capacity was added during the year, bringing the total installed capacity to around 15.1 GW.[36] More than half of these additions were in New Zealand, followed by notable developments in the Philippines, Türkiye, Indonesia, the United States and Japan.[37]

FIGURE 18.
Renewable Power Total Installed Capacity and Additions, by Technology, 2024





Source: See endnote 16 for this section.

+18%

annual growth in global renewable capacity in 2024.

Total installed **concentrated solar thermal power** (CSP) capacity grew by 350 MW to reach 7.2 GW in 2025.[38] The positive dynamics of 2023 continued, with several new projects initiated in China, where the CSP pipeline continued to expand and the first projects of the country's current five-year period were connected to the grid.[39] China's favourable policies for CSP are helping the country to drive the global CSP market.[40]

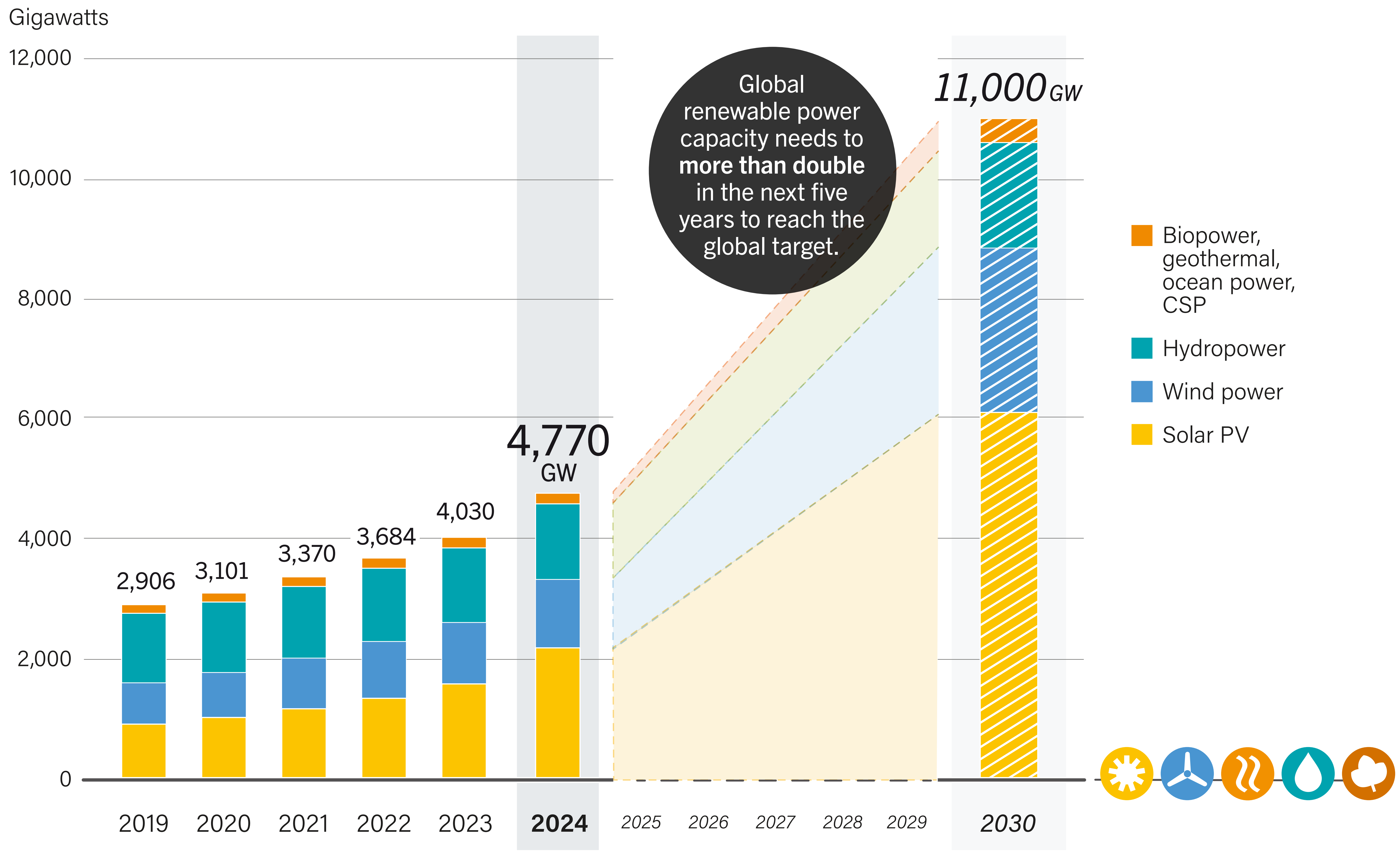
For **ocean power**, the global installed capacity remained relatively unchanged in 2024, with 1.6 MW (net) added.[41] The installed capacity increased by 2.6 MW in the Russian Federation and fell by 1 MW in the Republic of Korea (with downsizing or decommissioning of an existing plant).[42] Policy and investment activity increased compared to previous years.[43]

Despite the progress of recent years, at the end of 2024 the world remained far from its collective renewable power capacity target of 11,000 GW by 2030.[44] Meeting this goal will require more than doubling the current installed capacity within just six years, with unprecedented acceleration in deployment.[45] (→ *See Figure 19.*)

+1,040 GW/year

needed annually from 2025 to 2030 to meet the global tripling target, nearly 40% higher than the record set in 2024.

FIGURE 19.
Renewable Power Capacity by Technology, 2019-2024, Compared to 2030 Global Tripling Target



Source: See endnote 45 for this section.


© AU USAnakul, shutterstock.com

68%
of energy education still focuses on fossil fuels.
Only **32%** is dedicated to renewables as of 2024.

1,100 GW
global solar PV manufacturing capacity by end-2024.
Nearly double current PV demand.

MANUFACTURING, LABOUR AND SUPPLY CHAINS

The rapid scale-up in renewable energy deployment has been mirrored by a surge in manufacturing capacity, particularly for solar PV. Global solar manufacturing capacity was expected to exceed 1,100 GW by the end of 2024, nearly double the solar PV demand in 2024.[46] This oversupply has driven module prices down by more than half since early 2023, squeezing profit margins and triggering market instability.[47] In 2024 alone, around 300 GW of polysilicon and 200 GW of wafer manufacturing projects – worth an estimated USD 25 billion – were cancelled.[48] Vulnerabilities in the solar PV supply manufacturing sector have prompted new efforts to strengthen supply chain resilience and diversify sourcing amid growing deployment needs.[49]

In the wind sector, uncertainties due to stop-start government policies and unpredictable procurement cycles have created high demand volatility.[50] These factors combined with permitting bottlenecks have led to razor-thin or even negative margins and have rendered investment in the supply chain unviable.[51] In some key regions (Europe, Americas) investment in the supply chain has been insufficient to meet ambitious targets and expected demand beyond the next couple of years.[52] China continued to dominate turbine manufacturing as well as the world's supply chain for critical components and raw materials.[53] Chinese turbine manufacturers represented 6 of the world's top 10 and, for the first time, held the top four spots.[54] While heavily reliant on their home market, China's biggest manufacturers looked to expand sales overseas and opened new factories around the world.[55] Despite record installations and orders, however, intense competition and oversupply of components further reduced profitability for Chinese manufacturers.[56]

The workforce needed to sustain the energy transition is falling short.[57] Addressing workforce and skills challenges is essential to maintain the momentum of renewable energy growth and to achieve global net zero greenhouse gas emissions by 2050. In 2023, the renewable energy sector employed around 16.2 million people.[58] (→ *See Sidebar 5.*)

By 2030, a global shortfall of 7 million skilled workers is projected, particularly in engineering, project management and technical installation roles.[59] The demand for green skills[i] is rising much faster than the supply. In 2023, job postings requiring at least one green skill increased 22.4%, while the green talent pool grew by 12.3% across the 48 countries covered in a recent study.[60] This mismatch is compounded by a misalignment in education and training systems. As of 2024, 68% of energy-related degree programmes focused on fossil fuels, with only 32% dedicated to renewables.[61]

The fast development of the renewable energy manufacturing industry is increasingly attracting attention to the working conditions along supply chains. Governments, industry players and civil society organisations are looking into safeguards to ensure that the industry develops with respect for worker's rights. Focus is also given to solutions for avoiding or mitigating potential environmental impacts of renewables deployment.[62] (→ *See Sidebar 6.*)

i Green skills refer to the abilities that support environmentally sustainable practices, including those related to energy efficiency, renewable energy, waste reduction, and environmental conservation.

SIDEBAR 5. RENEWABLE ENERGY EMPLOYMENT: DATA AND TRENDS

In 2023, global employment in the renewable energy sector reached a record 16.2 million jobs, up from 13.7 million in 2022[i]. (→ *See Figure 20.*) The majority of job growth in renewables was in the solar PV sector, which increased by 2.2 million jobs in 2023 to reach 7.1 million, or 44% of the global total. The second largest share of renewable energy jobs was in the bioenergy sector, which employed 3.9 million people, or 24% of the total. Hydropower accounted for 14% (2.3 million people), while wind energy represented 9% (1.5 million people).

Trends in renewable energy jobs vary widely across regions, shaped by policy frameworks, investment levels and the availability of skilled labour. Asia continued to account for the largest share of global renewable energy employment in 2023, with China alone hosting 7.4 million jobs, around 45% of the global total. This is due largely to China's integrated renewable energy supply chain, supported by infrastructure investment, comprehensive industrial strategies for manufacturing and deployment, and relatively low material, capital and labour costs compared to other global players. More than 60% of China's renewable energy jobs were in solar PV in 2023. The rest of Asia accounted for around 2.2 million jobs in the renewables sector that year.

The EU's renewable energy workforce reached 1.8 million in 2023, concentrated mainly in solar PV (around 40%), followed by biomass and wind energy. To strengthen skills and boost employment in renewables, the EU introduced new policies and initiatives in 2024, including the Renewable Energy Skills Partnership. This initiative aims to equip workers with the skills needed for manufacturing and managing renewable energy technologies, with a goal of creating more than 3.5 million jobs by 2030 in support of EU energy and climate targets. In early 2025, the EU-funded initiative RESkill4NetZero was launched, aiming to accelerate workforce reskilling from other sectors and to address the rising demand for renewable energy jobs across Member States.

Brazil had around 1.6 million renewable energy jobs in 2023, despite being a net importer of renewable energy products and services. The biofuels sector, supported by the government's relatively high biofuel blending mandates, comprised the bulk of these jobs (63%), followed by solar PV (17%) and hydropower (11%). In 2024, Brazil reinforced its commitment to growing the bioenergy workforce through policies such as the Fuel of the Future Law and the National Biogas Roadmap, emphasising skills development to support the sector's expansion.

India and the United States each had around 1 million jobs in renewables in 2023. Meanwhile, across the entire African continent, renewable energy employment was just 324,000, despite its significant potential. This reflects the region's small share of global investment in renewables. To realise Africa's potential and boost renewable energy jobs, it is crucial to enhance skills development as well as workforce training and to strengthen regional supply chains across both the supply and demand sectors.

Across many developing countries, the anticipated rise in employment from the energy transition has yet to materialise, mainly because of slower renewable energy deployment and skill shortages. Despite hosting around 60% of the global labour force, developing countries held only 7% of global manufacturing jobs in renewables and enabling technologies in 2023[ii]. Meanwhile, developing countries accounted for 80% of job growth in the upstream supply of raw materials for renewables and enabling technology sectors since 2019, including materials such as minerals and bioenergy feedstocks.


© A HIP A HUB STOCK; shutterstock.com


© Xiangli Li; shutterstock.com

i The renewable energy employment data in this sidebar are sourced from IRENA and cover direct and indirect jobs. Direct employment refers to jobs created by core activities, excluding those involved in the production of intermediate inputs used to manufacture renewable energy equipment or to construct and operate facilities. Indirect employment includes jobs in upstream industries that support and supply these core activities. This may include workers involved in producing materials such as steel or plastics, or in providing financial and other related services.

ii Manufacturing jobs in renewable energy and enabling technologies include manufacturing jobs across electric vehicles, batteries, heat pumps, solar PV and wind energy.

continued next page

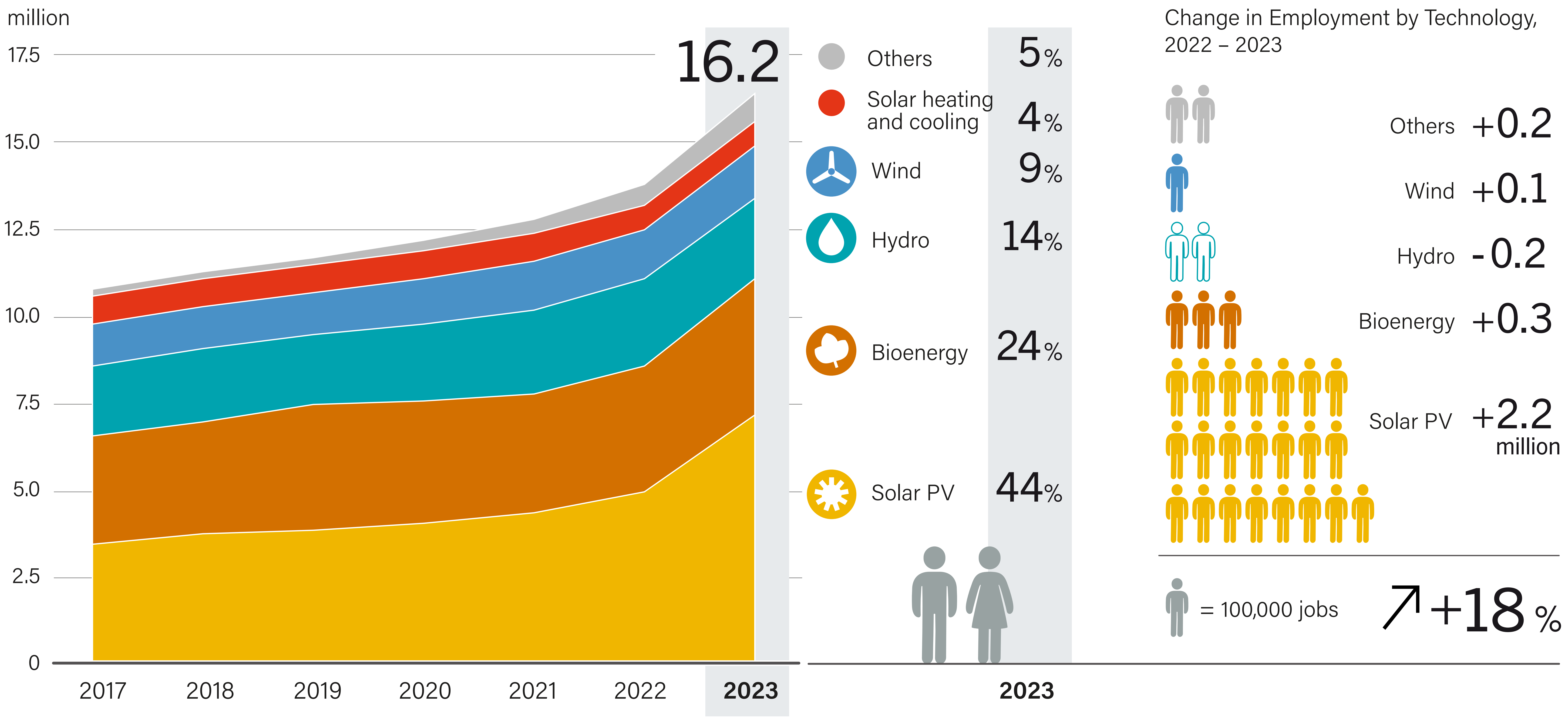
continued

Globally, despite substantial growth in renewable energy employment in some countries and regions, direct and indirect renewable energy jobs accounted for only 0.4% of the total labour force of 3.65 billion in 2023, while direct and indirect jobs in all energy sectors made up around 1.8%.

Expanding the renewable energy workforce globally, especially in developing countries, requires education and skills development that is inclusive of gender, social equity and the reskilling of workers from the fossil fuel sector. As of May 2025, 22 countries had submitted their latest round of Nationally Determined Contributions (NDCs) towards reducing greenhouse gas emissions under the Paris Agreement, but fewer than 10 of these countries referred to skilling or vocational training in the renewable energy sector to support their climate goals. They included Andorra, Brazil, Canada, Kenya, the United Arab Emirates, the United Kingdom and Uruguay.

Although renewable energy employment is expanding, much of the growth remains regionally concentrated. Realising the full potential of jobs in renewables will require coherent policies and enabling institutional frameworks, investment, education, skilling and reskilling across regions and communities.

FIGURE 20.
Global Renewable Energy Employment, by Technology, 2017-2023



Note: Employment data shown in this figure refers to direct and indirect jobs in renewable energy. Indirect employment includes employment in the upstream industries that supply and support the core activities of renewable energy deployment. Workers in such positions may be engaged in the production of steel, plastics or other materials, or provide financial and other services.

Source: See endnote 58 for this section.

SIDEBAR 6. RENEWABLE ENERGY AND SUSTAINABILITY: 2024 IN FOCUS

With the fast pace needed for renewable energy deployment, concerns have emerged about the potential social and environmental impacts. Many of these concerns may be driven by misinformation, yet others can stem from real challenges that can arise from scaling up any infrastructure. There is growing understanding of how to anticipate, avoid or mitigate the potential impacts of renewables development through effective regulation, stakeholder engagement and best practices.

Key focus areas include land use change, biodiversity protection, respect for human rights (including Indigenous Peoples and workers' rights), and the impacts of rising demand for minerals deemed critical for renewable energy and electrification, such as copper and lithium. In 2024, a variety of relevant guidance documents were released and initiatives undertaken, including:

- A multi-stakeholder panel appointed by the UN Secretary-General released the "Guiding Principles on Critical Energy Transition Minerals", focused on human rights, environmental preservation, and fair benefit sharing in minerals extraction and processing.
- The Nature Conservancy published the report *Enabling a Community-Powered Energy Transition*, showcasing good practices in stakeholder engagement to generate tangible benefits for host communities.
- The Renewables Grid Initiative, with the Institute for European Energy and Climate Policy, launched Engage4Energy, a toolkit to help developers and authorities facilitate stakeholder participation.
- Climate Action Network Europe, in collaboration with Eclareon, developed a 10-step permitting checklist aimed at accelerating renewables deployment while protecting nature and promoting public engagement.
- The Indigenous Peoples Global Coordinating Committee issued principles for a just energy transition, centred on Indigenous rights; Free, Prior and Informed Consent (FPIC) and Indigenous-led renewable initiatives.
- The Business & Human Rights Resource Centre and Indigenous Peoples' Rights International published recommendations to foster fair benefit sharing, Indigenous co-ownership and leadership in renewable energy projects.
- The International Union for the Conservation of Nature and Natural Resources (IUCN) published an overview of approaches for enhancing biodiversity while developing solar and wind projects.
- SolarPower Europe and The Nature Conservancy jointly called for EU policy makers to incentivise "nature-inclusive" solar parks that deliver biodiversity gains, backed by monitoring frameworks and regulatory incentives.

Several governments also introduced new measures in relevant areas in 2024.

Human rights and Indigenous Peoples rights: Brazil advanced legal recognition of Indigenous Peoples' territories, adding three more territories to the ones previously recognised, while Peru's national biodiversity strategy acknowledges the key role of Indigenous Peoples in biodiversity conservation. Mexico's electricity law defines the concept of energy justice and enacts the state's obligation to promote it, including respect for human rights and the rights of Indigenous and Afro-Mexican people. In the EU, the Corporate Sustainability Due Diligence Directive of 2024 mandates human rights and environmental due diligence for large companies above 1,000 employees and USD 487 million (EUR 450 million) turnover. However, civil society organisations have criticised EU efforts to simplify social and environmental regulations under the "omnibus" directive.

Land use change: South Africa requires agro-ecosystem assessments for renewable energy projects on farmland under the Protection and Development of Agriculture Land Act. Viet Nam's 2024 electricity law and land law respectively aim to streamline permitting for renewable projects and introduce mechanisms to prevent speculative land use. France and Germany introduced legal definitions for agrivoltaics, setting limits on land conversion and yield reduction per project. Canada's Clean Fuel Regulation defines feedstock criteria based on land use and biodiversity conservation.

Citizen participation: Japan's Renewable Energy Act, Mexico's electricity law and Spain's offshore wind regulations all mandate consultations with potentially affected communities prior to the submission of energy project permits. South Africa's Climate Change Act outlines principles of a "just transition", including public transparency and decent work standards.

Industry certification: The Hydropower Sustainability Alliance awarded four new certifications in 2024 under its sustainability standard, to projects in Brazil, New Zealand, the Philippines and Zambia. The Solar Stewardship Initiative issued the first site certification under the environmental, social and governance (ESG) standard and launched the supply chain traceability standard.

Source: See endnote 62 for this section.

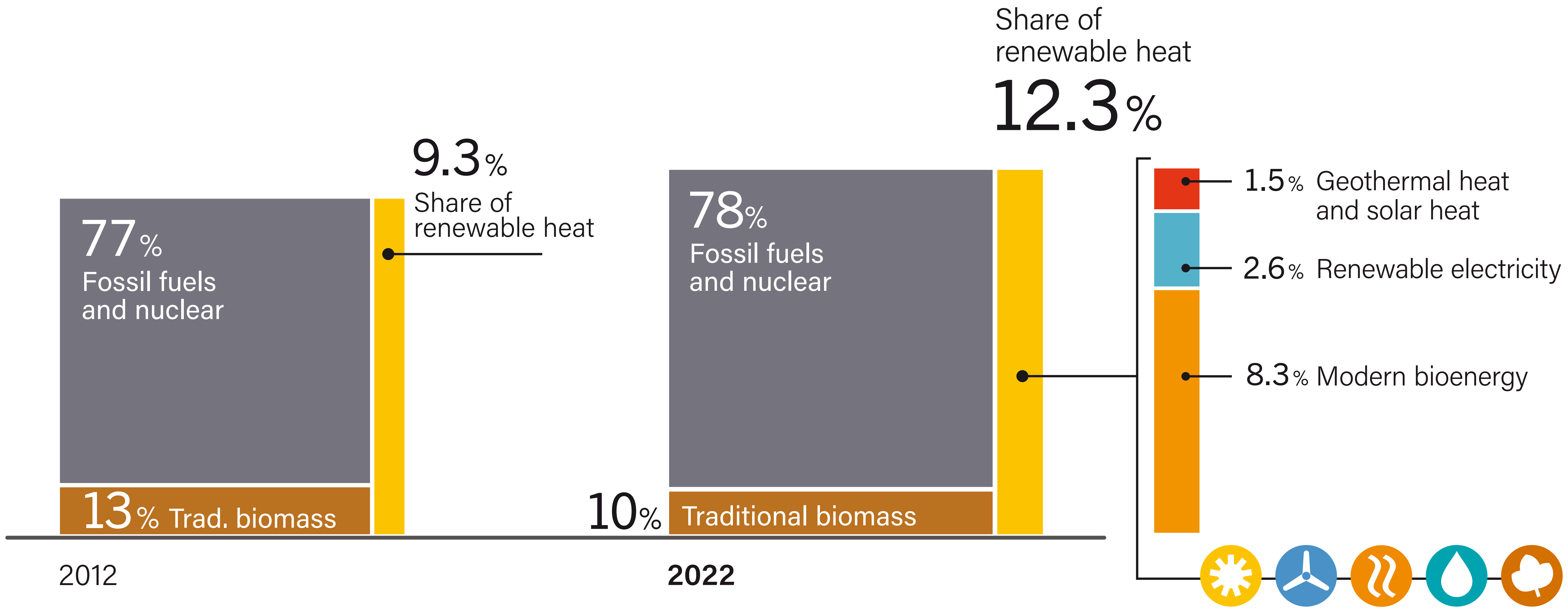
RENEWABLE HEAT AND FUELS

In 2022 (latest data available), the share of modern[i] renewable energy in total **heat** production reached 12.3%.[63] (→ *See Figure 21.*) The share of traditional biomass in total heat supply fell to 10%.[64] Meanwhile, fossil fuels remained dominant, maintaining a stable and high share of around 77%.[65]

Total renewable heat supply increased 3.2% in 2022.[66] Modern bioenergy provided 8.3% of global heat in 2024, with solid bioenergy playing a major role in supplying district heat networks.[67] The EU led the pellet market, accounting for 44% of production and 50% of consumption in 2023 – mainly for residential use; after years of growth, production stagnated in 2023 because of higher input prices, falling industrial demand and a record warm winter.[68] Renewable electricity for heat grew steadily, highlighting the growing role of electrification in the heat sector.[69] However, direct renewable heating technologies continue to provide only a modest contribution to global heat supply, due in part to limited policy support.[70]

i Modern renewable energy in total heat production includes modern bioenergy, renewable electricity, geothermal heat and solar heat. It excludes traditional biomass used for heating.

FIGURE 21.
Share of Renewable Heat Production, by Energy Source, 2012 and 2022



Source: See endnote 63 for this section.

3.2%

growth in total renewable heat supply in 2022.

Toftlund District Heating Solar Park, Denmark

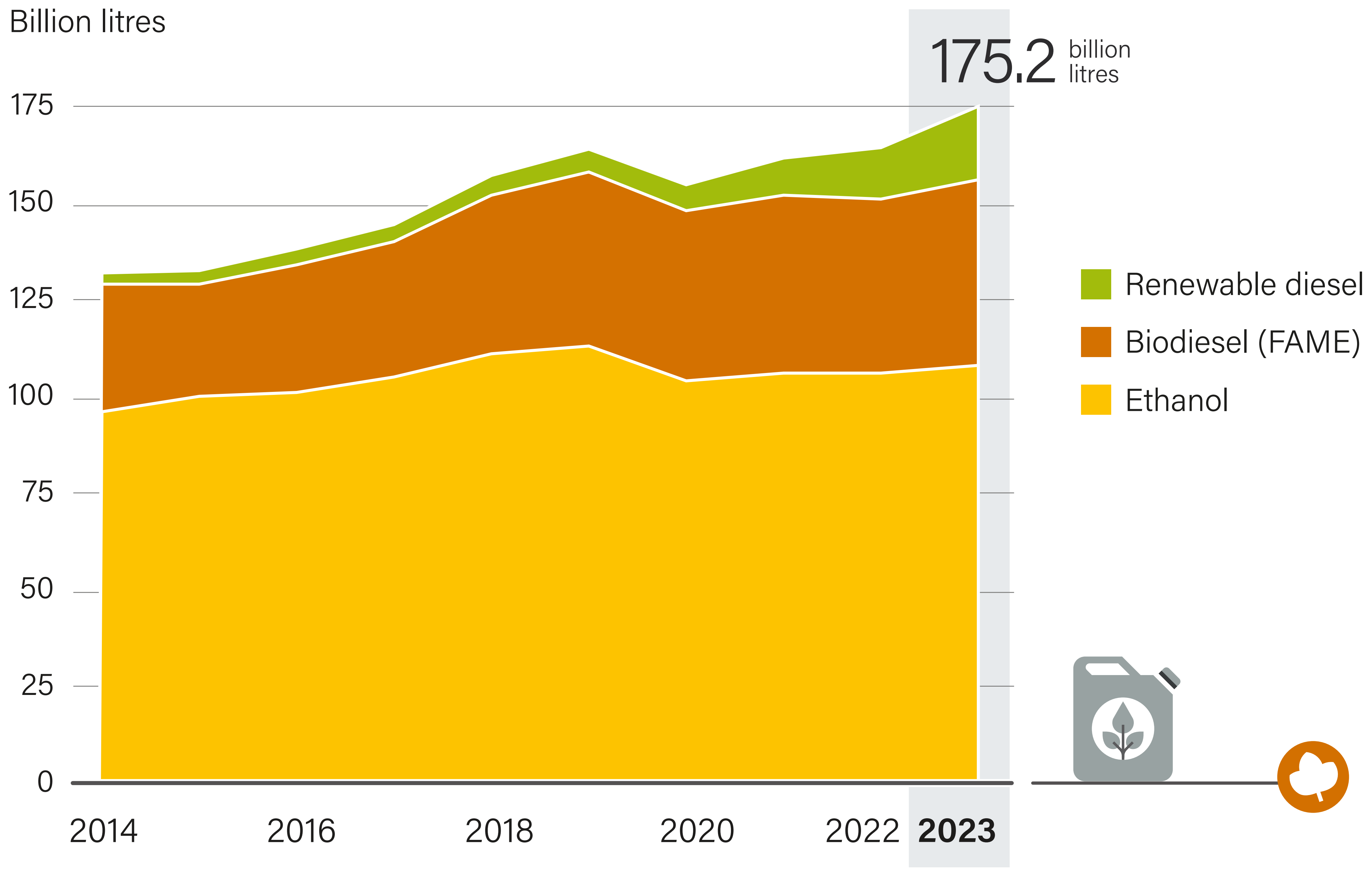
Geothermal heat, which does not include ground-source heat pumps, supplied around 245 TWh (882 petajoules), with China alone accounting for an estimated two-thirds of global geothermal heat output.[71] Due to China's rapid expansion in this sector, the country now produces 43% more geothermal heat than the entire world did in 2019.[72] Among other leading countries, geothermal continued to grow in Türkiye; Iceland saw only modest increases, and Japan experienced a decline.[73]

By the end of 2024, **solar thermal heating systems** were supplying direct heat to millions of residential, commercial and industrial clients in at least 134 countries.[74] The global market for solar thermal water collectors contracted 14.2% in 2024, due mainly to an ongoing decline in China, the largest market.[75] However, during the year, China also commissioned the world's largest solar thermal plant, demonstrating continued investment in large-scale applications despite the overall market declin.[76] (→ *See Snapshot China.*) Small-scale systems continued to lose market share in several regions, whereas demand grew for large-scale solar collectors (water, air and concentrating systems) – including for district heating systems and industrial process heat – as cities and companies sought to decarbonise their operations.[77] Solar thermal heating technologies continued to face multiple challenges, including market competition due to a lack of awareness and an imbalance in incentives.[78]

Liquid biofuel production rose 7% in 2023, reaching a total of 175.2 billion litres, led by Brazil, India, Indonesia, and the United States.[79] (→ *See Figure 22.*) In 2024, following a full year of B35 implementation – the world's highest national mandate for blending biodiesel in petrol – Indonesia reported palm oil-based biodiesel production of 13 billion litres and consumption of 12.6 billion litres.[80] Ethanol and renewable diesel production hit record highs in the United States, while the EU remained the largest bio-based diesel market despite a decline in Swedish blend mandates.[81] In 2024, Brazil enacted the Fuel of the Future law, setting blending levels for biomethane, higher blending mandates for ethanol (from 22% to 27%, with a potential to reach 35%) and biodiesel (increasing one percentage point annually, starting 2025, to reach 20% by march 2030), and also setting greenhouse gas reduction targets for the aviation sector and a national programme for green diesel.[82] Sustainable aviation fuel (SAF) production grew but still covered less than 1% of aviation fuel demand; in 2024, new SAF mandates in India, Indonesia and the Republic of Korea are expected to drive future growth.[83]


© Keshi Studio; shutterstock.com

FIGURE 22.
Global Supply of Ethanol, Biodiesel and Renewable Diesel, 2014-2023



Note: FAME stands for Fatty Acid Methyl Ester, a type of biodiesel produced through the transesterification of vegetable oils or animal fats with methanol. It is commonly used in transport and is typically blended with fossil diesel in varying proportions (*e.g.*, B7, B20)

Source: See endnote 79 for this section.

SNAPSHOT CHINA

WORLD'S LARGEST CONCENTRATED SOLAR THERMAL SYSTEM

Kunlewan International Tourism Resort, which opened in May 2024, is located in Handan city in the northern Chinese province of Hebei. It hosts the world's largest concentrated solar thermal system, with a total of 4,159 solar collectors installed across the 114,000 square metre solar mirror field[i]. Adjusted by a sun-tracking system, the mirrors focus sunlight onto receiver tubes, heating oil that stores thermal energy at 150-180°C. The heated oil is then piped to the energy conversion system, which supplies heating and cooling for the leisure resort through plate heat exchangers, ammonia absorption chillers and lithium bromide absorption chillers.

Energy generated from the solar system is stored in two types of units: heat storage tanks and cold storage tanks. For system control and management, the energy data control centre connects all equipment across the resort with a tracking system and a distributed control system (DCS) for industrial automation. This enables continuous 24-hour operation, even when unattended. A dedicated system adjusts the project's energy distribution based on varying weather conditions. The space beneath the solar collectors is used as a car park with more than 3,000 parking spaces and over 400 electric vehicle charging stations.

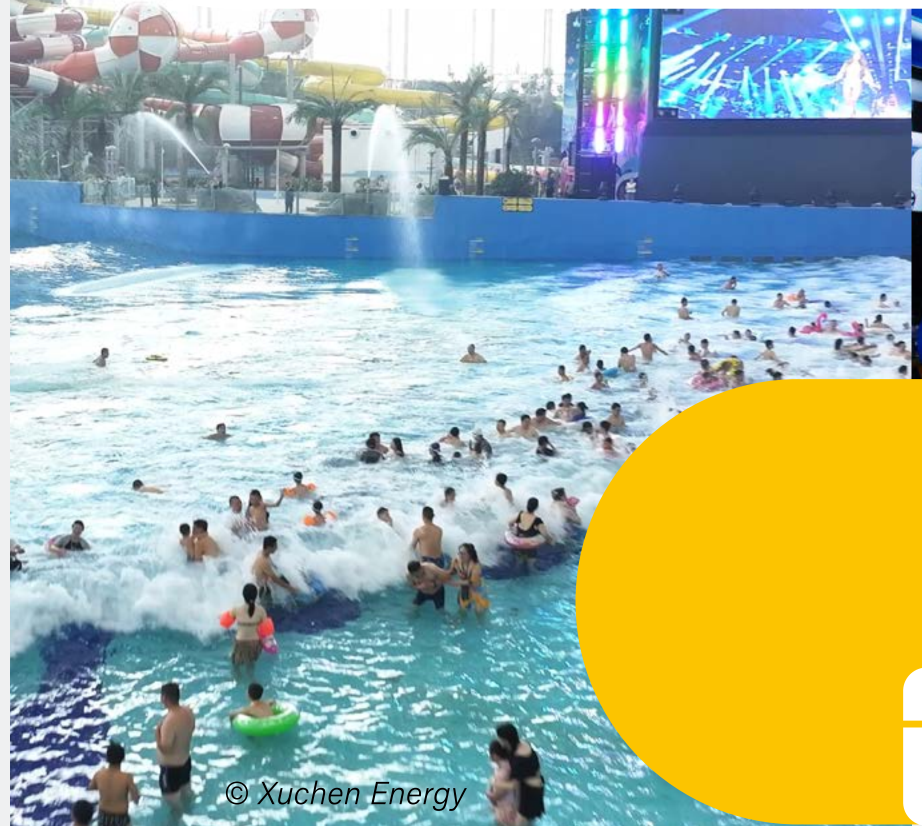
This approach enables year-round operation and consistent indoor temperatures, demonstrating how renewables can provide stable, climate-resilient infrastructure for public amenities across all seasons. Kunlewan's four core components – an aquatic recreation centre, indoor ski hall, commercial plaza and hotels – consume around 117,708 megawatt-hours (MWh) of thermal energy annually for water heating, air conditioning, and ice and snow production. The solar mirror field captures around 114,422 MWh per year, meeting up to 97% of the demand and avoiding an estimated 38,000 tonnes of CO_2 emissions annually.

As the first demonstration project integrating large-scale renewables in China's tourism sector, Kunlewan is supported by both public entities and the private sector. It is invested and developed by Handan Jianxu New Energy, established jointly by Inner Mongolia Xuchen Energy (the technical supplier and operator of the solar field) and Handan Jiaojian Zhanghe Development Co., Ltd. (a local state-owned enterprise). A total of USD 734.2 million (CNY 5.3 billion) was invested in the project, including USD 165 million (CNY 1.2 billion)[ii] in corporate bonds issued by Handan Construction Investment Group, a wholly state-owned enterprise.

i The solar thermal capacity of the field is an estimated 77 megawatts.
ii Investment amounts are converted using exchange rates as of April 2024.
Source: See endnote 76 for this section.


© Xuchen Energy

114,422 MWh
of thermal energy produced annually


© Xuchen Energy


© Xuchen Energy

Table 1.
Top Five Countries for Total Renewable Energy Supply by Technology/Source, 2024

	1	2	3	4	5
Total renewable power capacity	**China**	United States	Brazil	India	Germany
Solar PV	**China**	United States	India	Germany	Japan
Wind power	**China**	United States	Germany	India	Brazil
Hydropower	**China**	Brazil	Canada	United States	Russian Federation
Biopower	**Germany**	United Kingdom	United States	China	Italy
Geothermal power	**United States**	Indonesia	Philippines	Türkiye	New Zealand
Total biofuels production	**United States**	Brazil	Indonesia	China	India
Total pellets production	**United States**	Viet Nam	Germany	Canada	Latvia
Solar water heating collector capacity	**China**	Türkiye	Brazil	United States	India

Source: See endnote 84 for this section.

Solar PV in China

Table 2.
Top Five Countries for Per Capita Renewable Energy Supply by Technology/Source, 2024

	1	2	3	4	5
Total renewable power capacity **per capita**	**Iceland**	Norway	Sweden	Austria	Finland
Solar PV	**Netherlands**	Australia	Germany	Estonia	Spain
Wind power	**Sweden**	Finland	Denmark	Ireland	Norway
Hydropower	**Norway**	Iceland	Canada	Sweden	Paraguay
Biopower	**Germany**	Czech Republic	United Kingdom	Latvia	Italy
Geothermal power	**Iceland**	New Zealand	Costa Rica	El Salvador	Nicaragua
Total biofuels production **per capita**	**Sweden**	United States	Finland	Brazil	Denmark
Total pellets production **per capita**	**Estonia**	Latvia	Austria	Germany	United States
Solar water heating collector capacity **per capita**	**Barbados**	Cyprus	Greece	Israel	Austria

Source: See endnote 85 for this section.

© Kirill Chernyshev, shutterstock.com

Geothermal Power Plant in Iceland

ENERGY SYSTEMS AND INFRASTRUCTURE

In 2024, the power sector continued to spearhead the adoption of renewable energy. During the year, 33 countries generated more than half of their electricity from renewable sources, and 15 countries successfully integrated more than 30% variable renewable electricity – solar and wind power specifically – into their electricity mix.[1] (→ *See Figure 23.*)

The power system infrastructure is evolving to support the upward trend of electrification and the integration of more distributed and variable renewable electricity into the world's grids.[2] In 2024, in addition to reinforcing and expanding transmission networks and interconnections, regulators and system operators increasingly focused on flexibility measures – including energy storage, demand response and the use of digital technologies – to ensure grid stability and reliable supply.[3]

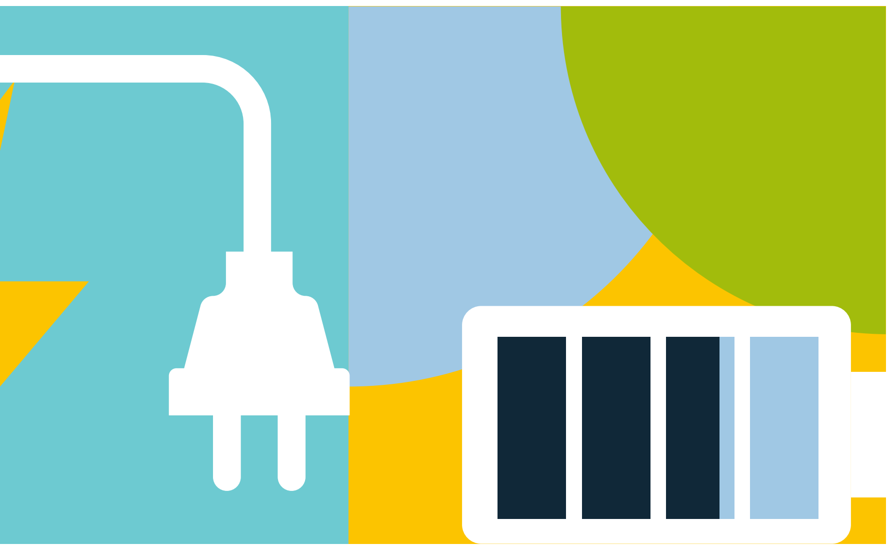
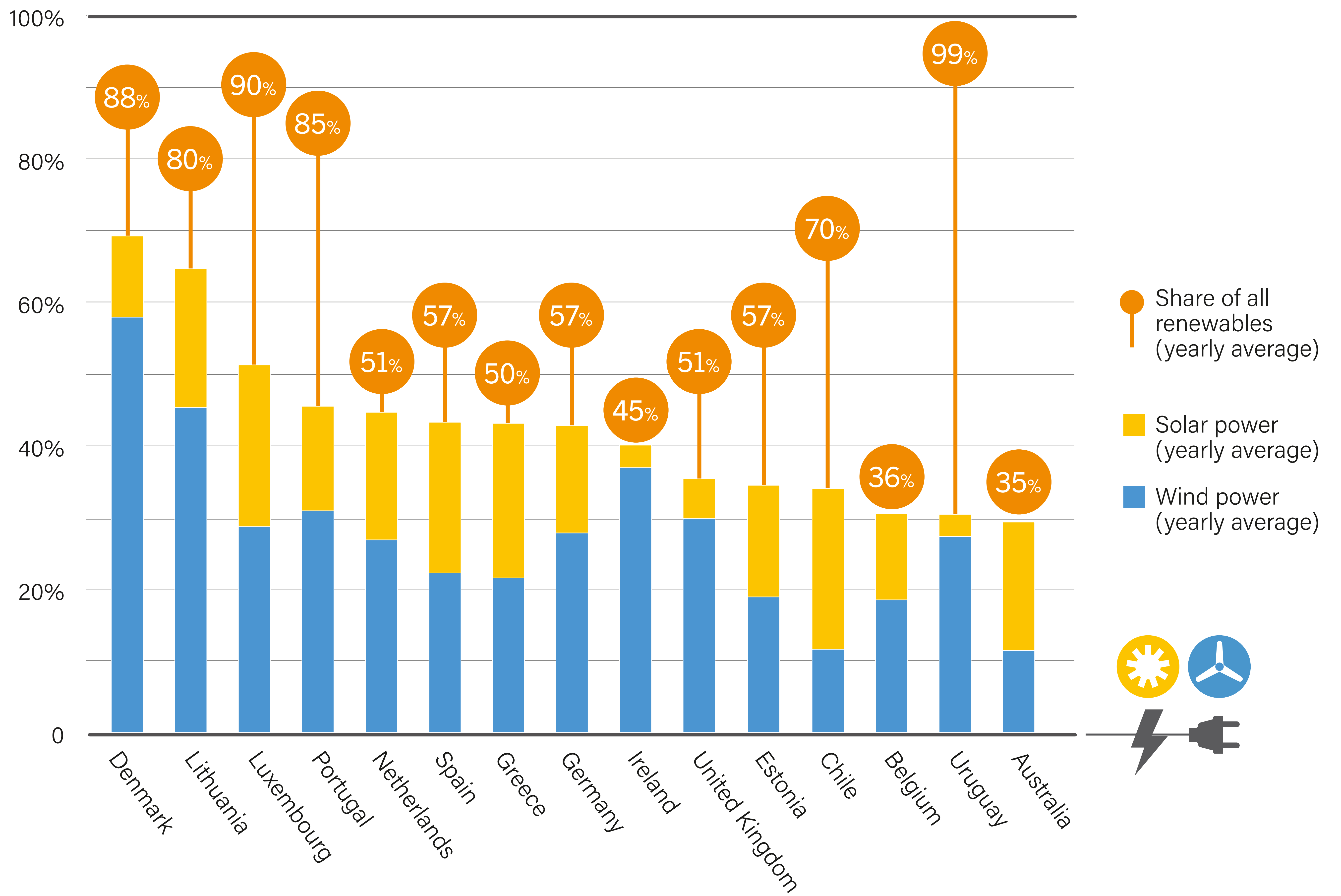


FIGURE 23.
Countries with High Shares of Wind and Solar Generation in Their Power Systems, 2024



Note: Renewable energy sources for electricity generation include all modern renewables (geothermal, hydropower, modern bioenergy, ocean energy, solar energy and wind power).

Source: See endnote 1 for this section.

ELECTRICITY GRIDS

The optimisation and expansion of power networks continued to attract investment and policy attention in 2024, with total **grid investment** reaching USD 390 billion, up 15% compared to 2023.[4]

At the November 2024 United Nations Climate Change Conference in Baku, Azerbaijan (COP 29), 65 countries signed the Global Energy Storage and Grids Pledge, committing to deploy 1,500 GW of energy storage and to develop or refurbish 25 million kilometres of grid infrastructure by 2030.[5] Additionally, 57 countries endorsed the Green Energy Zones and Corridors Pledge, which aims to accelerate the development of renewable energy and transmission infrastructure through international co-operation.[6]

Meanwhile, challenges with **grid congestion and connection queues** continued. As of mid-2024, an estimated 1,650 GW of renewable energy capacity in advanced development stages was awaiting grid connection, up 150 GW from a year earlier.[7] Interconnection queues in the United States expanded 30% in 2023, with connection timelines tripling over a two-decade period to around five years from the request date to the commercial operation date.[8]

In China, despite record investment of USD 17 billion in the first four months of 2024, power grids struggled to keep pace with wind and solar capacity additions.[9] Many counties and cities across five Chinese provinces suspended their approvals for connecting new small-scale solar projects to distribution grids during the year.[10]

In the EU, to compensate for grid congestion, system operators engaged in remedial actions[i] covering an estimated 57.3 TWh in 2023, up 14.5% compared with 2022.[11]

Policy interest has grown in pursuing system upgrades and flexibility through battery storage, demand-side response, sector coupling, the use of distributed resources and the integration of new actors such as aggregators and local energy communities in power system design.[12] Policies include mandatory long-term grid planning as well as provisions to streamline permitting, give priority status to grid expansion projects, and prioritise grid optimisation and flexibility solutions prior to grid expansion.[13] Several countries have mandated that new variable renewable energy capacity be paired with storage capacity. Market instruments such as variable network tariffs and constraint markets have emerged as tools to balance power networks.[14] (→ *See Snapshot United Kingdom.*)

Grid-enhancing technologies – such as Dynamic Line Rating and Advanced Power Flow Control – progressed from pilot projects to operational deployment in 2024, and many are being integrated into utility planning and regulatory frameworks. Regulators and regional authorities (such as the US Federal Energy Regulatory Commission and the US state of Minnesota) have increasingly required the use of these technologies on transmission lines to improve grid efficiency.[15] Utilities worldwide are deploying operational grid-enhancing technologies, including National Grid in the US state of New York, Red Eléctrica de España (REE) in Spain, the German-Dutch transmission system operator TenneT, ISA Energia in Brasil and ISA Transelca in Colombia.[16]

To ensure the integration of higher shares of variable renewables – such as solar and wind power – technologies such as grid-forming batteries and inverters and the provision of virtual inertia have increasingly been integrated in grid modernisation strategies, along with demand response measures and improved forecasting.[17] Examples include the Grid Modernization Strategy of the US Department of Energy, the Inertia Report of the Australian Energy Market Operator, the System Stability & Resilience innovation priority of the UK's National Energy System Operator, the Roadmap for an Accelerated Energy Transition of Chile's power coordinator, the recommendations of the Grid Controller of India, and Eskom's (South Africa) inertia estimation tool in collaboration with the Global PST Consortium.[18]

Regional interconnection projects advanced in 2024. In Africa, these included the completion of the cross-border transmission project between Burundi, Rwanda and Tanzania; the securing of funding for an interconnection line between South Sudan and Uganda; and the announcement by Eastern Africa Power Pool countries of their launch of an intraday electricity market in 2025.[19] To the north, funding for the ELMED interconnection project between Tunisia and Italy advanced through a loan from the European Investment Bank, and an interconnection line between Iraq and Türkiye started operating.[20]

In South America, Ecuador and Peru launched a tender for a new interconnector, and in Central Asia, Azerbaijan, Kazakhstan and Uzbekistan signed a memorandum of understanding to connect their power systems through an undersea high-voltage cable.[21]

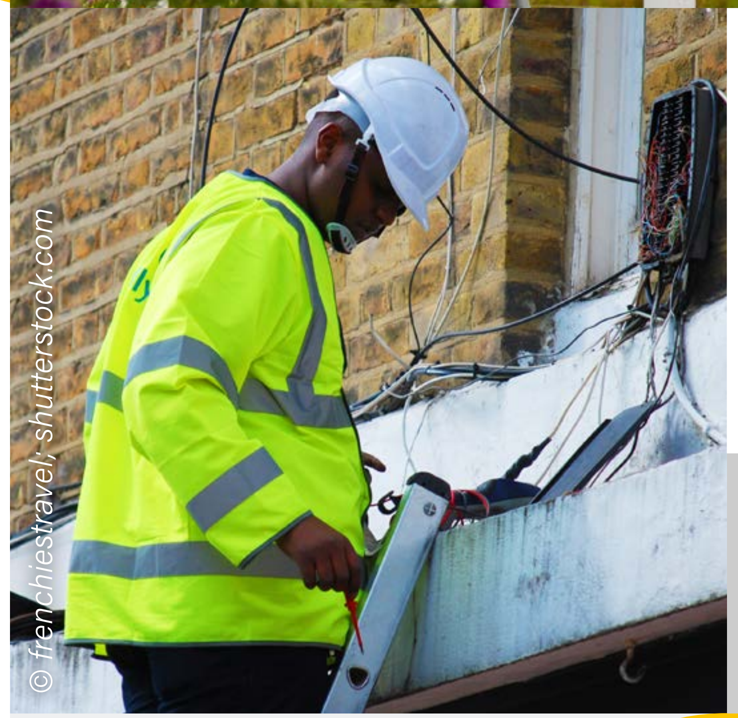
© Vladimir Tretyakov; shutterstock.com

390 USD billion

total grid investment in 2024.

i Remedial actions are defined by the European Commission as "any measure applied by a TSO [Transmission System Operator] or several TSOs, manually or automatically, in order to maintain operational security". See endnote 11.

© TTL Deez; shutterstock.com



© frenchiestravel; shutterstock.com

Consumers and producers propose bids to **increase or decrease their electricity use and generation** to adapt to grid limitations.

SNAPSHOT UNITED KINGDOM

LOCAL FLEXIBILITY MARKET TO TACKLE GRID BOTTLENECKS

Constraints refer to limitations in the transmission network that lead the system operator to force electricity producers to reduce their output in instances where generation is higher than the network's capacity. In recent years, grid constraints have been notable in the UK, especially between Scotland and England. The costs of these constraints – paid by the National Energy System Operator (NESO) – totalled an estimated USD 2.2 billion (GBP 1.6 billion) for the financial year 2022-2023.[i]

As part of the strategy to address these rising costs over the short term, NESO has set up the Local Constraint Market (LCM), wherein electricity users and producers in specific areas propose bids to increase or decrease their electricity use or generation at certain times. The market was designed to be open to a wider range of participants than the traditional Balancing Mechanism (BM), NESO's main tool to maintain real-time balance between electricity supply and demand. The BM works on an "intraday" basis by asking generators or consumers to adjust their output every half hour. Only participants formally registered in the BM can take part.

In contrast to the Balancing Mechanism, the Local Constraint Market allows participation from flexibility providers that may not be part of the Balancing Mechanism. These include energy suppliers, aggregators and other companies capable of adjusting their electricity use or generation locally. Many of these are also participants in the Capacity Market, which ensures that enough capacity is available at peak times. The LCM is a day-ahead market, and as such it offers the potential to reduce the volume and cost of actions required in the BM the following day.

In 2024, NESO ran a pilot initiative where households in Scotland adjusted the timing of their electricity use to absorb excess wind power generation. Over a 10-day period, 3 megawatts of demand response was contracted. In 2025, NESO continued its work to expand and improve the LCM.

SNAPSHOT
UNITED KINGDOM

i The largest proportion of constraint costs are payments to fossil gas generators, typically to increase output to meet demand and to replace constrained generation elsewhere. According to some estimations, payments to fossil gas generators accounted for 76% of constraint costs during the period January to September 2024.

Source: See endnote 14 for this section.

ENERGY STORAGE

Energy storage systems - such as batteries, pumped storage, thermal storage and hydrogen - can help stabilise power grids, especially in the context of increased penetration of variable renewables. **Battery energy storage systems** were the fastest growing energy storage technology in 2024. An estimated 69 GW of new battery storage capacity was deployed globally during the year, bringing the total installed capacity to an estimated 150 GW.[22] The grid-connected segment accounted for 78% of this growth.[23] (→ *See Figure 24.*)

China led in battery storage deployment with 67% of global new installations, driven by provincial policies requiring battery capacity to be co-located with new solar and wind power installations.[24] The United States and Canada were the second largest contributors of battery capacity, with the United States adding 10.4 GW for a total of 26 GW nationwide.[25] Strong growth also occurred in Europe, Latin America and the rest of the Asia Pacific region.[26]

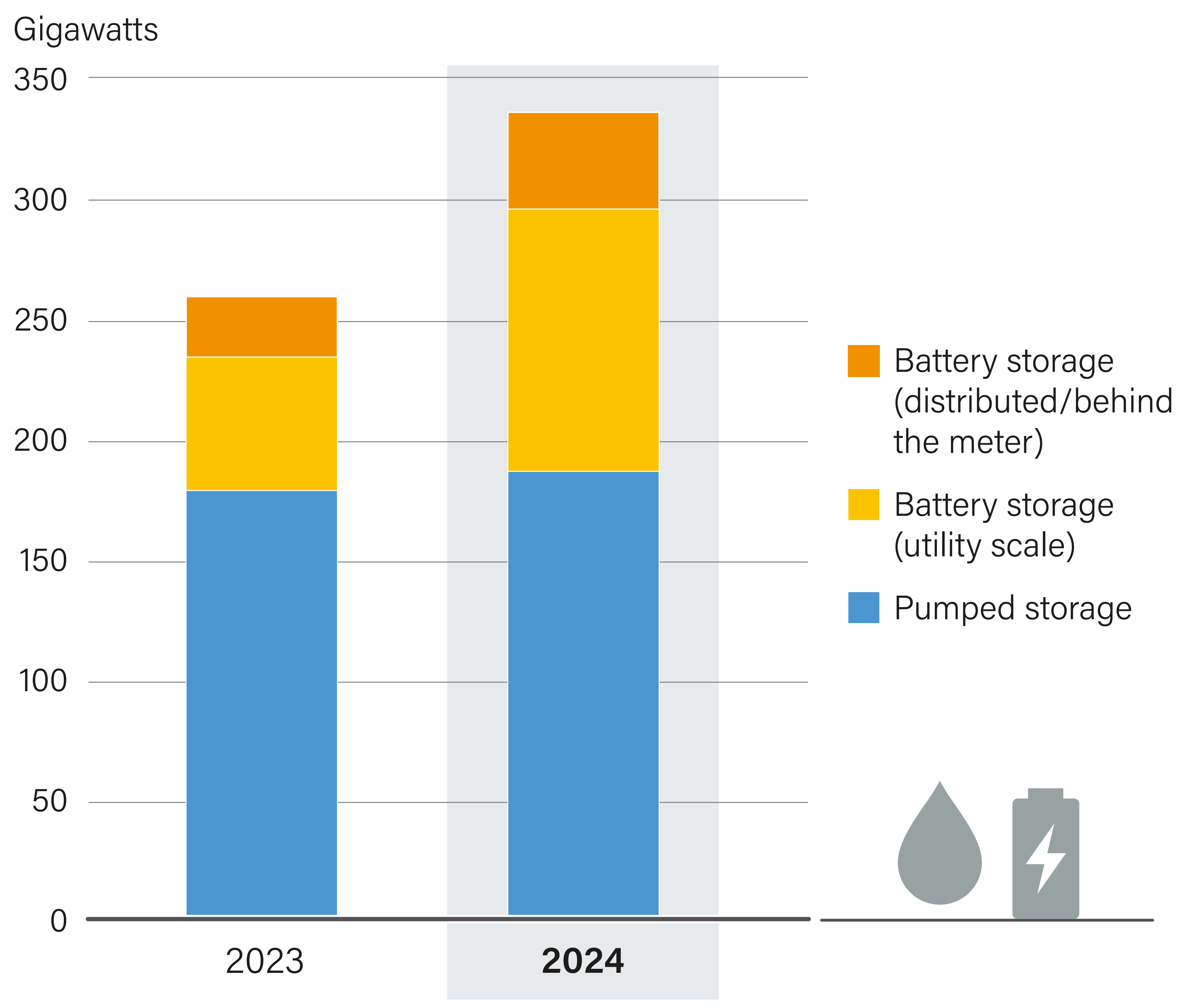
Both the capacity of battery installations and the duration[i] increased during the year. Altogether, around 17 installations of more than 1 GW were deployed in 2024, up from only 4 a year earlier, and an estimated 140 projects of more than 1 GW each were planned for 2025 and 2026.[27] In Europe, the average duration of battery storage increased from 1.4 hours in 2023 to 2.0 hours in 2024, whereas in the United States and Canada the average duration of new installations in 2024 was 3.0 hours.[28]

Global investment in stationary energy storage projects (excluding pumped storage and hydrogen) increased 36% in 2024 to reach USD 54 billion.[29] Meanwhile, the global average cost for battery storage projects dropped by one-third to USD 104 per megawatt-hour, driven by the lower price of battery packs due to oversupply caused by slowing sales of electric vehicles.[30]

Pumped storage remained the leading energy storage technology in 2024, with 189 GW of global installed capacity.[31] Capacity additions during the year totalled 8.4 GW, an increase of 4.5% compared to 2023.[32]

i The duration of a battery storage system refers to how long it can supply power to the grid.

FIGURE 24.
Energy Storage Capacity by Type, 2023 and 2024



Source: See endnote 23 for this section.

54 bn

Global investment in stationary energy storage projects in 2024.

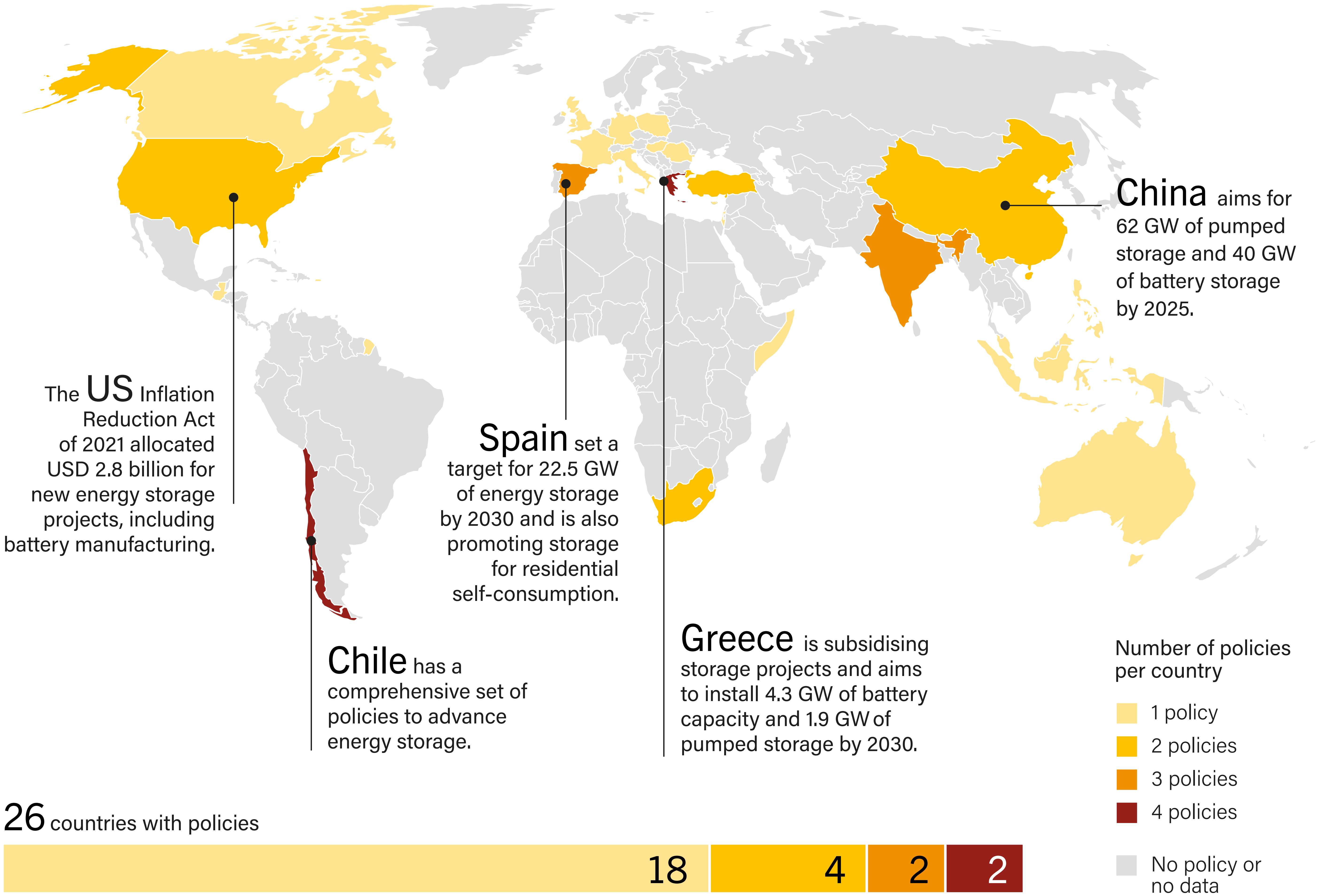
Thermal storage continued to gain attention in the industry sector, with projects focused on high-temperature energy storage. The global market for thermal energy storage systems was valued at USD 54.4 billion in 2024, up from USD 47.5 billion in 2023.[33]

By the end of 2024, at least 26 countries had announced or enacted **policies** to support energy storage (→ *see Figure 25*), a slight increase over 2023.[34] Although more than half of these countries had established targets for energy storage, the most common policy type was fiscal and financial incentives. Existing policies focus mainly on battery storage, including incentives for increased battery capacity to support grid stability, as well as support for the development of a domestic manufacturing industry.[35]

Incentives for energy storage were aimed mainly at both utility-scale and household-level battery storage development. Much less policy attention in 2024 went to pumped storage (with 5 countries setting new specific policies) and thermal storage (only 1 country).[36] Policy makers have increasingly explored long-duration energy storage[i] technologies, with both the United Kingdom and New South Wales in Australia introducing mechanisms to support their development in early 2025.[37]

i Refers to systems with a discharge duration of above 8 hours, although this duration can vary according to diverse definitions.

FIGURE 25.
Countries with Targets, Regulations and Financial Incentives for Energy Storage, as of 2024



Source: See endnote 34 for this section.

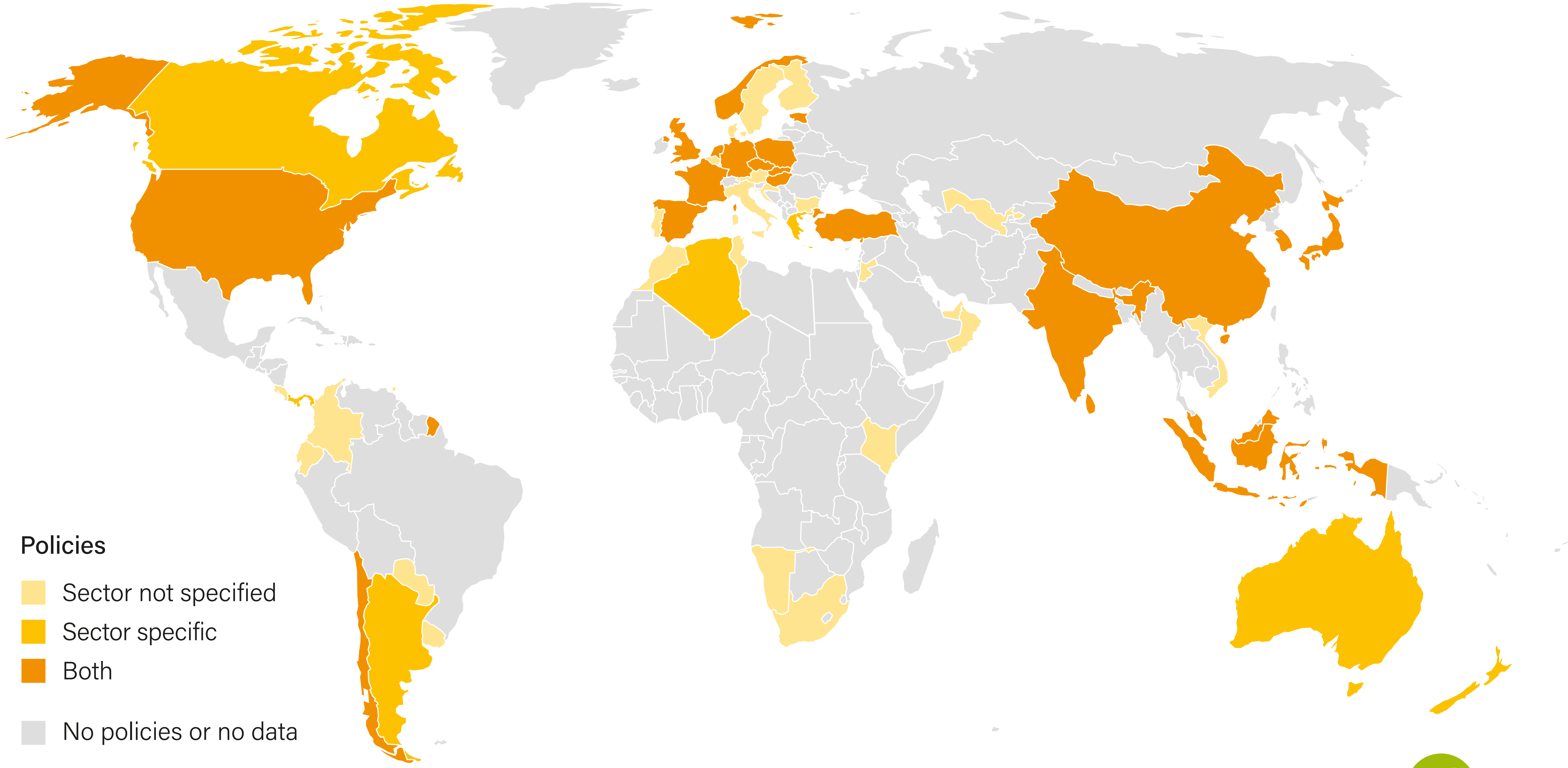
HYDROGEN

In 2023, renewables-based hydrogen accounted for less than 1% of total global hydrogen production, with the vast majority of the world's hydrogen still being produced from fossil gas and around 20% from coal.[38] In 2024, investment in renewable hydrogen fell 42% relative to 2023, to USD 8.4 billion.[39] This sharp decline reflects growing uncertainty about the market readiness of the technology and the ability to lower overall costs. According to some estimations, only 12% of hydrogen projects that are considered "low carbon"[i] globally have secured purchase agreements with potential customers.[40]

As of mid-2025, a total of 55 countries had enacted, planned or announced green hydrogen[ii] policies (→ *see Figure 26*), of which 14 were announced or enacted in 2024 and early 2025.[41] An important share of these policies focus on the development of national hydrogen industries and do not target specific end-use sectors. Policies targeting end-use sectors mostly address transport, followed by the industry sector, whereas the buildings and agriculture sectors are only marginally represented in hydrogen strategies.[42]

Fiscal and financial incentives increasingly entered the hydrogen policy landscape in 2024 and early 2025, a change from previous years when countries focused mainly on setting targets through strategies and roadmaps. Although some countries (such as Greece) increased the ambition of their hydrogen targets in 2024, others reduced it (for example, Portugal lowered its 2030 target from 5.5 GW to 3 GW).[43] At least four countries – Chile, India, Morocco and Oman – set specific measures to secure land for hydrogen production.[44]

FIGURE 26.
Countries with Policies for Renewable Hydrogen Development, by End-use Sector, as of Mid-2025



Source: See endnote 41 for this section.

i Definitions of "low carbon" hydrogen vary: while they all include renewable energy, some also include other technologies such as nuclear energy or fossil fuel projects with carbon capture and storage.

ii Green hydrogen is defined as hydrogen produced using electrolysis, powered from renewable sources. See endnote 41 for this section.

RENEWABLES IN ENERGY DEMAND

Setting a record annual growth for the decade, the world's total final energy consumption (TFEC) increased 2.2% in 2024.[1] This growth was driven in part by rising energy demand in emerging economies and a surge in electricity use, due largely to record-high temperatures increasing the need for space cooling, the expansion of data centres, and growing electrification in energy-intensive manufacturing activities and transport.[2]

Despite overall absolute growth in renewable energy demand, the share of renewables in the end-use sectors of industry, buildings, agriculture and transport remained low at 13.4% in 2022 (latest data available), up slightly from 12.7% in 2021.[3] (→ *See Figure 27.*) In terms of percentage points, the renewable energy share grew 1.33% in the agriculture sector, 1.72% in the buildings sector, and 1.28% in the industry sector, with the share in the transport sector showing almost no change in 2022.[4]

SECTORAL TRENDS

The **industry** sector accounted for 34% of TFEC in 2022, and the share of renewable energy use in industry was the highest among the sectors, at 18.1% (up from 16.8% in 2021 and 12.7% in 2012).[5] The largest energy consumers in the industrial sector in 2022 were the iron and steel and chemicals and petrochemicals sub-sectors (which together accounted for 33% of industrial consumption), followed by non-metallic minerals (such as glass, ceramic and cement) at 12.8%.[6] Other key consumers were food and tobacco (6.5%), non-ferrous metals (5.7%), paper pulp and printing (5.4%) and mining and quarrying (2.6%).[7] China accounted for more than 38% of the industry sector's global energy use, followed by the United States and India, with 9.6% and 9.3% respectively.[8]

© shutterstock.com

Heat consumption represented 73.8% of the industry sector's total final energy consumption in 2022, of which 87.6% was from fossil fuels and 12.4% from renewables.[i,9] The renewable energy mix of the heat consumed by industries was dominated by modern bioenergy at 89%, followed by electric heat (10.4%) and very small shares of solar and geothermal heat (0.1% and 0.2%, respectively).[10]

The **buildings** sector accounted for 31% of TFEC in 2022, with a renewable energy share of 17.7%, up from 12.1% a decade earlier.[11] This reflects an increase in the direct use of renewables in buildings, as well as the higher penetration of renewables in the power sector.[12] The main energy consumers in buildings are thermal uses, such as heating, domestic hot water, cooking and cooling spaces. Although heat accounts for most of the energy consumption in buildings, cooling is the fastest growing end use and was the main driver of rising electricity demand in the sector in 2024.[13]

Global energy consumption in the buildings sector fell slightly in 2023, due mainly to warmer winters and lower heating demand, which was offset in part by increases in other end uses.[14] Meanwhile, electricity use in buildings is rising: in 2024, the buildings sector accounted for nearly 60% of the overall growth in electricity consumption.[15] Factors included heatwaves leading to growing demand for space cooling in countries such as India and China, and rising electricity demand from data centres.[16] (→ *See Box 1.*) The United States, European Union (EU) and China together accounted for almost half of all energy consumption in buildings in 2023.[17]

i Renewables-based district heating supplies 3.4% of the renewable heat in the industry sector. See endnote 9 for this section.

73.8%

was the share of heat in the industry sector total final energy consumption in 2022.

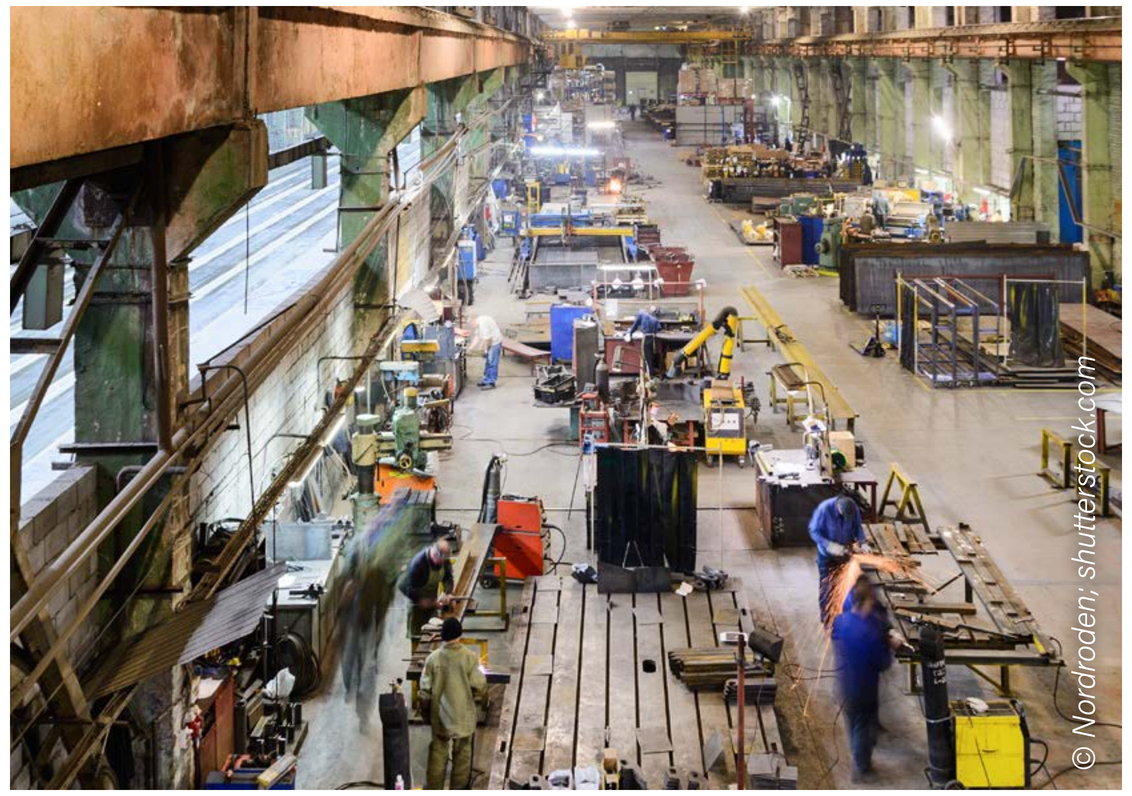
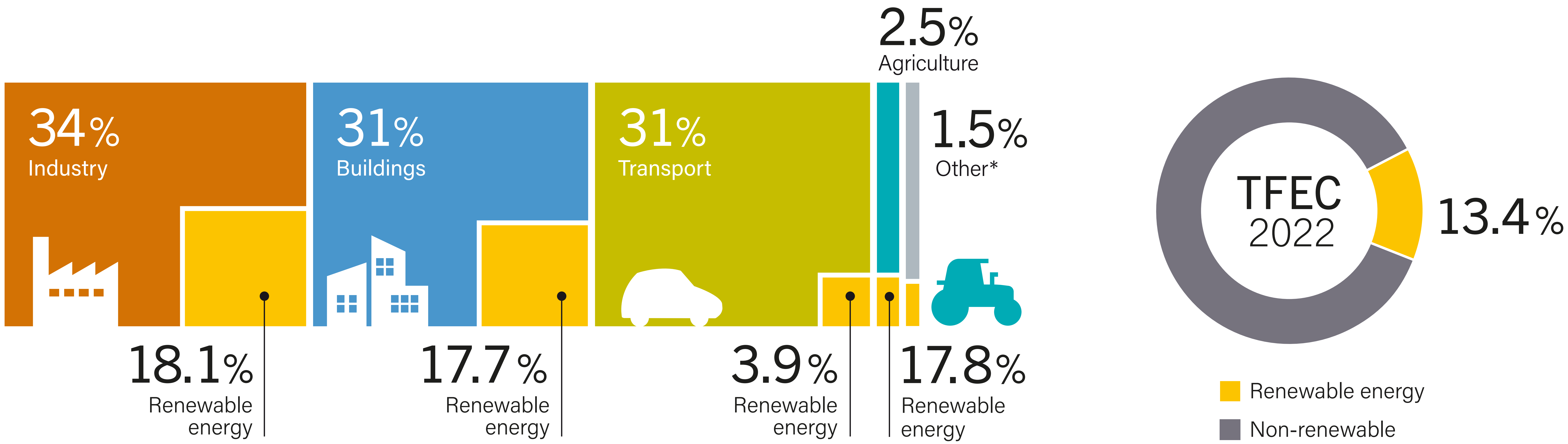


FIGURE 27.
Renewable Share of Total Final Energy Consumption (TFEC), by Sector, 2022



Source: See endnote 3 for this section.

BOX 1. IMPACTS OF AI AND DATA CENTRES ON RISING ELECTRICITY DEMAND

Artificial intelligence (AI) applications and digital infrastructures have emerged as structural forces that are reshaping global electricity demand, presenting challenges to power system planning, sustainability targets and energy resilience in key regions. As of 2022, data centres and data transmission networks each accounted for around 1% to 1.5% of total global electricity consumption, driven by the growth in digital services and cloud computing in recent years.

Global electricity demand rose 4.3% between 2023 and 2024, compared to an annual average growth rate of 2.5% over the previous decade. Electricity demand from data centres and cryptocurrency mining increased by an estimated 20% (or 111 terawatt-hours) in 2024 alone. This contributed around 0.4% to the total global growth in electricity demand, with cryptocurrency mining accounting for around 40% of this increase.

Large language models (LLMs) for AI applications are trained on vast datasets using power-intensive processors and large-scale computing infrastructure. While more efficient techniques and training methods are under development, such as DeepSeek's sparse computing approach, the increasing size and complexity of AI models continue to drive overall energy consumption.

Asia Pacific and North America host the largest concentrations of data centre capacity in terms of power demand, with major hubs including Beijing and Shanghai in China, and the US regions of Northern Virginia and the San Francisco Bay Area. Data centres also add significant demands in other markets: in Ireland, they accounted for 21% of total electricity demand in 2023, up from 5% in 2015.

Increased pressure on grid infrastructure is influencing national planning and regulatory responses. Several jurisdictions – including Amsterdam (Netherlands), China, Germany, Ireland, Singapore and a US county – have introduced restrictions on new data centre connections to manage the load and to comply with environmental requirements.

Looking ahead, electricity demand from data centres globally could rise an estimated 160-165% by 2030 compared to 2022, according to some projections. In Europe, this demand could increase overall regional electricity consumption up to 30%. Despite improvements in facility-level energy efficiency, electricity demand from AI and data centres is expected to continue surging over the next decade.

Data centre in Chongqing, China

Source: See endnote 16 for this section.

Energy efficiency in buildings improved 2.6% globally in 2023, a significant increase compared to the average 1.4% annual improvement seen in the previous decade.[18] Overall growth in energy demand overshadowed improvements in energy efficiency.[19]

The **agriculture** sector – which includes agriculture, fisheries and forestry – represented 2.5% of TFEC in 2022, up from 2.2% in 2021.[20] China alone accounted for one-fifth (20.1%) of this consumption, and Brazil, the EU, India and the United States together made up 41%.[21] Nearly three-quarters of the energy consumed in the agriculture sector is in the form of heat, of which 10% is renewable; almost all of this is modern bioenergy, with some geothermal, while solar thermal heating remains limited.[22]

The share of renewables in the agriculture sector's TFEC in 2022 was 17.8%, up from 11.4% in 2012.[23] The main energy uses in the sector are machinery[i] (used in land preparation, planting, pumping and irrigation, harvesting and on-farm storage) and the warming of greenhouses and livestock housing.[24]

The **transport** sector represented 31% of TFEC in 2022.[25] The share of renewables in the sector was below 4%, with minimal growth over the decade 2012-2022.[26] Of the modern renewables used in the sector in 2022, biofuels represented the vast majority (3.5% of TFEC), while renewable electricity made up only 0.4%.[27] During the decade, overall transport energy demand grew 12%, and non-renewable energy use in the sector rose 11%.[28]

i In low-income countries, the main energy source in the agriculture sector is human and animal work. The downstream activities of the food processing chain are not included in the sectoral calculations. See endnote 24 for this section.

DRIVERS OF RENEWABLE ENERGY ADOPTION

Electrification

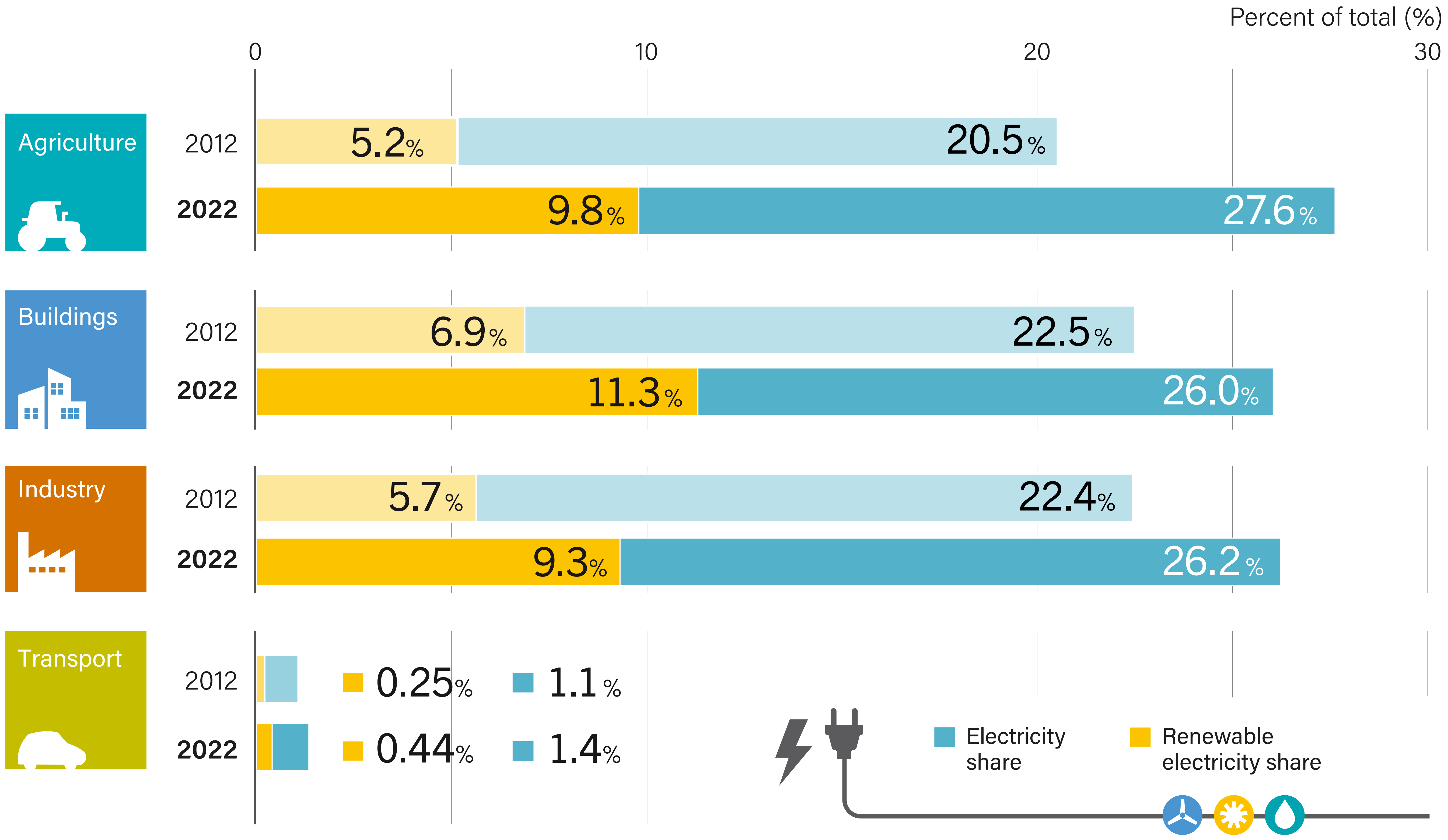
A key vector for renewable energy adoption in demand sectors is the electrification of end uses, including through the uptake of technologies such as heat pumps, electric vehicles and electric arc furnaces.[29] In 2022, the share of electricity in the world's TFEC was 23%, up slightly from 22% in 2020.[30] (→ *See Figure 28.*)

Electricity accounted for 26.2% of the **industry** sector TFEC in 2022 (renewable electricity was 9.3% of TFEC).[31] High-temperature industrial processes remain heavily reliant on fossil fuels, despite technological advances in electrification, such as industrial heat pumps and electric steam crackers.[32] Non-energy-intensive sectors have electrified more rapidly. The technologies needed to electrify heavy industries are still in early development stages, and the sector may suffer from a lock-in of assets due to significant upfront investments.[33]

In the **buildings** sector, the adoption of electric appliances such as heat pumps for heating and cooling can drive up the overall electricity share, which reached 26% of TFEC in 2022 (11.3% of TFEC was renewable electricity).[34] Heat pump sales fell 1% globally in 2024, reflecting a sharp 10% decline in the first half of the year.[35] In the second half of the year, sales recovered strongly in some regions, such as the United States (up 15%) and Japan (up 5%), but this increase was not sufficient to compensate for the decline in Europe (down 21%) and the lack of growth in China.[36] Possible reasons for the European sales decline include the slowdown of the construction sector, high prices of electricity compared to fossil gas and uncertainty about supporting policies.[37]

The highest share of electricity in TFEC was in the **agriculture** sector, accounting for 27.6% in 2022 (renewable electricity was 9.8% of TFEC).[38] Electrification can be advanced by switching to electric agricultural equipment (such as tractors and water pumps). The share of renewables in the electricity supply is supported by increases in on-farm renewable electricity generation.[39]

FIGURE 28.
Electricity and Renewable Electricity Shares of Total Final Energy Consumption, by End-Use Sector, 2012 and 2022



Source: See endnote 30 for this section.

In 2023, the global installed solar water pump capacity reached 1.1 gigawatts (GW), up 1.8% from 2022.[40] India was home to 94% of this capacity.[41] Globally, however, diesel fuel accounts for nearly three-quarters (74%) of the energy used for water pumping.[42] The biggest challenge to the widespread adoption of solar irrigation systems is affordability. Other factors that influence farmers' willingness to adopt electric machinery include upfront costs, machine sizes, battery autonomy and the availability of charging infrastructure.[43]

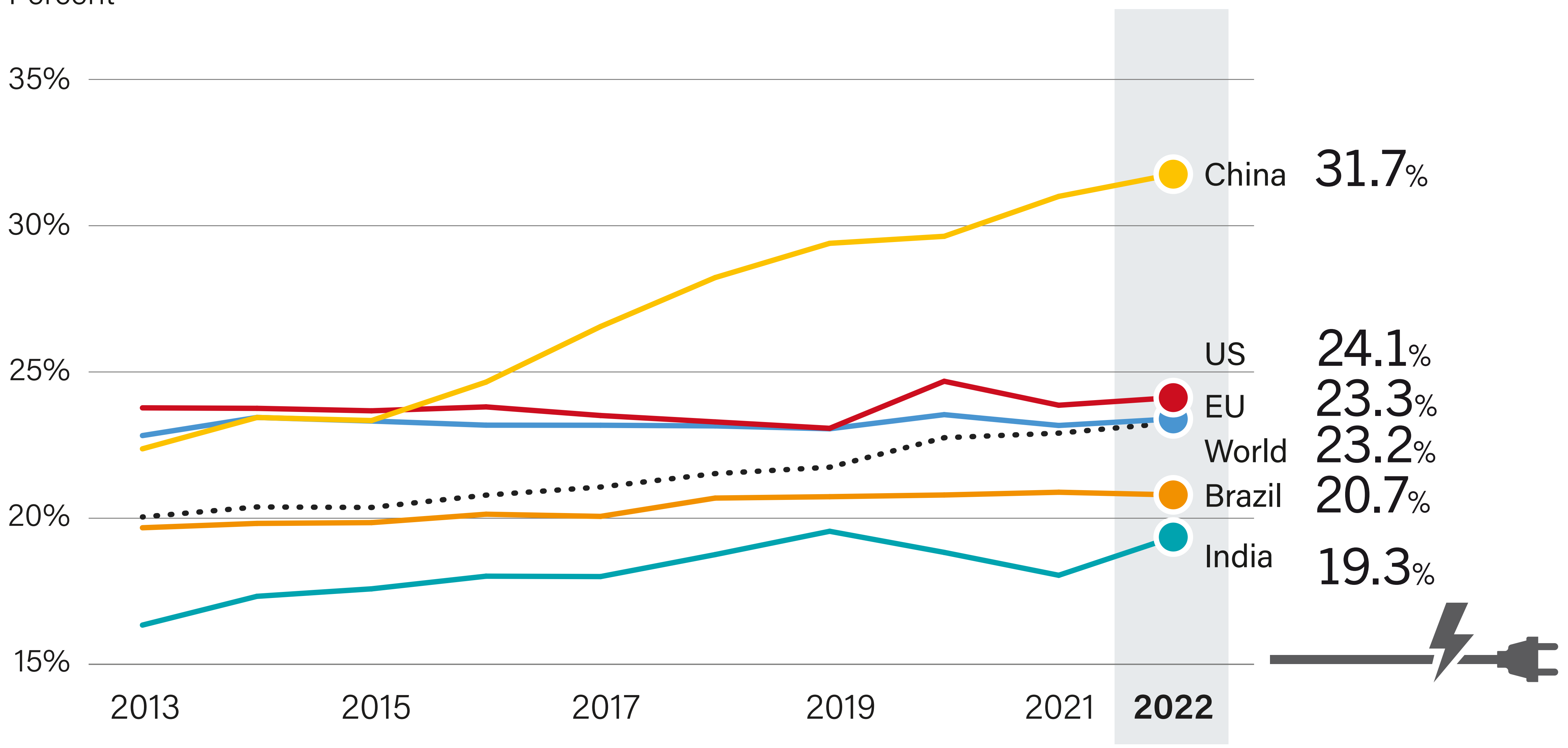
The **transport** sector has the lowest electrification rate of all demand sectors in 2022, at 1.4% of TFEC, with renewable electricity representing 0.4% of TFEC. However renewable electricity use in the sector grew 15% in 2022.[44] Electrification of transport relies heavily on the adoption of electric vehicles and the availability of charging infrastructure.

Electric vehicle sales continued an upward trend in 2024, with more than 17 million units sold globally, representing more than one-fifth of global car sales.[45] Electric vehicle adoption is expanding beyond China (the leading market) and high-income countries, with record sales reported in emerging economies such as Brazil, India, Thailand and Türkiye.[46]

The number of charging points globally has doubled since 2022.[47] Electrification of rail transport also advanced, with many countries and regions exploring rail development and electrification.[48] India, the world's fourth biggest railway network, achieved 98.8% rail electrification by the end of 2024, and China, the second largest rail network, reached 75% as of 2023.[49]

By country, China had the highest share of electricity in its TFEC, and the fastest rate of electrification, growing from 22.3% in 2012 to 31.7% in 2022.[50] The industry sector was responsible for almost 50% of the surge in China's electricity demand between 2022 and 2024 (with solar PV manufacturing accounting for one-third of this increase).[51] The buildings sector, including growing demand for cooling, accounted for 40% of the growth in China's electricity demand.[52] While the share of renewables in China is rising steadily, the country depended on fossil fuels for 62% of its electricity generation as of 2024.[53] India, another major energy-consuming country, also showed an upward electrification trend from 2012 to 2022, with economic expansion and a surging interest in cooling driving the increase in electricity demand.[54] (→ *See Figure 29.*)

FIGURE 29.
Share of Electricity in Total Final Energy Consumption in Major Country/ Region, 2013-2022



Source: See endnote 54 for this section.

The industry sector accounted for almost

50%

of China's electricity demand growth between 2022 and 2024.

Demand from Private Actors

The private sector emerges as an important leader in the global uptake of renewables — especially renewable electricity — in demand sectors, through the adoption of electricity purchase agreements (PPAs) and the deployment of small-scale solar PV for self-consumption.[55]

Corporate PPAs rose 35% in 2024.[56] Growth was driven mainly by the appetite of technology companies to secure power supply for data centres, although the industry and services sectors also increasingly signed long-term power supply contracts.[57] (→ *See Sidebar 7.*)

The adoption of small-scale solar PV systems by companies and households has surged in several regions in response to high electricity prices and sometimes unreliable grid services.[58] Pakistan was the top destination for exports of Chinese solar PV modules in fiscal year 2024, amounting to an estimated USD 2.1 billion.[59] The main end users were industry, agriculture, and buildings, mostly for self-consumption.[60] In Lebanon, private households and businesses have driven a spectacular increase in solar PV installations, rising from 100 megawatts (MW) in 2020 to 1,300 MW in 2023.[61] In South Africa, the national utility Eskom reported capacity additions of behind-the-meter solar PV of 273 MW_{peak} per month on average between March and September 2023.[62] In Türkiye, 90% of solar PV installations during 2021-2025 were small-scale, licence-exempt power plants, primarily for self-consumption.[63]

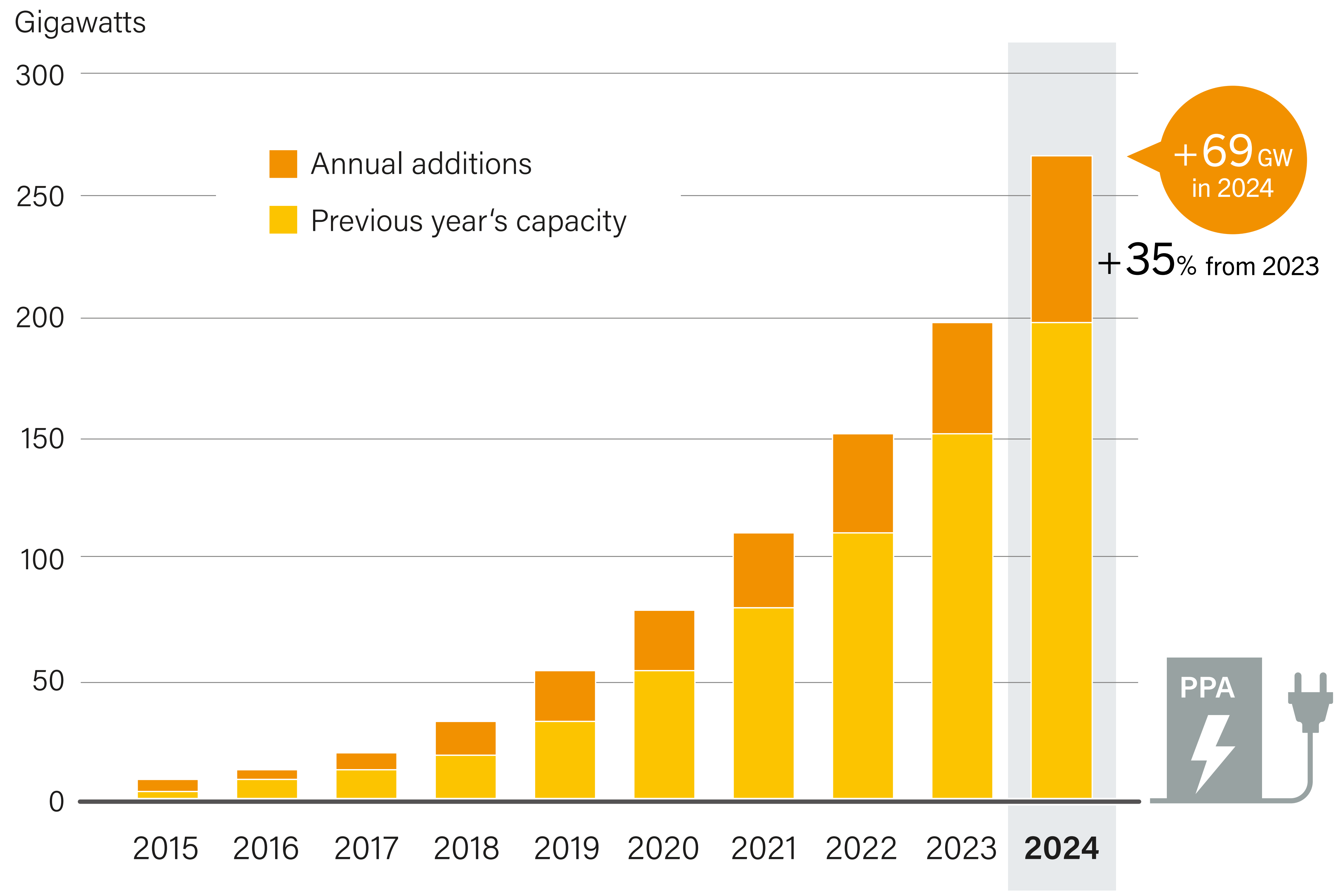
SIDEBAR 7. POWER PURCHASE AGREEMENTS (PPAS)

In 2024, the global volume of renewable power capacity contracted through corporate power purchase agreements (PPAs) increased an estimated 35%, representing around 69 GW of new capacity. (→ *See Figure 30*).

Data centre operators accounted for the majority of these PPAs, largely through direct third-party contracts. The biggest US-based information technology companies – Amazon, Google, Microsoft and Meta – collectively signed 15 GW worth of PPAs across Asia-Pacific, Europe, and North America; this excludes a 10 GW framework agreement that Microsoft signed with Brookfield, a large global investor in renewable power projects. Also in 2024, the manufacturing sector signed around 9 GW of PPAs, followed by the services sector with around 6 GW. The mining sector was also an important PPA off-taker. Solar PV and wind power technologies were the most contracted renewable energy sources for PPAs in 2024.

The largest increase in **corporate** PPAs was in the **United States**, which added 19 GW. Some suppliers reported record growth in long-term US renewable energy contracts. However, technology companies in the United States have also entered into nuclear PPAs. Contracts that include nuclear energy represented 14% of companies' total contracted capacity between February 2024 and May 2025.

FIGURE 30.
Corporate Renewable Power Purchase Agreements, Global Capacity and Annual Additions, 2015-2024



continued next page

In **Europe**, solar PV and wind power accounted for around 80% of the newly contracted PPA capacity, with some estimates totalling about 19 GW. Corporate PPAs made up 87% of the European market by deal count and 83% by contracted volume, with 157 corporate actors signing their first PPAs in 2024. The IT sector led in contracted volumes (3.8 GW), while capital goods[i] recorded the highest number of deals. Consumer goods accounted for 1.46 GW of first-time buyer volumes. The most contracted technology was solar PV, followed by wind power, mainly onshore.

In the **Asia-Pacific** region, renewable PPAs were supported by policies and regulations in several countries. Examples include Malaysia's Corporate Renewable Energy Supply Scheme, Thailand's Utility Green Tariff, and Viet Nam's Direct Power Purchase Agreement regulation. Corporate PPAs also increased in Japan, with the dynamic market rising to a cumulative total of nearly 500 deals by the end of 2024, up from 226 a year earlier. In China, where a "green electricity"[ii] trading pilot programme was launched in 2021, official rules were issued in 2024 to regulate the attribution of green electricity certificates. Merck China signed a 10-year PPA with the public utility China Resources Public, through green electricity certificates.

Africa saw progress in both utility and corporate renewable PPAs. Burkina Faso, Côte d'Ivoire and South Africa all advanced solar procurement through 20- to 25-year PPAs. The utility actors Eskom and SONABEL led multiple agreements, and corporate contracts included the global mining and commodities company Glencore.

In **South America**, renewable energy procurement through PPAs was driven by industry demand. In Chile, CODELCO pursued 100% clean energy via long-term solar contracts, and the Spanish energy producer Grenergy secured a 12-year PPA for grid-supply. Brazil's green hydrogen projects relied on renewable PPAs for electricity supply.

Virtual power purchase agreements (VPPAs) have emerged in corporate renewable energy procurement. VPPAs are financial contracts where the buyer agrees to purchase renewable energy at a predetermined price, without taking physical delivery of the electricity. Instead, the electricity is sold into the wholesale market, and the buyer receives renewable energy certificates (RECs), allowing companies to support renewable projects while managing energy price volatility. In 2024, the global REC market reached an estimated USD 16.2 billion, up from USD 13.7 billion in 2023.


© Snapshot freddy, shutterstock.com


© kittirat roekburi, shutterstock.com

i Capital goods are the buildings, machines, and equipment that are used to produce products or provide services. Consumer goods are defined as products that people buy for their own use. (Definitions of capital and consumer goods from the Cambridge Business English Dictionary, Cambridge University Press)

ii Under Chinese rules for medium- and long-term electricity transactions, the definition of green electricity includes wind power, solar power, conventional hydropower, biomass power, geothermal power and ocean power.

Source: See endnote 57 for this section.

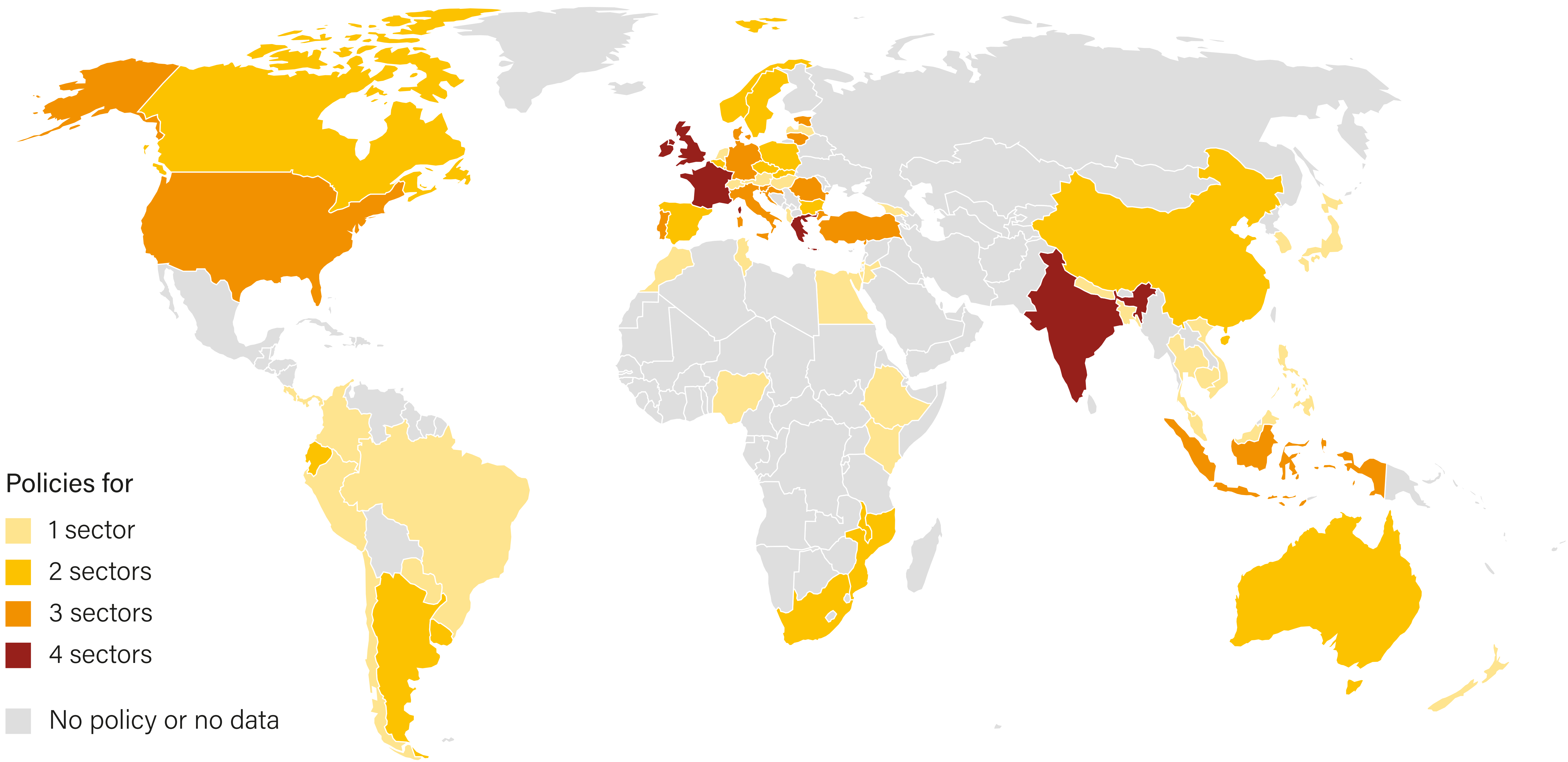
Policy Developments

Overall, the slow rates of renewable energy adoption across end-use sectors reflect a lack of co-ordinated, cross-sectoral policies created from a demand perspective. Of the 69 countries that had national policies specifically targeting one or more end-use sectors as of 2024, only 5 countries had policies[i] targeting all four sectors.[64] (→ *See Figure 31.*) The majority of countries targeted the transport and buildings sectors, whereas the agriculture and industry sectors were less represented in national renewable energy policies.[65]

i Policies in this figure include national regulations and fiscal or financial incentives for the integration of renewables in end-use sectors. They do not include sub-national policies or bans on fossil fuel boilers unless these specifically target the integration of renewables. Incentives for the acquisition of enabling technologies such as heat pumps or electric vehicles are not included.

© konten amatiran; shutterstock.com

FIGURE 31.
Countries with National Renewable Energy Policies for End-Use Sectors, as of 2024



69 countries with national renewable energy policies for end-use sectors

Number of countries with renewable energy policies in end-use

Industry	Buildings	Transport	Agriculture
19	43	44	20

Source: See endnote 64 for this section.

Regulations such as mandates for biofuel blends in the **transport** sector and for renewable energy integration in **buildings** remained the main mechanisms for increasing the adoption of renewables, together with financial incentives for installing on-site renewable generation systems.

In the **agriculture** sector, most new policies supporting renewables in 2024 focused on the adoption of solar PV technologies for farming activities.[66] This included incentivising the installation of solar irrigation systems, with several countries incorporating deployment targets for such systems in their Nationally Determined Contributions (NDCs) towards reducing greenhouse gas emissions under the Paris Agreement.

Incentives and regulations also promoted the uptake of agrivoltaics and, to a lesser extent, anaerobic digesters for biogas production.[67] Recent examples include the USD 1.84 billion (EUR 1.7 billion) budget allocated in Italy to the deployment of agrivoltaics, subsidies in Morocco for the purchase of solar pumps, and the United Kingdom Farming Investment Fund supporting the acquisition of new equipment for farmers, which includes solar PV to increase farm productivity.[68] EU countries such as Romania and Portugal, in transposing the region's Common Agricultural Policy (CAP), have proposed subsidies for the installation of on-farm solar and wind generation.[69]

In the **buildings** sector, fiscal and financial incentives such as subsidies, rebates and tax exemptions have dominated the policy landscape, to encourage installations of rooftop solar PV and solar thermal systems, as well as the use of heat pumps to replace gas boilers. Regulations also have gained traction, including bans on fossil fuel boilers; building codes that incorporate mandatory shares of renewables and obligations to integrate solar PV or solar thermal systems in new buildings; and requirements to integrate renewable energy into district heating networks.[70] Austria's new Renewable Heat Act extended the existing ban on central heating systems based on fossil oil and coal to cover all fossil fuel-based heating systems in new buildings, as a way to advance decarbonisation of the building sector by 2040.[71] Similar bans were enacted in the Czech Republic, Scotland and Slovenia.[72]

Reducing energy use in buildings is also in policymakers focus, given the sector significant contribution to TFEC.[73] In 2024, governments representing more than 70% of the world's energy demand implemented or updated national energy efficiency policies, including for buildings.[74] The EU reinforced its Energy Efficiency Directive by setting targets for a 4% annual efficiency improvement and an 11.7% annual decline in energy use by 2030.[75] The EU's revised Energy Performance of Buildings Directive requires new buildings to be solar-ready and targets cutting residential energy use 16% by 2030 and up to 22% by 2035.[76]

The affordability of building renovations and efficient equipment have attracted policy attention as well.[77] However, as of 2024, energy efficiency requirements did not cover nearly half of the global newly built surface.[78]

With the surge in energy consumption from cooling, countries have increasingly focused on developing national cooling strategies.[79] (→ *See Sidebar 8.*)

© Red Stock, shutterstock.com

© Zigmunds Dizgalvis, shutterstock.com

In the **agriculture sector**, most new policies supporting renewables in 2024 focused on the adoption of **solar PV technologies** for farming activities.

SIDEBAR 8. NATIONAL COOLING ACTION PLANS

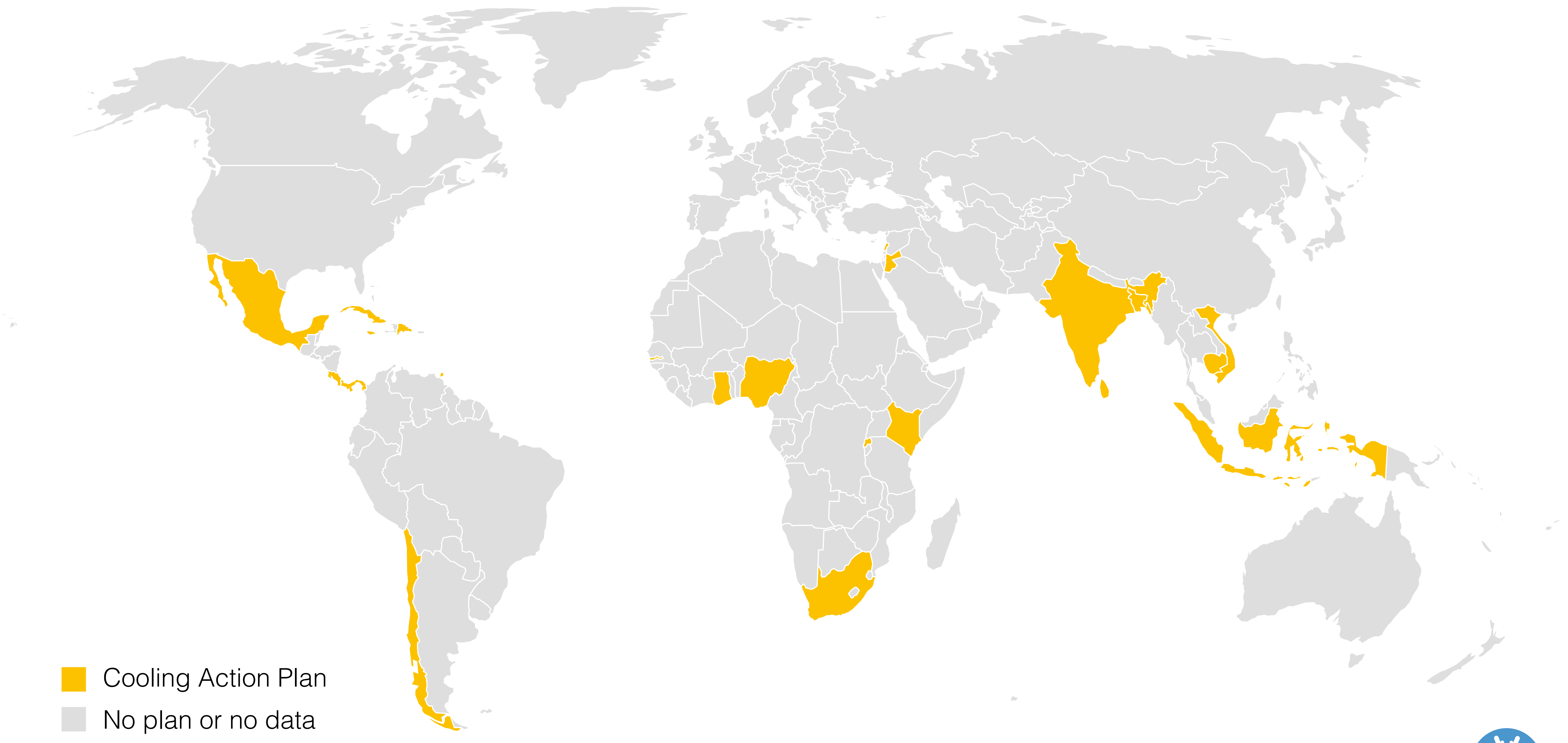
Driven by global warming, population growth, urbanisation, and rising incomes, demand for cooling has more than tripled since 1990 and now accounts for over 10% of global electricity use. Around 2 billion air conditioners are in operation worldwide, and an estimated 14 billion cooling devices will be needed by 2050. Unchecked growth threatens to raise emissions, strain electricity grids, trigger outages and worsen air pollution.

Access to cooling remains deeply unequal, even as the risks of extreme heat grow worldwide. As of 2021, only 15% of the 3.5 billion people living in hot climates owned an air conditioner, with even lower rates in Sub-Saharan Africa and South Asia. Yet heat-related deaths are rising in all regions, driven not only by high temperatures but also by sudden extremes, especially early in the warm season. Among people aged 65 and older, heat-related mortality rose by 61% between 2002–2004 and 2019–2021, exceeding 300,000 globally. Although access to effective cooling already averts an estimated 190,000 deaths each year, its benefits remain concentrated in higher-income households and regions.

To respond, many governments have adopted National Cooling Action Plans (NCAPs), strategies that integrate efficiency, refrigerant transition, building design and equitable access. As of 2024, at least 23 countries had adopted NCAPs or similar strategies (→ *see Figure 32*), often supported by the United Nations Development Programme and the Clean Cooling Collaborative.

These plans typically include phase-down targets for hydrofluorocarbons (HFCs) – potent greenhouse gases commonly used in cooling equipment – alongside minimum energy performance standards (MEPS), appliance labelling, incentives and building-level measures. Some NCAPs are aligned with countries' Nationally Determined Contributions (NDCs) under the Paris Agreement and the Kigali Amendment to the Montreal Protocol, a global agreement to gradually reduce the production and use of HFCs.

FIGURE 32.
Countries with Cooling Action Plans, as of 2024



23 countries with National Cooling Action Plans

Note: Countries with published cooling plans are geographically diverse but concentrated in Africa, Asia and Latin America. Most national cooling plans have been published since 2020, reflecting growing attention to sustainable cooling in climate policy. Several major cooling demand centres still lack a dedicated national cooling plan.

continued next page

NCAPs share core elements – efficient appliances, sustainable refrigerants and passive cooling – and are increasingly incorporating renewable energy and behavioural change. As national priorities vary, some NCAPs target grid constraints or climate risks (e.g., in small island developing states), while others focus on stakeholder engagement or policy coherence.

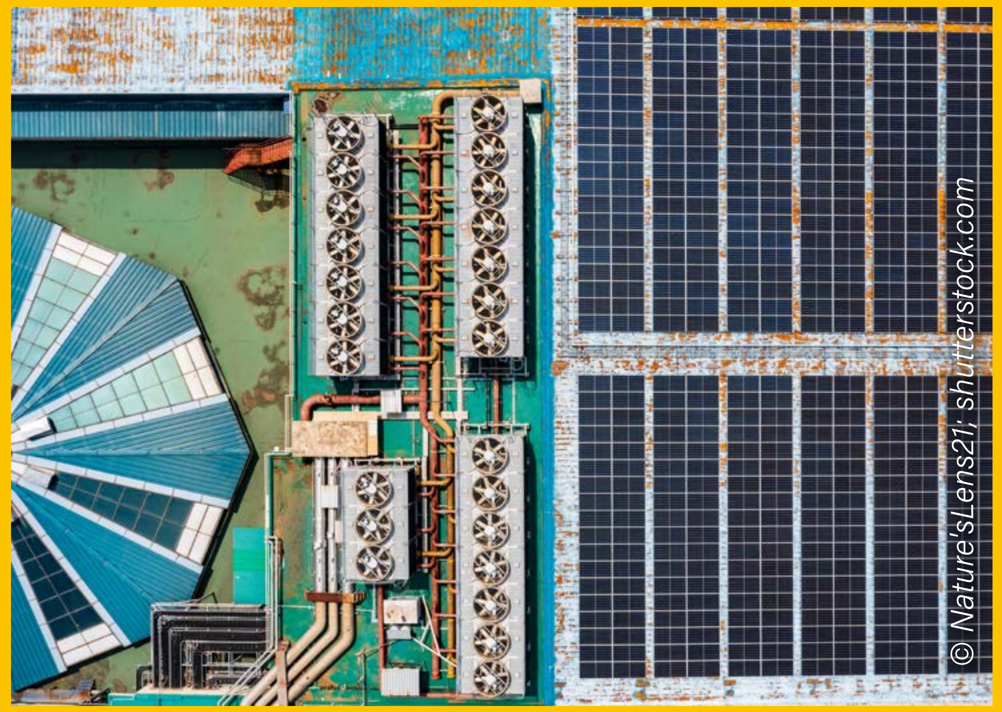
Equity-focused NCAPs also address affordability and access. Measures include support for public institutions, community cooling hubs and inclusive financing.

Beyond buildings, there is major potential to expand renewable-powered cooling in the cold chain sector – the temperature-controlled supply system for perishable goods like food, medicines and vaccines. Technologies such as solar PV-powered cooling and solar thermal-driven sorption cooling systems and geothermal solutions are gaining ground. Paired with thermal energy storage, ice storage, and thermally activated systems, these approaches enable load shifting, increase resilience, reduce emissions, ease grid pressure and help mitigate urban heat.

Scalable solutions include district cooling, super-efficient solar-powered fans, low-tech coolers and solar home systems. Off-grid renewables for health facilities provide reliable electricity in underserved areas, strengthening public health and infrastructure.

Cooling is no longer a marginal issue – it is central to adaptation, health and energy security. When well-implemented, NCAPs can cut emissions, save lives and strengthen energy systems. Global initiatives are scaling support, such as the Global Cooling Pledge, which aims to cut cooling-related emissions at least 68% by 2050 compared to 2022, and the Cooling Facility, a World Bank and Green Climate Fund initiative providing financing of USD 157 million.

As technologies evolve and ambition rises, countries that prioritise equitable, sustainable cooling will be better positioned to protect people, reinforce systems, and meet long-term climate and development goals.


© Nature'sLens21; shutterstock.com

Source: See endnote 79 for this section.

Policies focused on integrating renewables in the **industry** sector remain scarce. Mechanisms for decarbonising heavy industries such as cement, iron and steel include carbon pricing and emission trading schemes, as well as financial support through tax incentives or contracts for difference.[80] In 2024, China announced that its national emission trading scheme would apply to heavy industries (although the high volume of initial free allowances has triggered criticism), and Germany launched the first funding programme for carbon contracts for difference, with a budget of USD 4.2 billion (EUR 4 billion).[81] The EU's carbon border adjustment mechanism (CBAM), in its 2023-2025 transitional phase, requires producers of goods imported to the region to report direct and indirect emissions from production processes, potentially fostering greater renewable energy use.[82]

Industrial decarbonisation strategies enacted in recent years include the EU's Net Zero Industry Act, adopted in June 2024, and the US Inflation Reduction Act, which provide incentives for low-carbon technologies in the sector and can support the adoption of renewables.[83] In 2023, Japan required that large energy consumers submit plans for decarbonisation, including for renewable energy use.[84]

Significant focus has been given to green hydrogen projects to decarbonise the industry sector.[85] Meanwhile, in Scandinavian countries, carbon taxes have been seen as an important driver for industries to adopt bioenergy-based heat instead of fossil fuels.[86]

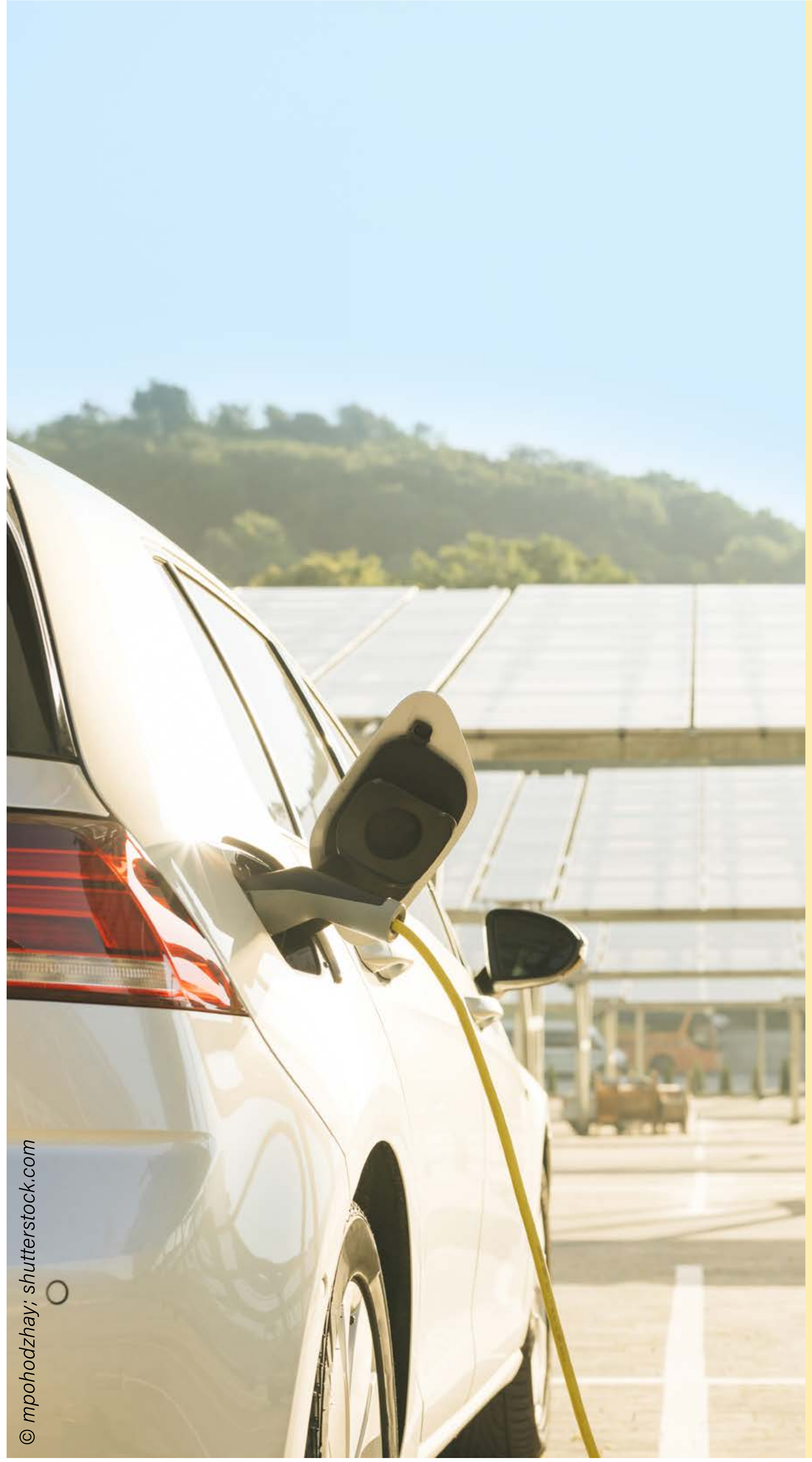
In the **transport sector**, jurisdictions such as Australia, Brazil, the Dominican Republic, the EU, the Republic of Korea and the United States have established standards for fuel efficiency and emission reduction as well as mandates for renewable energy shares (for example, for biofuels for the road transport or minimum blends of sustainable aviation fuels).[87] Financial support for electric vehicle adoption remained the most prominent policy in transport, with an emphasis on local manufacturing, infrastructure development, incentives for consumers and industries, and programmes to electrify public fleets and public transport.[88] In the EU, policy attention was given to carbon dioxide emission standards and targets.[89] In the maritime sector, a range of policies have been implemented that focus on advancing green shipping corridors to reduce emissions.[90]

© Bulent camci; shutterstock.com

CHALLENGES AND OPPORTUNITIES

CHALLENGES TO RENEWABLES IN 2024

- **Climate ambition weakened** as several governments rolled back previous commitments, while **trade restrictions** and unpredictable regulatory environments added uncertainty across renewable energy markets.
- **Fossil fuel subsidies** continued to distort energy markets, diverting public resources and disadvantaging renewables.
- Tight financial conditions, including **high interest rates, inflation, currency volatility, and debt burdens**, made capital harder to access, especially in developing economies. **Increasing running costs and uncertain returns** resulted in narrow market margins, further undermining investor confidence.
- Project development was slowed by structural barriers, including **permitting delays, misinformation**, and, in some cases, **public resistance. Skilled labour shortages** and **lack of grid capacity and flexibility** further limited deployment capacity.
- **Energy demand rose**, driven by an increase in demand for cooling, growing digital infrastructure and expanding electric vehicle fleets. At the same time, **energy access** remains a major challenge, with millions of people still lacking basic electricity services, especially in sub-Saharan Africa.
- **The uptake of renewables is concentrated in a limited set of technologies** – particularly solar PV and wind power – **and in specific regions**, leaving many parts of the world underserved.


© mpohodzhay; shutterstock.com

OPPORTUNITIES FOR 2025 AND BEYOND

- As governments seek to enhance **energy security and resilience**, renewables are becoming central to national energy strategies. **New commitments at the national and international levels** reflect growing recognition of renewable energy as essential for both climate mitigation and adaptation.
- **Distributed and off-grid solar PV systems** are expanding rapidly, particularly in emerging economies. This reflects growing demand from the public and demonstrates the viability of decentralised solutions.
- **The rise in power purchase agreements**, particularly among tech giants and industrial actors, underscores increasing confidence in renewables as a reliable and cost-effective energy source.
- **Sectoral integration and electrification** in housing, mobility, and industry are creating new opportunities for renewable energy adoption, as the transition becomes embedded in broader economic strategies.
- **Digitalisation and artificial intelligence** are further enhancing grid operations, improving system planning, and enabling smarter, more adaptive energy systems.


© Marion Billy; shutterstock.com

ENDNOTES | INTRODUCTION

1 International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', 26 March 2025, https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.

2 International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', 26 March 2025, https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.

3 Cameron Murray, 'Global BESS Deployments Soared 53% in 2024', Energy Storage News, 14 January 2025, https://www.energy-storage.news/global-bess-deployments-soared-53-in-2024; International Energy Agency, 'The Battery Industry Has Entered a New Phase – Analysis', 5 March 2025, https://www.iea.org/commentaries/the-battery-industry-has-entered-a-new-phase.

4 International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', 26 March 2025, https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.

5 International Energy Agency, 'Electricity 2025', 14 February 2025, https://www.iea.org/reports/electricity-2025; International Energy Agency, 'Growth in Global Energy Demand Surged in 2024 to Almost Twice Its Recent Average', 24 March 2025, https://www.iea.org/news/growth-in-global-energy-demand-surged-in-2024-to-almost-twice-its-recent-average; Giulia Petroni, 'Rising Temperatures Drive Surge in Energy Demand, IEA Says', *Wall Street Journal*, 24 March 2025, https://www.wsj.com/articles/rising-temperatures-drive-surge-in-energy-demand-iea-says-97ea9311.

6 International Energy Agency, 'Electricity 2025', 14 February 2025, https://www.iea.org/reports/electricity-2025; International Energy Agency, 'Artificial Intelligence – Topics', accessed 24 April 2025, https://www.iea.org/topics/artificial-intelligence; Jillian Ambrose, 'Ireland's Datacentres Overtake Electricity Use of All Urban Homes Combined', *The Guardian*, 23 July 2024, https://www.theguardian.com/world/article/2024/jul/23/ireland-datacentres-overtake-electricity-use-of-all-homes-combined-figures-show; Emily Jones, 'Georgia Was About to Retire Coal Plants. Then Came the Data Centers', Grist, 12 February 2025, https://grist.org/energy/georgia-was-about-to-retire-coal-plants-then-came-the-data-cen.

7 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025; David Stanway, 'Global Coal Power Capacity Inches Up in 2024, Data Shows', *Reuters*, 3 April 2025, https://www.reuters.com/business/energy/global-coal-power-capacity-inches-up-2024-data-shows-2025-04-03; International Energy Agency, 'Coal 2024', 18 December 2024, https://www.iea.org/reports/coal-2024.

8 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025.

9 Copernicus Climate Change Service (C3S), 'Copernicus: 2024 Is the First Year to Exceed 1.5°C Above Pre-Industrial Level', 10 January 2025, https://climate.copernicus.eu/copernicus-2024-first-year-exceed-15degc-above-pre-industrial-level.

10 Matt Mcgrath, 'LA Fires Made Worse by Climate Change, Say Scientists', BBC News, 28 January 2025, https://www.bbc.com/news/articles/cd9qy4knd8wo; Matt Mcgrath, 'Scientists Sure Warming World Made Spain's Storm More Intense', BBC News, 30 October 2024, https://www.bbc.com/news/articles/c98eylqeg06o; World Meteorological Organization, 'Extreme Weather and Climate Impacts Bite Latin America and Caribbean', 27 March 2025, https://wmo.int/news/media-centre/extreme-weather-and-climate-impacts-bite-latin-america-and-caribbean.

11 **Sidebar 1** from the following sources: International Energy Agency (IEA), 'Summit on the Future of Energy Security Background Paper', April 2025, https://www.iea.org/events/summit-on-the-future-of-energy-security; Libby George, 'In Deluge of Protests, Fuel Subsidies Prove Hard to Abolish', *Reuters*, 8 August 2024, https://www.reuters.com/world/africa/deluge-protests-fuel-subsidies-prove-hard-abolish-2024-08-08; Alassane Drabo, Kodjovi M. Eklou and Patrick A. Imam, 'Social Unrests and Fuel Prices: The Role of Macroeconomic, Social and Institutional Factors', International Monetary Fund, October 2023, https://www.imf.org/en/Publications/WP/Issues/2023/10/27/Social-Unrests-and-Fuel-Prices-The-Role-of-Macroeconomic-Social-and-Institutional-Factors-539677; World Health Organization, 'Increasing Access to Clean Cooking Through Subsidies', 2022, https://cdn.who.int/media/docs/default-source/air-pollution-documents/air-quality-and-health/increasing-access-to-clean-cooking-through-subsidies.pdf; IEA, 'Africa Energy Outlook 2022', May 2023, https://www.iea.org/reports/africa-energy-outlook-2022; IEA et al., 'Tracking SDG7: The Energy Progress Report', 2024, https://sun-connect.org/wpcont/uploads/SDG7-Report2024-0611-V9-highresforweb.pdf; Sustainable Energy for All, 'Energizing Finance Report 2024', October 2024, https://www.seforall.org/system/files/2024-11/seforall-report-ef-2024.pdf; Justinas Jasiūnas, Peter D. Lund and Jani Mikkola, 'Energy System Resilience – A Review', *Renewable and Sustainable Energy Reviews* 150 (1 October 2021): 111476, https://doi.org/10.1016/j.rser.2021.111476; Coalition for Disaster Resilient Infrastructure and G20 Working Group on Disaster Risk Reduction, 'A Compendium of Good Practices on Disaster Resilient Infrastructure (DRI)', 2024, https://cdri.world/upload/pages/G20_Brazil_Compendium.pdf; Cleo Varianou Mikellidou et al., 'Energy Critical Infrastructures at Risk from Climate Change: A State of the Art Review', *Safety Science*, Special Issue on societal safety, critical infrastructure reliability and related intersectoral governance, 110 (1 December 2018): 110-120, https://doi.org/10.1016/j.ssci.2017.12.022; Resecurity, 'Cyber Threats Against Energy Sector Surge as Global Tensions Mount', 15 April 2025, https://www.resecurity.com/blog/article/cyber-threats-against-energy-sector-surge-global-tensions-mount; IEA, 'Power Systems in Transition: Challenges and Opportunities Ahead for Electricity Security', 2020, https://www.iea.org/reports/power-systems-in-transition/cyber-resilience; Sarah G. Freeman et al., 'Attack Surface of Wind Energy Technologies in the United States', Idaho National Laboratory, January 2024, https://inl.gov/content/uploads/2024/02/INL-Wind-Threat-Assessment-v5.0.pdf; Sameer Patel and Ayyappan Rajesh, 'Expanding National Security Risks from Foreign-Manufactured Hardware', Observer Research Foundation, 31 January 2025, https://www.orfonline.org/expert-speak/expanding-national-security-risks-from-foreign-manufactured-hardware; US Department of Energy, 'Artificial Intelligence for Energy', accessed 25 April 2025, https://www.energy.gov/topics/artificial-intelligence-energy; Lauri Myllyvirta, 'Analysis: Clean energy contributed a record 10% of China's GDP in 2024', Carbon Brief, 19 February 2025, https://www.carbonbrief.org/analysis-clean-energy-contributed-a-record-10-of-chinas-gdp-in-2024; Linda Lew, 'China Asks Its Carmakers to Keep Key EV Technology at Home', Bloomberg, 12 September 2024, https://www.bloomberg.com/news/articles/2024-09-12/china-asks-its-carmakers-to-keep-key-ev-technology-at-home; Laura He, 'Chinese EV Giant BYD to Build $1 Billion Plant in Turkey', CNN, 9 July 2024, https://www.cnn.com/2024/07/09/business/china-ev-byd-turkey-plant-intl-hnk; Aditi Shah, 'India to Expand EV Manufacturing Incentives after Tesla Disappointment, Source Says', Reuters, 29 November 2024, https://www.reuters.com/business/autos-transportation/india-expand-ev-manufacturing-incentives-after-tesla-disappointment-source-says-2024-11-29/; Elaine Kurtenbach, 'EVs, Tariffs in the Spotlight as Chinese Automakers Take Leading Role at Shanghai Auto Show', MSN, https://www.msn.com/en-us/money/news/evs-in-the-spotlight-as-china-claims-a-leading-global-role-at-shanghais-auto-show/ar-AA1Dq1W9; Josh Boak, 'Trump Places 25% Tariff on Imported Autos. Carmakers Could Face Higher Costs and Lower Sales', AP News, 26 March 2025, https://apnews.com/article/autos-tariffs-trump-tax-imports-ford-gm-e53823ef7bbb7b3c46d11eca90aaa638; Rare Earth Exchanges, 'Tariff Shockwave: U.S. Slaps 82% Duties on Chinese Lithium Batteries, Rewiring the Global Energy Supply Chain', 12 April 2025, https://rareearthexchanges.com/news/battery-tariffs; Anton Spisak, 'The EU's Drive on China: What EV Tariffs Mean for Europe', Centre for European Reform, 31 October 2024, https://www.cer.eu/insights/eus-drive-china-what-ev-tariffs-mean-europe; International Energy Agency, 'Renewables 2024', 9 October 2024, https://www.iea.org/reports/renewables-2024; Ann Scott Tyson, 'What China's Renewable Energy Boom Means for the World', Christian Science Monitor, 17 May 2024, https://www.csmonitor.com/World/Asia-Pacific/2024/0517/What-China-s-renewable-energy-boom-means-for-the-world; BloombergNEF, 'Global Cost of Renewables to Continue Falling in 2025 as China Extends Manufacturing Lead: BloombergNEF', 6 February 2025, https://about.bnef.com/blog/global-cost-of-renewables-to-continue-falling-in-2025-as-china-extends-manufacturing-lead-bloombergnef; Anne Fischer, 'Clean Energy Manufacturing Support in Inflation Reduction Act', PV Magazine, 29 July 2022, https://pv-magazine-usa.com/2022/07/29/clean-energy-manufacturing-support-in-inflation-reduction-act; European Commission, 'The Net-Zero Industry Act', accessed 25 April 2025, https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en; Xie Ruohan, 'What China's Green "Overcapacity" Could Mean for the Global South', Eco-Business, 5 December 2024, https://www.eco-business.com/news/what-chinas-green-overcapacity-could-mean-for-the-global-south; FiscalNote, 'China's Energy Law 2025: Highlights for Renewables, Energy Security, and Private Companies', 17 March 2025, https://fiscalnote.com/blog/chinas-energy-law-2025; International Renewable Energy Agency, 'Geopolitics of the Energy Transition: Energy Security', 2024, https://www.irena.org/Publications/2024/Apr/Geopolitics-of-the-energy-transition-Energy-security.

12 Matt Simmons and Mike De Souza, 'Big Oil's Lobbying Playbook: A Summary of Big Oil's 2024 Federal Lobbying', Environmental Defence, March 2025, https://environmentaldefence.ca/wp-content/uploads/2025/03/Big-Oils-Lobbying-Playbook-2024-1.pdf; Dharna Noor, 'Big Oil Is Waging "Biggest Campaign of Political Interference in US History", Senator Says', *The Guardian*, 6 March 2025, https://www.theguardian.com/us-news/2025/mar/06/big-oil-investigation-congress-republicans; InfluenceMap, 'Fossil Fuel Climate Advocacy Update', March 2024, https://influencemap.org/briefing/Fossil-Fuel-Climate-Advocacy-Update-March-2024-27599; John Geddie, Tim Kelly and David Brunnstrom, 'Trump Seeks to Reshape Asia's Energy Supplies with US Gas', *Reuters*, 21 February 2025, https://www.reuters.com/business/energy/trump-seeks-reshape-asias-energy-supplies-with-us-gas-2025-02-21/; IEA, 'World Energy Investment 2025', June 2025, https://www.iea.org/reports/world-energy-investment-2025.

13 International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', 26 March 2025, https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.

14 International Energy Agency Photovoltaic Power Systems Programme, 'Snapshot of Global PV Markets 2025', April 2025, https://iea-pvps.org/snapshot-reports/snapshot-2025; Global Wind Energy Council, 'Global Wind Report 2025', 23 April 2025, 80, 85, https://www.gwec.net/reports/globalwindreport.

15 International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', 26 March 2025, https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.

16 REN21, 'REN21 Capacity Database', 2025.

17 REN21, 'REN21 Capacity Database', 2025.

18 International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', 26 March 2025, https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.

19 International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', 26 March 2025, https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.

20 SolarPower Europe, 'Global Market Outlook for Solar Power 2025-2029', 2025, https://www.solarpowereurope.org/insights/outlooks/global-market-outlook-for-solar-power-2025-2029/detail.

21 Based on data from the following: Global Wind Energy Council (GWEC), "Global Wind Report 2025", April 23, 2025, 80, 85, https://www.gwec.net/reports/globalwindreport; GWEC, "Global Wind Statistics 2025, Status End of 2024", unpublished document; with adjustments made for 2024 European data from WindEurope, "Wind Energy in Europe: 2024 Statistics and the Outlook for 2025-2030", February 27, 2025, 10-11, https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2024-statistics-and-theoutlook-for-2025-2030; updated statistics for the United States from J. Hensley, American Clean Power Association, personal communication with REN21, May 15, 2025.

22 Based on data from the following: Global Wind Energy Council (GWEC), "Global Wind Report 2025", April 23, 2025, 80, 85, https://www.gwec.net/reports/globalwindreport; GWEC, "Global Wind Statistics 2025, Status End of 2024", unpublished document; with adjustments made for 2024 European data from WindEurope, "Wind Energy in Europe: 2024 Statistics and the Outlook for 2025-2030", February 27, 2025, 10-11, https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2024-statistics-and-theoutlook-for-2025-2030; updated statistics for the United States from J. Hensley, American Clean Power Association, personal communication with REN21, May 15, 2025.

23 International Energy Agency, 'Electricity 2025', 14 February 2025, https://www.iea.org/reports/electricity-2025.

24 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

25 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

26 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

27 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

28 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025; International Energy Agency, 'Global EV Outlook 2024', 23 April 2024, https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-cars.

29 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025; International Energy Agency, 'Global EV Outlook 2024', 23 April 2024, https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-cars.

30 European Environment Agency, 'New Registrations of Electric Vehicles in Europe', 31 October 2024, https://www.eea.europa.eu/en/analysis/indicators/new-registrations-of-electric-vehicles; Reuters, 'Carmakers Scale Down Electrification Plans as EV Demand Slows', 12 September 2024, https://www.reuters.com/business/autos-transportation/carmakers-adjust-electrification-plans-ev-demand-slows-2024-09-06; International Energy Agency, 'Global EV Outlook 2024', 23 April 2024, https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-cars.

31 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

32 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

33 International Energy Agency, 'World Energy Outlook 2024', 16 October 2024, https://www.iea.org/reports/world-energy-outlook-2024.

34 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

35 **Figure 1** from International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

36 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

37 **Figure 2** from International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

38 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025.

39 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025; Giulia Petroni, 'Rising Temperatures Drive Surge in Energy Demand, IEA Says', *Wall Street Journal*, 24 March 2025, https://www.wsj.com/articles/rising-temperatures-drive-surge-in-energy-demand-iea-says-97ea9311.

40 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025; International Energy Agency, 'Data Centres & Networks', accessed 17 March 2025, https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks.

41 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025; David Stanway, 'Global Coal Power Capacity Inches Up in 2024, Data Shows', *Reuters*, 3 April 2025, https://www.reuters.com/business/energy/global-coal-power-capacity-inches-up-2024-data-shows-2025-04-03; International Energy Agency, 'Coal 2024', 18 December 2024, https://www.iea.org/reports/coal-2024.

42 David Stanway, 'Global Coal Power Capacity Inches Up in 2024, Data Shows', *Reuters*, 3 April 2025, https://www.reuters.com/business/energy/global-coal-power-capacity-inches-up-2024-data-shows-2025-04-03.

43 David Stanway, 'Global Coal Power Capacity Inches Up in 2024, Data Shows', *Reuters*, 3 April 2025, https://www.reuters.com/business/energy/global-coal-power-capacity-inches-up-2024-data-shows-2025-04-03.

44 Laura Cozzi et al., 'Electricity Access Continues to Improve in 2024 – after First Global Setback in Decades', IEA, 15 November 2024, https://www.iea.org/commentaries/electricity-access-continues-to-improve-in-2024-after-first-global-setback-in-decades.

45 Laura Cozzi et al., 'Electricity Access Continues to Improve in 2024 – after First Global Setback in Decades', IEA, 15 November 2024, https://www.iea.org/commentaries/electricity-access-continues-to-improve-in-2024-after-first-global-setback-in-decades.

46 Laura Cozzi et al., 'Electricity Access Continues to Improve in 2024 – after First Global Setback in Decades', IEA, 15 November 2024, https://www.iea.org/commentaries/electricity-access-continues-to-improve-in-2024-after-first-global-setback-in-decades.

47 International Energy Agency, 'Energy Efficiency 2024', 7 November 2024, https://www.iea.org/reports/energy-efficiency-2024/executive-summary.

48 International Energy Agency, 'Energy Efficiency 2024', 7 November 2024, https://www.iea.org/reports/energy-efficiency-2024/executive-summary.

49 United Nations Framework Convention on Climate Change, 'COP28 Agreement Signals "Beginning of the End" of the Fossil Fuel Era', 13 December 2023, https://unfccc.int/news/cop28-agreement-signals-beginning-of-the-end-of-the-fossil-fuel-era.

50 International Energy Agency, 'Electricity 2025', 14 February 2025, https://www.iea.org/reports/electricity-2025.

51 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025.

52 Jason Douglas and Tom Fairless, 'Trade War Explodes Across World at Pace Not Seen in Decades', *Wall Street Journal*, 25 March 2025, https://www.wsj.com/economy/trade/trade-war-explodes-across-world-at-pace-not-seen-in-decades-0b6d6513; Lawrence Berkeley National Laboratory, 'Grid Connection Backlog Grows by 30% in 2023, Dominated by Requests for Solar, Wind, and Energy Storage', 10 April 2024, https://emp.lbl.gov/news/grid-connection-backlog-grows-30-2023-dominated-requests-solar-wind-and-energy-storage; GlobalData Energy, 'Global Energy Frenzy Policy', Energy Monitor, 19 March 2025, https://www.energymonitor.ai/analyst-comment/global-energy-frenzy-policy.

53 The White House, 'President Trump Announces U.S. Withdrawal from the Paris Climate Accord', 1 June 2017, https://trumpwhitehouse.archives.gov/articles/president-trump-announces-u-s-withdrawal-paris-climate-accord; The White House, 'Fact Sheet: President Donald J. Trump Reinvigorates America's Beautiful Clean Coal Industry', 8 April 2025, https://www.whitehouse.gov/fact-sheets/2025/04/fact-sheet-president-donald-j-trump-reinvigorates-americas-beautiful-clean-coal-industry; Oliver Milman, 'How Trump Is Targeting Wind and Solar Energy – and Delighting Big Oil', *The Guardian*, 3 February 2025, https://www.theguardian.com/us-news/2025/feb/03/trump-war-on-clean-energy-big-oil; Reuters, 'Trump Orders Suspension of New Offshore Wind Power Leasing', 21 January 2025, https://www.reuters.com/sustainability/climate-energy/trump-signals-end-new-us-wind-power-leasing-2025-01-21; Benjamin Storrow, 'Trump Darkens Financial Outlook for Clean Tech Companies', E&E News, 27 February 2025, https://www.eenews.net/articles/trump-darkens-financial-outlook-for-clean-tech-companies; Sara Schonhardt, 'USAID Document: Climate Programs Are Being Shut Down', E&E News, 21 February 2025, https://www.eenews.net/articles/usaid-document-climate-programs-are-being-shut-down; Sara Schonhardt, 'Trump Drops 3 Agreements to Get Countries Off Coal', E&E News, 7 March 2025, https://www.eenews.net/articles/trump-drops-3-agreements-to-get-countries-off-coal.

54 Philip Blenkinsop, 'EU Gives Automakers "Breathing Space" on CO_2 Emission Targets', *Reuters*, 3 March 2025, https://www.reuters.com/business/autos-transportation/eu-propose-giving-automakers-three-years-meet-co2-emission-targets-2025-03-03.

55 Reuters, 'New Zealand to Push Through Law to Reverse Ban on Oil and Gas Exploration', 26 August 2024, https://www.reuters.com/markets/commodities/new-zealand-push-through-law-reverse-ban-oil-gas-exploration-2024-08-26; Eve Thomas, 'Which Governments Are Backpedalling on Climate Commitments?', Energy Monitor, 21 August 2024, https://www.energymonitor.ai/features/governments-are-backpedalling-on-climate-commitments-who-are-the-culprits.

56 BloombergNEF, 'Global Cost of Renewables to Continue Falling in 2025 as China Extends Manufacturing Lead: BloombergNEF', 6 February 2025, https://about.bnef.com/blog/global-cost-of-renewables-to-continue-falling-in-2025-as-china-extends-manufacturing-lead-bloombergnef; Ryan Kennedy, 'LCOE of Grid-Scale Solar Expected to Drop 2% Globally in 2025', pv magazine International, 7 February 2025, https://www.pv-magazine.com/2025/02/07/lcoe-of-grid-scale-solar-expected-to-drop-2-globally-in-2025.

57 **Figure 3** from BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment; International Renewable Energy Agency, 'Global Goal of Tripling Renewables Needs USD 1.5 Trillion Investment Per Year', 11 October 2024, https://www.irena.org/News/pressreleases/2024/Oct/Global-Goal-of-Tripling-Renewables-Needs-USD-1-point-5-Trillion-Investment-Per-Year.

ENDNOTES | POLICY AND COMMITMENTS

1 REN21, 'REN21 Policy Database', 2025.

2 United Nations Framework Convention on Climate Change, 'COP29 UN Climate Conference Agrees to Triple Finance to Developing Countries, Protecting Lives and Livelihoods', 24 November 2024, https://unfccc.int/news/cop29-un-climate-conference-agrees-to-triple-finance-to-developing-countries-protecting-lives-and.

3 United Nations Framework Convention on Climate Change, 'COP29 UN Climate Conference Agrees to Triple Finance to Developing Countries, Protecting Lives and Livelihoods', 24 November 2024, https://unfccc.int/news/cop29-un-climate-conference-agrees-to-triple-finance-to-developing-countries-protecting-lives-and.

4 International Institute for Sustainable Development, 'Out with the Old, Slow with the New', accessed 24 April 2025, https://www.iisd.org/publications/report/countries-underdelivering-fossil-clean-energy-finance-pledge.

5 International Institute for Sustainable Development, 'Out with the Old, Slow with the New', accessed 24 April 2025, https://www.iisd.org/publications/report/countries-underdelivering-fossil-clean-energy-finance-pledge.

6 World Economic Forum, '4 Key Takeaways from COP29, from Climate Finance to Carbon Markets', 26 November 2024, https://www.weforum.org/stories/2024/11/cop29-4-key-takeaways.

7 David Waskow et al., 'Key Outcomes from COP29: Unpacking the New Global Climate Finance Goal and Beyond', World Resources Institute, 27 November 2024, https://www.wri.org/insights/cop29-outcomes-next-steps.

8 COP29, 'COP29 Green Energy Pledge: Green Energy Zones and Corridors', accessed 24 April 2025, https://cop29.az/en/pages/cop29-green-energy-pledge-green-energy-zones-and-corridors.

9 COP29, 'COP29 Global Energy Storage and Grids Pledge', accessed 24 April 2025, https://cop29.az/en/pages/cop29-global-energy-storage-and-grids-pledge.

10 COP29, 'COP29 Hydrogen Declaration', accessed 10 March 2025, https://cop29.az/en/pages/cop29-hydrogen-declaration.

11 COP29, 'COP29 Hydrogen Declaration', accessed 10 March 2025, https://cop29.az/en/pages/cop29-hydrogen-declaration.

12 Roberto Bocca, 'G7 Countries Agree Phaseout for Unabated Coal Power, and Other Top Energy Stories', World Economic Forum, 8 May 2024, https://www.weforum.org/stories/2024/05/energy-news-g7-coal-phaseout-renewables-batteries.

13 Francesca Landini, 'G7 Offers Leeway to Germany, Japan in Deal to Quit Coal by 2035', *Reuters*, 30 April 2024, https://www.reuters.com/business/environment/g7-agree-deal-quit-coal-by-2035-with-caveat-2024-04-30.

14 Organisation for Economic Co-operation and Development (OECD) and International Institute for Sustainable Development, 'Fossil Fuel Subsidy Tracker', accessed 18 April 2025, https://fossilfuelsubsidytracker.org.

15 Organisation for Economic Co-operation and Development (OECD) and International Institute for Sustainable Development, 'Fossil Fuel Subsidy Tracker', accessed 18 April 2025, https://fossilfuelsubsidytracker.org.

16 Organisation for Economic Co-operation and Development (OECD) and International Institute for Sustainable Development, 'Fossil Fuel Subsidy Tracker', accessed 18 April 2025, https://fossilfuelsubsidytracker.org.

17 Laura Cozzi *et al.*, 'Electricity Access Continues to Improve in 2024 – after First Global Setback in Decades', International Energy Agency, 15 November 2024, https://www.iea.org/commentaries/electricity-access-continues-to-improve-in-2024-after-firstglobal-setback-in-decades.

18 Laura Cozzi et al., 'Electricity Access Continues to Improve in 2024 – after First Global Setback in Decades', International Energy Agency, 15 November 2024, https://www.iea.org/commentaries/electricity-access-continues-to-improve-in-2024-after-firstglobal-setback-in-decades.

19 Laura Cozzi et al., 'Electricity Access Continues to Improve in 2024 – after First Global Setback in Decades', International Energy Agency, 15 November 2024, https://www.iea.org/commentaries/electricity-access-continues-to-improve-in-2024-after-firstglobal-setback-in-decades. **Sidebar 2** 2 from the following sources: International Energy Agency (IEA), 'Electricity Access Continues to Improve in 2024 – After First Global Setback in Decades – Analysis', 15 November 2024, https://www.iea.org/commentaries/electricity-access-continues-to-improve-in-2024-after-first-global-setback-in-decades; World Bank, 'Pacte National de l'Énergie pour la République du Tchad', December 2024, https://thedocs.worldbank.org/en/doc/808746a6d507a18c7379af60fffe07da-0010012025/original/M300-AES-Compact-Chad.pdf; GOGLA, 'Côte d'Ivoire', 2024, https://www.gogla.org/wp-content/uploads/2024/11/Cote-dIvoire-Country-Brief.pdf; Lighting Global, 'Democratic Republic of Congo: A fledgling off-grid market in a difficult context', November 2018, https://www.lightingglobal.org/country/democratic-republic-of-congo; World Bank, 'Compact Énergétique National – République du Niger', December 2024, https://thedocs.worldbank.org/en/doc/aa1c1df323bc70ef9a9b0b0aa7ba8144-0010012025/original/M300-AES-Compact-Niger.pdf; World Bank, 'National Energy Compact For the Federal Republic of Nigeria', January 2025, https://thedocs.worldbank.org/en/doc/2340747bcba6747a15a4ff8cba935fce-0010012025/original/M300-AES-Compact-Nigeria.pdf; World Bank, 'National Energy Compact for Zambia', January 2025, https://thedocs.worldbank.org/en/doc/54ece4387e7fd4bde8f1b29f55aa579d-0010012025/original/M300-AES-Compact-Zambia.pdf; World Bank, 'Pacte National pour l'Énergie de la République du Sénégal', January 2025, https://thedocs.worldbank.org/en/doc/852a120aa85ab5eea4c1d3a176ff84ac-0010012025/original/M300-AES-Compact-Senegal.pdf; IEA, 'Ethiopia Energy Outlook', 8 November 2019, https://www.iea.org/articles/ethiopia-energy-outlook; World Bank, 'Mission 300: Providing Access to Electricity to 300 Million People in Sub-Saharan Africa by 2030', 23 September 2024, https://www.worldbank.org/en/news/video/2024/09/23/mission-300-providing-access-to-electricity-to-300-million-people-in-sub-saharan-africa-by-2030; World Bank, 'Accelerating Sustainable & Clean Energy Access Transformation Program Using the Multiphase Programme', 9 December 2024, https://projects.worldbank.org/en/projects-operations/procurement-detail/OP00327440; REN21, REN21 Policy Database, accessed 5 June 2025.

20 United Nations Framework Convention on Climate Change, '2024 NDC Synthesis Report', 2024, https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs/2024-ndc-synthesis-report.

21 Climate Watch, 'NDC Tracker', accessed 25 May 2025, https://www.climatewatchdata.org/2020-ndc-tracker.

22 Pilita Clark, 'Year in a Word: Greenlash', *Financial Times*, 28 December 2024, https://www.ft.com/content/0f72b2b4-e6cd-4372-9191-adce668bf2fb.

23 United Nations Economic Commission for Africa, 'Only 13 of the 195 Parties to the Paris Agreement Communicated Their NDC 3.0 by the Deadline of 10 February 2025', 13 February 2025, https://www.uneca.org/stories/only-13-of-the-195-parties-to-the-paris-agreement-communicated-their-ndc-3.0-by-the-deadline; Daisy Dunne, 'Analysis: 95% of Countries Miss UN Deadline to Submit 2035 Climate Pledges', Carbon Brief, 10 February 2025, https://www.carbonbrief.org/analysis-95-of-countries-miss-un-deadline-to-submit-2035-climate-pledges.

24 United Nations Framework Convention on Climate Change, 'Nationally Determined Contributions Registry', 2025, https://unfccc.int/NDCREG.

25 **Figure 5** from REN21, 'REN21 Policy Database', 2025. Carbon tax policies based on World Bank, 'Carbon Pricing Dashboard', accessed 5 May 2025, https://carbonpricingdashboard.worldbank.org/map_data; ETS policies based on International Carbon Action Partnership, 'ETS Map', accessed 5 May 2025, https://icapcarbonaction.com/en/ets; net zero emission targets based on Net Zero Tracker, 'Data Explorer', accessed 5 May 2025, https://zerotracker.net/.

26 REN21, 'REN21 Policy Database', 2025.

27 REN21, 'REN21 Policy Database', 2025.

28 International Carbon Action Partnership, 'Brazil adopts cap-and-trade system', 28 November 2024, https://icapcarbonaction.com/en/news/brazil-adopts-cap-and-trade-system; Ministry of Climate Change and Environmental Coordination, Government of Pakistan, 'Pakistan Policy Guidelines for Trading in Carbon Markets', 2024, https://www.spar6c.org/guidance/pakistan-policy-guidelines-trading-carbon-markets.

29 REN21, 'REN21 Policy Database', 2025.

30 World Bank, 'Carbon Pricing Dashboard: Instrument Detail', 2024, https://carbonpricingdashboard.worldbank.org/compliance/instrument-detail.

31 REN21, 'REN21 Policy Database', 2025.

32 REN21, 'REN21 Policy Database', 2025.

33 REN21, 'REN21 Policy Database', 2025.

34 REN21, 'REN21 Policy Database', 2025.

35 Government of Canada, '2030 Emissions Reduction Plan: Clean Air, Strong Economy', 29 March 2022, https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030.html; UK Government, 'Net Zero Strategy: Build Back Greener', 5 April 2022, https://www.gov.uk/government/publications/net-zero-strategy; Die Bundesregierung, 'Neues Klimaschutzgesetz ist in Kraft', 17 July 2024, https://www.bundesregierung.de/breg-de/service/archiv/klimaschutzgesetz-2197410.

36 **Figure 6** from REN 21, 'REN21 Policy Database', 2025. Net zero emission targets based on Net Zero Tracker, 'Data Explorer', accessed 5 May 2025, https://zerotracker.net/.
37 REN21, 'REN21 Policy Database', 2025.
38 REN21, 'REN21 Policy Database', 2025.
39 reNEWS, 'Scotland Ditches 2030 Climate Targets', 18 April 2024, https://renews.biz/92637/scotland-ditches-2030-climate-targets.
40 Pietro Rocco and Toby Kwan, 'How Far Has the Dial Really Moved in Climate Finance since COP29?', 28 May 2025, https://www.carbontrust.com/news-and-insights/insights/how-far-has-the-dial-really-moved-in-climate-finance-since-cop29; United Nations Environment Programme Finance Initiative, 'COP29 Outcomes: Balancing Progress and Challenges on the Road to Climate Action', 2024, https://www.unepfi.org/themes/climate-change/cop29-outcomes-balancing-progress-and-challenges-on-the-road-to-climate-action; Daisy Dunne, 'Analysis: 95% of Countries Miss UN Deadline to Submit 2035 Climate Pledges', Carbon Brief, 10 February 2025, https://www.carbonbrief.org/analysis-95-of-countries-miss-un-deadline-to-submit-2035-climate-pledges.
41 **Sidebar 3** from the following sources: Austyn Gaffney and Mira Rojanasakul, 'Where Coal Is Retiring, and Hanging On, in the U.S.', *New York Times*, 6 February 2025, https://www.nytimes.com/interactive/2025/02/06/climate/coal-plants-retirement.html; COP29, 'Azerbaijan Launches Climate Finance Action Fund in Package of Initiatives for COP29', 19 July 2024, https://cop29.az/en/media-hub/news/azerbaijan-launches-climate-finance-action-fund-in-package-of-initiatives-for-cop29; BloombergNEF, 'Why Banks Are Walking Back Climate Pledges: BNEF', 3 March 2025, https://www.bloomberg.com/news/videos/2025-03-03/why-banks-are-walking-back-climate-pledges-bnef-video; Ron Bousso, 'European Oil Giants Step Back from Renewables Path', *Reuters*, 18 November 2024, https://www.reuters.com/business/energy/european-oil-giants-step-back-renewables-path-2024-11-18; Business Standard, 'UN's NZBA in Trouble: Why Big Banks Are Pulling Out of Climate Accords', 20 January 2025, https://www.business-standard.com/world-news/european-banks-reconsider-net-zero-banking-alliance-membership-us-125012000709_1.html; Saul Elbein, 'Oil and Gas Firms Backpedaling on Climate Goals, Report Finds'. *The Hill* (blog), 18 July 2024, https://thehill.com/policy/energy-environment/4779842-energy-companies-backpedaling-climate-goals-report; Emily Jones, 'Georgia Was About to Retire Coal Plants. Then Came the Data Centers', *Grist*, 12 February 2025, https://grist.org/energy/georgia-was-about-to-retire-coal-plants-then-came-the-data-cen; Proctor, Darrell, 'Global Utility Alliance Calls for Tripling Renewable Energy Capacity', *POWER Magazine*, 19 April 2024, https://www.powermag.com/global-utility-alliance-calls-for-tripling-renewable-energy-capacity; Reuters, 'Carmakers Scale Down Electrification Plans as EV Demand Slows', 12 September 2024, https://www.reuters.com/business/autos-transportation/carmakers-adjust-electrification-plans-ev-demand-slows-2024-09-06.
42 Qusay Hassan *et al.*, 'The Renewable Energy Role in the Global Energy Transformations', *Renewable Energy Focus* 48, 1 March 2024, https://doi.org/10.1016/j.ref.2024.100545.
43 REN21, 'REN21 Policy Database', 2025.
44 REN21, 'REN21 Policy Database', 2025.
45 REN21, 'REN21 Policy Database', 2025.
46 United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States, 'List of SIDS', accessed 25 May 2025, https://www.un.org/ohrlls/content/list-sids; United Nations Development Programme, 'Advancing a Just Energy Transition in SIDS', 10 February 2025, https://www.undp.org/publications/advancing-just-energy-transition-sids.
47 Divya Karyza, 'Indonesia to Abandon 23% Renewable Energy Target – Regulations', *The Jakarta Post*, 16 January 2024, https://www.thejakartapost.com/business/2024/01/16/indonesia-to-abandon-23-renewable-energy-target-by-2025.html.
48 European Commission, 'Renewables Directive Sectoral Targets Reach Transposition Deadline', accessed 9 June 2025, https://energy.ec.europa.eu/news/renewables-directive-sectoral-targets-reach-transposition-deadline-2025-05-21_en.
49 **Figure 7** from REN21, 'REN21 Policy Database', 2025.
50 REN21, 'REN21 Policy Database', 2025.
51 REN21, 'REN21 Policy Database', 2025.
52 REN21, 'REN21 Policy Database', 2025.
53 REN21, 'REN21 Policy Database', 2025.
54 REN21, 'REN21 Policy Database', 2025.
55 REN21, 'REN21 Policy Database', 2025.
56 REN21, 'REN21 Policy Database', 2025.
57 REN21, 'REN21 Policy Database', 2025.
58 IRENA et al., 'Delivering on the UAE Consensus: Tracking Progress Toward Tripling Renewable Energy Capacity and Doubling Energy Efficiency by 2030', October 2024, https://www.irena.org/Publications/2024/Oct/UAE-Consensus-2030-tripling-renewables-doubling-efficiency.
59 IRENA et al., 'Delivering on the UAE Consensus: Tracking Progress Toward Tripling Renewable Energy Capacity and Doubling Energy Efficiency by 2030', October 2024, https://www.irena.org/Publications/2024/Oct/UAE-Consensus-2030-tripling-renewables-doubling-efficiency.
60 IRENA et al., 'Delivering on the UAE Consensus: Tracking Progress Toward Tripling Renewable Energy Capacity and Doubling Energy Efficiency by 2030', October 2024, https://www.irena.org/Publications/2024/Oct/UAE-Consensus-2030-tripling-renewables-doubling-efficiency.
61 IRENA et al., 'Delivering on the UAE Consensus: Tracking Progress Toward Tripling Renewable Energy Capacity and Doubling Energy Efficiency by 2030', October 2024, https://www.irena.org/Publications/2024/Oct/UAE-Consensus-2030-tripling-renewables-doubling-efficiency.
62 **Figure 8** from REN21, 'REN21 Policy Database', 2025.
63 REN21, 'REN21 Policy Database', 2025.
64 REN21, 'REN21 Policy Database', 2025.
65 REN21, 'REN21 Policy Database', 2025.
66 REN21, 'REN21 Policy Database', 2025.
67 European Commission, 'Latvia – Final Updated NECP 2021-2030 (Submitted in 2024)', 2024, https://commission.europa.eu/publications/latvia-final-updated-necp-2021-2030-submitted-2024_en.
68 Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen, 'Bundeskabinett beschließt Novelle des Gebäudeenergiegesetzes', 2023, https://www.bmwsb.bund.de/SharedDocs/pressemitteilungen/Webs/BMWSB/DE/2023/04/geg-bmwk.html.
69 REN21, 'REN21 Policy Database', 2025; European Commission, 'National Energy and Climate Plans', accessed 3 June 2025, https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en.
70 REN21, 'REN21 Policy Database', 2025.
71 **Figure 9** from REN21, 'REN21 Policy Database', 2025.
72 REN21, 'REN21 Policy Database', 2025.
73 REN21, 'REN21 Policy Database', 2025.
74 REN21, 'REN21 Policy Database', 2025.
75 REN21, 'REN21 Policy Database', 2025.
76 REN21, 'REN21 Policy Database', 2025.
77 REN21, 'REN21 Policy Database', 2025.
78 REN21, 'REN21 Policy Database', 2025.
79 REN21, 'REN21 Policy Database', 2025.
80 **Snapshot XX** from...
81 REN21, 'REN21 Policy Database', 2025.
82 REN21, 'REN21 Policy Database', 2025.
83 REN21, 'REN21 Policy Database', 2025.
84 REN21, 'REN21 Policy Database', 2025.
85 REN21, 'REN21 Policy Database', 2025.
86 REN21, 'REN21 Policy Database', 2025.
87 REN21, 'REN21 Policy Database', 2025.
88 REN21, 'REN21 Policy Database', 2025.
89 Reuters, 'US to Rescind Rule That Lowered Solar, Wind Project Fees on Federal Land', *Reuters*, 14 May 2025, https://www.reuters.com/sustainability/climate-energy/us-rescind-rule-that-lowered-solar-wind-project-fees-federal-land-2025-05-14.
90 Reuters, 'New Zealand to Introduce Bill to Reverse Oil and Gas Exploration Ban', 9 June 2024, https://www.reuters.com/business/energy/new-zealand-introduce-bill-reverse-oil-gas-exploration-ban-2024-06-09/.
91 Helena Horton, 'UK Government Scraps Plan to Ban Sale of Gas Boilers by 2035', *The Guardian*, 6 January 2025, https://www.theguardian.com/environment/2025/jan/06/uk-government-scraps-plan-to-ban-sale-of-gas-boilers-by-2035.
92 International Energy Agency, 'State of Energy Policy 2024', 2024, https://www.iea.org/reports/state-of-energy-policy-2024.
93 International Energy Agency, 'State of Energy Policy 2024', 2024, https://www.iea.org/reports/state-of-energy-policy-2024.
94 International Energy Agency, 'State of Energy Policy 2024', 2024, https://www.iea.org/reports/state-of-energy-policy-2024.
95 International Energy Agency, 'State of Energy Policy 2024', 2024, https://www.iea.org/reports/state-of-energy-policy-2024; International Energy Agency, 'Global Critical Minerals Outlook 2025', May 2025, https://www.iea.org/reports/global-critical-minerals-outlook-2025.
96 International Energy Agency, 'State of Energy Policy 2024', 2024, https://www.iea.org/reports/state-of-energy-policy-2024.

ENDNOTES | INVESTMENT AND FINANCE

1 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.
2 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.
3 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.
4 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment. **Figure 10** from Ibid.
5 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.
6 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.
7 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.
8 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.
9 International Energy Agency, 'Renewables 2024', 9 October 2024, https://www.iea.org/reports/renewables-2024.
10 International Energy Agency, 'Renewables 2024', 9 October 2024, https://www.iea.org/reports/renewables-2024.
11 International Energy Agency, 'Renewables 2024', 9 October 2024, https://www.iea.org/reports/renewables-2024.
12 International Energy Agency, 'Renewables 2024', 9 October 2024, https://www.iea.org/reports/renewables-2024.
13 International Renewable Energy Agency, 'Tripling Renewable Power by 2030: The Role of the G7 in Turning Targets into Action', 2024, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Apr/IRENA_G7_Tripling_renewable_power_2024.pdf.
14 'International Renewable Energy Agency, 'Tripling Renewable Power by 2030: The Role of the G7 in Turning Targets into Action', 2024, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Apr/IRENA_G7_Tripling_renewable_power_2024.pdf. **Figure 11** from Ibid.
15 International Energy Agency, 'World Energy Investment 2024', 6 June 2024, https://www.iea.org/reports/world-energy-investment-2024.
16 International Energy Agency, 'Reducing the Cost of Capital', February 2024, https://www.iea.org/reports/reducing-the-cost-of-capital.
17 International Energy Agency, 'Reducing the Cost of Capital', February 2024, https://www.iea.org/reports/reducing-the-cost-of-capital.
18 International Energy Agency, 'Reducing the Cost of Capital', February 2024, https://www.iea.org/reports/reducing-the-cost-of-capital.
19 Alessia Stedile and Emma Gordon, 'How a High Cost of Capital Is Holding Back Energy Development in Kenya and Senegal', Sun-Connect, 16 February 2025, https://sun-connect.org/how-a-high-cost-of-capital-is-holding-back-energy-development-in-kenya-and-senegal.
20 International Energy Agency, 'Reducing the Cost of Capital', February 2024, https://www.iea.org/reports/reducing-the-cost-of-capital.
21 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.
22 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment. **Figure 12** from Ibid.
23 Danilo Onorino, 'Global Solar Investment Reaches Record $521 Billion in 2024, Led by China', LinkedIn, 26 February 2025, https://www.linkedin.com/pulse/global-solar-investment-reaches-record-521-billion-2024-onorino-2blhf.
24 Danilo Onorino, 'Global Solar Investment Reaches Record $521 Billion in 2024, Led by China', LinkedIn, 26 February 2025, https://www.linkedin.com/pulse/global-solar-investment-reaches-record-521-billion-2024-onorino-2blhf.
25 Danilo Onorino, 'Global Solar Investment Reaches Record $521 Billion in 2024, Led by China', LinkedIn, 26 February 2025, https://www.linkedin.com/pulse/global-solar-investment-reaches-record-521-billion-2024-onorino-2blhf.
26 Danilo Onorino, 'Global Solar Investment Reaches Record $521 Billion in 2024, Led by China', LinkedIn, 26 February 2025, https://www.linkedin.com/pulse/global-solar-investment-reaches-record-521-billion-2024-onorino-2blhf.
27 Danilo Onorino, 'Global Solar Investment Reaches Record $521 Billion in 2024, Led by China', LinkedIn, 26 February 2025, https://www.linkedin.com/pulse/global-solar-investment-reaches-record-521-billion-2024-onorino-2blhf.
28 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.
29 Global Wind Energy Council, 'Global Wind Report 2025', April 2025, https://www.gwec.net/reports/globalwindreport.
30 Global Wind Energy Council, 'Global Wind Report 2025', April 2025, https://www.gwec.net/reports/globalwindreport.
31 Global Wind Energy Council, 'Global Wind Report 2025', April 2025, https://www.gwec.net/reports/globalwindreport.
32 Global Wind Energy Council, 'Global Wind Report 2025', April 2025, https://www.gwec.net/reports/globalwindreport.
33 Global Wind Energy Council, 'Global Wind Report 2025', April 2025, https://www.gwec.net/reports/globalwindreport.
34 Atin Jain, 'Soaring Costs Stress US Offshore Wind Companies, Ruin Margins', BloombergNEF, August 2023, https://about.bnef.com/blog/soaring-costs-stress-us-offshore-wind-companies-ruin-margins.
35 Atin Jain, 'Soaring Costs Stress US Offshore Wind Companies, Ruin Margins', BloombergNEF, August 2023, https://about.bnef.com/blog/soaring-costs-stress-us-offshore-wind-companies-ruin-margins.
36 Atin Jain, 'Soaring Costs Stress US Offshore Wind Companies, Ruin Margins', BloombergNEF, August 2023, https://about.bnef.com/blog/soaring-costs-stress-us-offshore-wind-companies-ruin-margins.
37 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.
38 IFP Energies Nouvelles, 'Biofuel Dashboard 2024', 30 January 2025, https://www.ifpenergiesnouvelles.com/article/biofuels-dashboard-2024.
39 IFP Energies Nouvelles, 'Biofuel Dashboard 2024', 30 January 2025, https://www.ifpenergiesnouvelles.com/article/biofuels-dashboard-2024.
40 World Oil, 'Major Companies Bet on Biofuels with Over 40 Projects Planned by 2030', 20 November 2024, https://worldoil.com/news/2024/11/20/major-companies-bet-on-biofuels-with-over-40-projects-planned-by-2030
41 World Oil, 'Major Companies Bet on Biofuels with Over 40 Projects Planned by 2030', 20 November 2024, https://worldoil.com/news/2024/11/20/major-companies-bet-on-biofuels-with-over-40-projects-planned-by-2030.
42 International Energy Agency Solar Heating & Cooling Programme, 'Solar Heat World Wide 2024', June 2024, https://www.iea-shc.org/Data/Sites/1/publications/Solar-Heat-Worldwide-2024.pdf.
43 International Energy Agency Solar Heating & Cooling Programme, 'Solar Heat World Wide 2024', June 2024, https://www.iea-shc.org/Data/Sites/1/publications/Solar-Heat-Worldwide-2024.pdf.
44 International Energy Agency Solar Heating & Cooling Programme, 'Solar Heat World Wide 2024', June 2024, https://www.iea-shc.org/Data/Sites/1/publications/Solar-Heat-Worldwide-2024.pdf.
45 Emma Penrod, 'Analysts See 'a Real Fear in the Market' as Renewable Energy Stocks Plummet on Election Results', Utility Dive, 7 November 2024, https://www.utilitydive.com/news/market-gear-renewable-energy-stocks-plummet/732225.
46 Benjamin Storrow, 'Trump Darkens Financial Outlook for Clean Tech Companies', E&E News, 27 February 2025, https://www.eenews.net/articles/trump-darkens-financial-outlook-for-clean-tech-companies.
47 Benjamin Storrow, 'Trump Darkens Financial Outlook for Clean Tech Companies', E&E News, 27 February 2025, https://www.eenews.net/articles/trump-darkens-financial-outlook-for-clean-tech-companies.
48 Kevin Crowley and Will Mathis, 'BP's Crisis Marks the Tombstone for Big Oil's Green Pivot', Bloomberg, 3 March 2025, https://www.bloomberg.com/news/features/2025-03-03/bp-s-crisis-marks-end-of-big-oil-s-green-pivot. **Sidebar 4** from the following sources: roughly one-third, around 20%, and more than 60% from International Energy Agency (IEA), 'The Oil and Gas Industry in Net Zero Transitions', 2023, https://doi.org/10.1787/fd522f59-en. Investments of 5-15% from the following: P. Bindman, 'Oil majors BP and Shell's spending on renewables flatlines in 2023', Energy Monitor, 7 February 2024, https://www.energymonitor.ai/finance/corporate-strategy/weekly-data-oil-majors-bp-and-shells-spending-on-renewables-flatlines-in-2023; TotalEnergies, 'Investor Presentations', 11 April 2025, https://totalenergies.com/investors/investors-presentations; Equinor, '2023 Progress on Our Energy Transition Plan', accessed 11 April 2025, https://cdn.equinor.com/files/h61q9gi9/global/2c8cbe4a3ac14ec6466b78ada31951561339cc6a.pdf?2023-progress-on-the-energy-transition-plan.pdf; Equinor, 'Equinor Fourth Quarter and Full Year 2024 Results',

5 February 2025, https://www.equinor.com/news/equinor-fourth-quarter-and-full-year-2024-results. Smaller shares from IEA, op. cit. this note; S. Jack, 'Norwegian oil giant Equinor cuts green investment in half', BBC News, 6 February 2025, https://www.bbc.com/news/articles/c1jg7k1kjwyo; A. Kumar, 'BP cuts renewable investment and boosts oil and gas in strategy shift', *Reuters*, 27 February 2025, https://www.reuters.com/markets/commodities/bp-ramps-up-oil-gas-spending-10-billion-ceo-rebuilds-confidence-2025-02-26; C. Domonoske, 'Making oil is more profitable than saving the planet. These numbers tell the story', NPR, 12 December 2023, https://www.npr.org/2023/12/11/1217802769/oil-prices-exxon-mobil-green-energy-solar-wind-cop28-climate-talks; geopolitical disruptions from R. Bousso, 'Big oil backtracks on renewables push as climate agenda falters', *Reuters*, 27 December 2024, https://www.reuters.com/business/energy/big-oil-backtracks-renewables-push-climate-agenda-falters-2024-12-27; World Economic Magazine, 'How Saudi Aramco balances oil production with green energy investments', 24 June 2024, https://worldecomag.com/how-saudi-aramco-balances-oil-production-with-green-energy-investments; Chevron Policy Affairs Government and Public, '$500 million investment in emerging lower carbon technologies', 30 April 2024, https://www.chevron.com/newsroom/2024/q2/500-million-investment-in-emerging-lower-carbon-technologies; Reuters, 'Chevron arm launches $500 million fund to invest in low carbon technologies', 17 April 2024, https://www.reuters.com/sustainability/climate-energy/chevron-arm-launches-500-million-fund-invest-low-carbon-technologies-2024-04-16; Rebecaa F. Elliot, 'Why are oil giants backing away from green energy', *New York Times*, 18 November 2024, https://www.nytimes.com/2024/11/18/business/energy-environment/cop-oil-gas-green-energy.html; ExxonMobil Corporation, 'ExxonMobil announces plans to 2030 that build on its unique advantages', 11 December 2024, https://investor.exxonmobil.com/news-events/press-releases/detail/1178/exxonmobil-announces-plans-to-2030-that-build-on-its-unique. **Figure 13** from Ibid.

49 Kevin Crowley and Will Mathis, 'BP's Crisis Marks the Tombstone for Big Oil's Green Pivot', Bloomberg, 3 March 2025, https://www.bloomberg.com/news/features/2025-03-03/bp-s-crisis-marks-end-of-big-oil-s-green-pivot.

50 Sara Schonhardt, 'USAID Document: Climate Programs Are Being Shut Down', E&E News, 21 February 2025, https://www.eenews.net/articles/usaid-document-climate-programs-are-being-shut-down.

51 Emma Penrod, 'Policy Uncertainty Could Trigger 'Recession' for Renewables, Analyst Says', Utility Dive, 30 April 2025, https://www.utilitydive.com/news/ira-tariffs-uncertainty-renewable-solar-storage-mercom/746694.

52 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

53 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

54 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

55 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

56 Renewable energy and energy efficiency data from BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment; fossil fuel investment data from IEA, 2025 World Energy Investment Trends, June 2025, https://www.iea.org/reports/world-energy-investment-2025. **Figure 14** from Ibid.

57 Rafael Martinez-Gordon, Chiara Delmastro and Jianlan Dou, 'Is a Turnaround in Sight for Heat Pump Markets?', International Energy Agency, 7 February 2025, https://www.iea.org/commentaries/is-a-turnaround-in-sight-for-heat-pump-markets.

58 Rafael Martinez-Gordon, Chiara Delmastro and Jianlan Dou, 'Is a Turnaround in Sight for Heat Pump Markets?', International Energy Agency, 7 February 2025, https://www.iea.org/commentaries/is-a-turnaround-in-sight-for-heat-pump-markets.

59 Rafael Martinez-Gordon, Chiara Delmastro and Jianlan Dou, 'Is a Turnaround in Sight for Heat Pump Markets?', International Energy Agency, 7 February 2025, https://www.iea.org/commentaries/is-a-turnaround-in-sight-for-heat-pump-markets.

60 Rafael Martinez-Gordon, Chiara Delmastro and Jianlan Dou, 'Is a Turnaround in Sight for Heat Pump Markets?', International Energy Agency, 7 February 2025, https://www.iea.org/commentaries/is-a-turnaround-in-sight-for-heat-pump-markets.

61 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

62 Maria Gallucci, 'Global Clean Industry Investment Fell Sharply in 2024', Canary Media, 14 February 2025, https://www.canarymedia.com/articles/clean-industry/chart-global-clean-industry-investment-fell-sharply-in-2024.

63 Maria Gallucci, 'Global Clean Industry Investment Fell Sharply in 2024', Canary Media, 14 February 2025, https://www.canarymedia.com/articles/clean-industry/chart-global-clean-industry-investment-fell-sharply-in-2024.

64 Maria Gallucci, 'Global Clean Industry Investment Fell Sharply in 2024', Canary Media, 14 February 2025, https://www.canarymedia.com/articles/clean-industry/chart-global-clean-industry-investment-fell-sharply-in-2024.

65 Hydrogen Council, 'Hydrogen Insights 2024', September 2024, https://hydrogencouncil.com/wp-content/uploads/2024/09/Hydrogen-Insights-2024.pdf.

66 Hydrogen Council, 'Hydrogen Insights 2024', September 2024, https://hydrogencouncil.com/wp-content/uploads/2024/09/Hydrogen-Insights-2024.pdf.

67 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

68 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

69 Eamon Farhat, 'Grid Investment Must Outpace Renewables for Net Zero, BNEF Says', Bloomberg, 21 May 2024, https://www.bloomberg.com/news/articles/2024-05-21/grid-investment-must-outpace-renewables-for-net-zero-bnef-says.

ENDNOTES | RENEWABLES IN ENERGY SUPPLY

1 International Energy Agency, 'World Extended Energy Balances', July 2024, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
2 Data for 2022 and 2015, and for **Figure 15** from International Energy Agency, 'World Extended Energy Balances', July 2024, https://www.iea.org/data-and-statistics/data-product/world-energy-balances. Data are based on the IEA World Energy Balances and have been processed by REN21 to produce these figures. Electricity consumption includes electricity used for both heating and transport.
3 International Energy Agency, 'World Extended Energy Balances', July 2024, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
4 International Energy Agency, 'World Extended Energy Balances', July 2024, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
5 International Energy Agency, 'World Extended Energy Balances', July 2024, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
6 Data for 2024 and **Figure 16** from Malgorzata Wiatros-Motyka, Nicolas Fulghum and Dave Jones, 'Global Electricity Review 2024', Ember, 8 May 2024, https://ember-energy.org/latest-insights/global-electricity-review-2024.
7 Malgorzata Wiatros-Motyka, Nicolas Fulghum and Dave Jones, 'Global Electricity Review 2024', Ember, 8 May 2024, https://ember-energy.org/latest-insights/global-electricity-review-2024.
8 Malgorzata Wiatros-Motyka, Nicolas Fulghum and Dave Jones, 'Global Electricity Review 2024', Ember, 8 May 2024, https://ember-energy.org/latest-insights/global-electricity-review-2024.
9 Malgorzata Wiatros-Motyka, Nicolas Fulghum and Dave Jones, 'Global Electricity Review 2024', Ember, 8 May 2024, https://ember-energy.org/latest-insights/global-electricity-review-2024.
10 Malgorzata Wiatros-Motyka, Nicolas Fulghum and Dave Jones, 'Global Electricity Review 2024', Ember, 8 May 2024, https://ember-energy.org/latest-insights/global-electricity-review-2024.
11 Malgorzata Wiatros-Motyka, Nicolas Fulghum and Dave Jones, 'Global Electricity Review 2024', Ember, 8 May 2024, https://ember-energy.org/latest-insights/global-electricity-review-2024.
12 Data for 2024 and **Figure 17** from REN21, 'REN21 Capacity Database', 2025.
13 REN21, 'REN21 Capacity Database', 2025.
14 REN21, 'REN21 Capacity Database', 2025.
15 REN21, 'REN21 Capacity Database', 2025.
16 International Energy Agency Photovoltaic Power Systems Programme, 'Snapshot of Global PV Markets 2025', April 2025, https://iea-pvps.org/snapshot-reports/snapshot-2025; Global Wind Energy Council, 'Global Wind Report 2025', 23 April 2025, 80, 85, https://www.gwec.net/reports/globalwindreport. **Figure 18** from Ibid.
17 International Hydropower Association, personal communication with REN21, June 2025.
18 International Energy Agency Photovoltaic Power Systems Programme, 'Snapshot of Global PV Markets 2025', April 2025, https://iea-pvps.org/snapshot-reports/snapshot-2025
19 International Energy Agency Photovoltaic Power Systems Programme, 'Snapshot of Global PV Markets 2025', April 2025, https://iea-pvps.org/snapshot-reports/snapshot-2025
20 Hamza Jilani, 'Chinese Battery Glut Plugs into Solar Boom to Power Pakistan', *Financial Times*, 2 June 2025, https://www.ft.com/content/2b4c598e-a4b3-4c6e-9c38-97e46357f819.
21 International Energy Agency Photovoltaic Power Systems Programme, 'Snapshot of Global PV Markets 2025', April 2025, https://iea-pvps.org/snapshot-reports/snapshot-2025
22 Based on data from the following: Global Wind Energy Council (GWEC), 'Global Wind Report 2025', April 23, 2025, 80, 85, https://www.gwec.net/reports/globalwindreport; GWEC, 'Global Wind Statistics 2025, Status End of 2024', unpublished document; with adjustments made for 2024 European data from WindEurope, 'Wind Energy in Europe: 2024 Statistics and the Outlook for 2025-2030', February 27, 2025, 10-11, https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2024-statistics-and-the-outlook-for-2025-2030; and updated statistics for the United States from J. Hensley, American Clean Power Association, personal communication with REN21, 15 May 2025.
23 Based on data from the following: Global Wind Energy Council (GWEC), 'Global Wind Report 2025', April 23, 2025, 75, 85, https://www.gwec.net/reports/globalwindreport; GWEC, 'Global Wind Statistics 2025, Status End of 2024', unpublished document; with adjustments made for 2024 European data from WindEurope, 'Wind Energy in Europe: 2024 Statistics and the Outlook for 2025-2030', February 27, 2025, 10-11, https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2024-statistics-and-the-outlook-for-2025-2030; and from J. Hensley, American Clean Power Association, personal communication with REN21, 15 May 2025.
24 Based on data from the following: Global Wind Energy Council (GWEC), 'Global Wind Report 2025', April 23, 2025, 75, 85, https://www.gwec.net/reports/globalwindreport; GWEC, 'Global Wind Statistics 2025, Status End of 2024', unpublished document; with adjustments made for 2024 European data from WindEurope, 'Wind Energy in Europe: 2024 Statistics and the Outlook for 2025-2030', February 27, 2025, 10-11, https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2024-statistics-and-the-outlook-for-2025-2030; and from J. Hensley, American Clean Power Association, personal communication with REN21, 15 May 2025.
25 Based on data from the following: Global Wind Energy Council (GWEC), 'Global Wind Report 2025', April 23, 2025, 75, 85, https://www.gwec.net/reports/globalwindreport; GWEC, 'Global Wind Statistics 2025, Status End of 2024', unpublished document; with adjustments made for 2024 European data from WindEurope, 'Wind Energy in Europe: 2024 Statistics and the Outlook for 2025-2030', February 27, 2025, 10-11, https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2024-statistics-and-the-outlook-for-2025-2030; and from J. Hensley, American Clean Power Association, personal communication with REN21, 15 May 2025.
26 World Wind Energy Association, 'WWEA Annual Report 2024', April 2025, 5, https://wwindea.org/AnnualReport2024; Global Wind Energy Council, 'Global Wind Report 2025', 23 April 2025, 2, 12-34, https://www.gwec.net/reports/globalwindreport.
27 GWEC, 'Global Wind Report 2025', 23 April 2025, 5, 12, 70-72, https://www.gwec.net/reports/globalwindreport; and based on data from GWEC, 'Global Wind Statistics 2025, Status End of 2024', unpublished document.
28 International Hydropower Association, personal communication with REN21, June 2025.
29 International Hydropower Association, personal communication with REN21, June 2025.
30 International Hydropower Association, personal communication with REN21, June 2025.
31 International Hydropower Association, personal communication with REN21, June 2025.
32 REN21, 'REN21 Capacity Database', 2025.
33 International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', 26 March 2025, https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.
34 Ember, 'Global Electricity Review 2025', 8 April 2025, https://ember-energy.org/latest-insights/global-electricity-review-2025; EurObserv'ER, '23rd Annual Overview Barometer: The State of Renewable Energies in Europe', 2024, https://www.eurobserv-er.org/23rd-annual-overview-barometer.
35 Estimated electricity generation in 2024 based on International Energy Agency, 'Renewables Energy Progress Tracker', 9 October 2024, https://www.iea.org/data-and-statistics/data-tools/renewables-data-explorer.
36 Estimated added and total capacity based on the following sources: Germany from Federal Environment Agency (Umwelt Bundesamt), 'Erneuerbare Energien in Deutschland Daten zur Entwicklung im Jahr 2024', March 2025, https://www.umweltbundesamt.de/publikationen/erneuerbare-energien-in-deutschland-2024; Iceland from Orkustofnun, 'Raforkuvinnsla', viewed May 2025, https://orkustofnun.is/raforkueftirlit/raforkuvinnsla; Indonesia from Ministry of Energy and Mineral Resources, 'Laporan Kinerja Ditjen EBTKE Tahun 2024' (Performance Report 2024 of the Directorate General of New, Renewable Energy and Energy Conservation), 49, 63, 82-85, https://www.esdm.go.id/assets/media/content/content-laporan-kinerja-ditjen-ebtke-tahun-2024.pdf; Kasumi Yasukawa, '2023 Japan Country Report', International Energy Agency Geothermal, July 2024, https://www.iea-gia.org/our-members/japan; Kenya from Energy and Petroleum Regulatory Authority, Biannual Energy and Petroleum Statistics Report, https://www.epra.go.ke/annual-reports; Luis C.A. Gutiérrez-Negrín, '2023 Mexico Country Report', International Energy Agency Geothermal, November 2024, https://www.iea-gia.org/our-members/mexico; New Zealand Ministry of Business Innovation and Employment, 'Electricity Statistics', https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/electricity-statistics, accessed May 2025; Philippines from Independent Electricity Market Operator (IEMOP), 'Annual Market Outcomes 2024', 2 April 2025, https://www.iemop.ph/home-media/publications, and from Energy Development Corporation, 'EDC inaugurates 28.9-MW Palayan Bayan binary geothermal power plant, Philippines', press release, 5 July 2024, https://www.energy.com.ph/edc-inaugurates-28-9-mw-palayan-bayan-binary-geothermal-power-plant-philippines; Türkiye from Energy Market Regulatory Authority (EMRA/EPDK), 'Electricity Market Sector Report',

accessed May 2025, http://www.epdk.org.tr; United States from U.S. Energy Information Administration, 'EIA-Form 860M', February 2025, https://www.eia.gov/electricity/data/eia860m; capacity data for other countries from International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', 2025, https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.

37 Estimated added and total capacity based on the following sources: Germany from Federal Environment Agency (Umwelt Bundesamt), 'Erneuerbare Energien in Deutschland Daten zur Entwicklung im Jahr 2024', March 2025, https://www.umweltbundesamt.de/publikationen/erneuerbare-energien-in-deutschland-2024; Iceland from Orkustofnun, 'Raforkuvinnsla', viewed May 2025, https://orkustofnun.is/raforkueftirlit/raforkuvinnsla; Indonesia from Ministry of Energy and Mineral Resources, 'Laporan Kinerja Ditjen EBTKE Tahun 2024' (Performance Report 2024 of the Directorate General of New, Renewable Energy and Energy Conservation), 49, 63, 82-85, https://www.esdm.go.id/assets/media/content/content-laporan-kinerja-ditjen-ebtke-tahun-2024.pdf; Kasumi Yasukawa, '2023 Japan Country Report', International Energy Agency Geothermal, July 2024, https://www.iea-gia.org/our-members/japan; Kenya from Energy and Petroleum Regulatory Authority, Biannual Energy and Petroleum Statistics Report, https://www.epra.go.ke/annual-reports; Luis C.A. Gutiérrez-Negrín, '2023 Mexico Country Report', International Energy Agency Geothermal, November 2024, https://www.iea-gia.org/our-members/mexico; New Zealand Ministry of Business Innovation and Employment, 'Electricity Statistics', https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/electricity-statistics, accessed May 2025; Philippines from Independent Electricity Market Operator (IEMOP), 'Annual Market Outcomes 2024', 2 April 2025, https://www.iemop.ph/home-media/publications, and from Energy Development Corporation, 'EDC inaugurates 28.9-MW Palayan Bayan binary geothermal power plant, Philippines', press release, 5 July 2024, https://www.energy.com.ph/edc-inaugurates-28-9-mw-palayan-bayan-binary-geothermal-power-plant-philippines; Türkiye from Energy Market Regulatory Authority (EMRA/EPDK), 'Electricity Market Sector Report', accessed May 2025, http://www.epdk.org.tr; United States from U.S. Energy Information Administration, 'EIA-Form 860M', February 2025, https://www.eia.gov/electricity/data/eia860m; capacity data for other countries from International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', 2025, https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.

38 Richard Thonig, Alina Gilmanova and Johan Lilliestam, CSP.Guru, 2025, https://doi.org/10.5281/zenodo.8191855.

39 China Solar Thermal Alliance, 'Blue Book of China's Concentrating Solar Power Industry 2024', 2025, https://www.solarpaces.org/wp-content/uploads/2024/02/Blue-Book-of-Chinas-Concentrating-Solar-Power-Industry-2023.pdf.

40 China Solar Thermal Alliance, 'Blue Book of China's Concentrating Solar Power Industry 2024', 2025, https://www.solarpaces.org/wp-content/uploads/2024/02/Blue-Book-of-Chinas-Concentrating-Solar-Power-Industry-2023.pdf.

41 International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', 2025, https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.

42 International Renewable Energy Agency, 'Renewable Capacity Statistics 2025', https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025.

43 International Energy Agency, 'OES 2024 Annual Report', March 2025, https://www.ocean-energy-systems.org/publications/oes-annual-reports/document/oes-annual-report-2024/, The EU, US, and Canada have evolved beyond R&D to directly support commercial viability and market integration. The European Commission launched targeted calls to improve ocean energy performance, operations and maintenance, and reduce cost. The US Department of Energy committed a record USD 141 million in 2024 to wave and tidal energy through programmes like Oceans of Opportunity and the Marine Energy Technologies Acceleration Act. Canada's 2024 federal budget introduced several refundable tax credits 15% for clean electricity, 30% for clean manufacturing, and 30% for clean tech. All of which are explicitly eligible for ocean energy developers. Bill C-49 also established a new joint federal provincial regulatory framework for offshore renewables in Nova Scotia and Newfoundland & Labrador.

44 International Energy Agency, 'COP28 Tripling Renewable Capacity Pledge', June 2024, https://www.iea.org/reports/cop28-tripling-renewable-capacity-pledge.

45 Global 2030 capacity target by technology based on International Energy Agency, 'COP28 Tripling Renewable Capacity Pledge', June 2024, https://www.iea.org/reports/cop28-tripling-renewable-capacity-pledge; Global 2024 capacity based on REN21, 'REN21 Capacity Database', 2025. **Figure 19** from Ibid.

46 International Energy Agency, 'Renewables 2024', 9 October 2024, https://www.iea.org/reports/renewables-2024.

47 International Energy Agency, 'Renewables 2024', 9 October 2024, https://www.iea.org/reports/renewables-2024.

48 International Energy Agency, 'Renewables 2024', 9 October 2024, https://www.iea.org/reports/renewables-2024.

49 Leslie Hooke, 'European Solar Industry Pins Hopes on New EU Procurement Rules', *Financial Times*, 15 May 2025, https://www.ft.com/content/example-link; Times of India, 'Avaada Butibori Plant Is India's 1st to Make 720Wp Solar Modules', 11 June 2025, https://timesofindia.indiatimes.com/city/nagpur/avaada-butibori-plant-is-indias-1st-to-make-720wp-solar-modules/articleshow/121762386.cms.

50 Global Wind Energy Council, 'Global Wind Report 2025', 23 April 2025, 19, https://www.gwec.net/reports/globalwindreport.

51 Global Wind Energy Council, 'Global Wind Report 2025', 23 April 2025, 9, 18, 19, https://www.gwec.net/reports/globalwindreport. In some key regions (Europe, Americas) investment in the supply chain has been insufficient to meet ambitious targets and expected future demand, from Ibid., 18-19. Supply chain bottlenecks have stalled projects and led developers to opt out of tenders, from C. Jenns, 'The Supply Chain Limitations Facing the Wind Turbine Market', Power Technology, April 24, 2025, https://www.power-technology.com/features/the-supply-chain-limitations-facing-the-wind-turbine-market.

52 GWEC, 'Global Wind Report 2025', 23 April 2025, 18-19, https://www.gwec.net/reports/globalwindreport. Supply chain bottlenecks have stalled projects and led developers to opt out of tenders, from C. Jenns, 'The Supply Chain Limitations Facing the Wind Turbine Market', Power Technology, 24 April 2025, https://www.power-technology.com/features/the-supply-chain-limitations-facing-the-wind-turbine-market. In Europe, investments have been made in the wind energy supply chain to meet demand for the next couple of years, but more will be required to meet future demand, from G. Costanzo, WindEurope, personal communication with REN21, 12 May 2025.

53 F. Zhao, GWEC, personal communication with REN21, 12 May 2025; C. Jenns, 'The Supply Chain Limitations Facing the Wind Turbine Market', Power Technology, 24 April 2025, https://www.power-technology.com/features/the-supply-chain-limitations-facing-the-wind-turbine-market.

54 BloombergNEF, 'Chinese Manufacturers Lead Global Wind Turbine Installations, BloombergNEF Report Shows', March 17, 2025, https://about.bnef.com/blog/chinese-manufacturers-lead-global-wind-turbine-installations-bloombergnef-report-shows/. China had the top four spots, with no European or US manufacturers in the first three, for the first time since BNEF started publishing the ranking in 2013; the top five were Goldwind, Envision, Windey, MingYang, with Vestas (Denmark) falling to fifth, from idem. The top three globally were Goldwind, Envision and MingYang (all China), with Vestas leading outside of China, from Wood Mackenzie, 'Chinese OEMs Sweep the Global Wind Podium for the First Time', March 14, 2025, https://www.woodmac.com/press-releases/2024-press-releases/chinese-oems-sweep-the-global-wind-podium-for-the-first-time/.

55 BloombergNEF, 'Chinese Manufacturers Lead Global Wind Turbine Installations, BloombergNEF Report Shows', March 17, 2025, https://about.bnef.com/blog/chinese-manufacturers-lead-global-wind-turbine-installations-bloombergnef-report-shows/; and from GWEC, 'Global Wind Report 2025', April 23, 2025, 51, https://www.gwec.net/reports/globalwindreport. For example, Goldwind opened a manufacturing base in Brazil; SANY was constructing an assembly plant in Kazakhastan; Envision is establishing production capacity in India and investing in Kazakhstan and Saudi Arabia; MingYang is involved in joint ventures in Italy and South Korea, all from GWEC, op. cit. this note.

56 Wood Mackenzie, 'Chinese OEMs Sweep the Global Wind Podium for the First Time', March 14, 2025, https://www.woodmac.com/press-releases/2024-press-releases/chinese-oems-sweep-the-global-wind-podium-for-the-first-time/.

57 Clean Energy Wire, 'Skills Shortage Growing Challenge for Global Energy Transition', December 2024, https://www.cleanenergywire.org/dossiers/skills-shortage-growing-challenge-global-energy-transition.

58 International Renewable Energy Agency, 'Renewable Energy and Jobs: Annual Review 2024', October 2024, https://www.irena.org/Publications/2024/Oct/Renewable-energy-and-jobs-Annual-review-2024. **Sidebar 5** from the following sources: Climate Watch, 'NDC Tracker', accessed 25 May 2025, https://www.climatewatchdata.org/2020-ndc-tracker; Cornerstone of Rural Electrification (CORE), 'National Training and Certification Programme on Solar Rooftop PV in Thailand', accessed 26 May 2025, https://core-initiative.org/government-activities/

technical-support-for-the-design-and-implementation-of-a-training-and-certification-programme-in-thailand; European Commission, '8 New Blueprint Alliances Tackle Skills Gaps in Industrial Ecosystems', accessed 26 May 2025, https://pact-for-skills.ec.europa.eu/about/news-and-factsheets/8-new-blueprint-alliances-tackle-skills-gaps-industrial-ecosystems-2024-10-01_en; European Commission, 'Pact for Skills: Launch of Large-Scale Renewable Energy Skills Partnership', accessed 26 May 2025, https://employment-social-affairs.ec.europa.eu/news/pact-skills-launch-large-scale-renewable-energy-skills-partnership-2023-03-21_en; Government of Brazil, 'Lula Enacts Fuel of the Future Law: "Brazil Will Drive the World's Largest Energy Revolution" – Planalto', accessed 26 May 2025, https://www.gov.br/planalto/en/latest-news/2024/10/lula-enacts-fuel-of-the-future-law-201cbrazil-will-drive-the-worlds-largest-energy-revolution201d; International Energy Agency (IEA), 'World Energy Employment 2024 – Analysis', 13 November 2024, https://www.iea.org/reports/world-energy-employment-2024; IEA, 'World Energy Employment 2023 – Analysis', 15 November 2023, https://www.iea.org/reports/world-energy-employment-2023; International Renewable Energy Agency, 'Renewable Energy and Jobs: Annual Review 2024', 1 October 2024, https://www.irena.org/Publications/2024/Oct/Renewable-energy-and-jobs-Annual-review-2024; Ben Payton, 'How Bridging the Skills Gap Can Boost Africa's Green Energy Transition', Reuters, 19 November 2024, https://www.reuters.com/sustainability/climate-energy/how-bridging-skills-gap-can-boost-africas-green-energy-transition-2024-11-19; World Bank Open Data, 'Labor Force, Total', accessed 26 May 2025, https://data.worldbank.org/indicator/SL.TLF.TOTL.IN; World Biogas Association, 'Collaboration Between Countries Is the Highlight of the World Biogas Association BRAZIL Congress 2024', 9 October 2024, https://www.worldbiogasassociation.org/collaboration-between-countries-is-the-highlight-of-the-world-biogas-association-brazil-congress-2024.

59 Renewable Energy Institute, 'Closing the Green Skills Gap: Empowering the Next Generation of Renewable Energy Professionals', https://www.renewableinstitute.org/closing-the-green-skills-gap-empowering-the-next-generation-of-renewable-energy-professionals.

60 LinkedIn Economic Graph, 'Global Green Skills Report 2023', 2023, https://economicgraph.linkedin.com/content/dam/me/economicgraph/en-us/global-green-skills-report/green-skills-report-2023.pdf.

61 World Economic Forum, 'The Green Skills Gap: Educational Reform in Favour of Renewable Energy Is Now Urgent', 2024, https://www.weforum.org/stories/2024/04/green-skills-gap-educational-reform-renewable-energy.

62 **Sidebar 6** from the following sources: REN21, 'Renewable Energy and Sustainability Report', 30 January 2024, https://www.ren21.net/renewable-energy-and-sustainability-report-2024; Global Wind Energy Council, 'Global Wind Report 2025', 2025, https://www.gwec.net/reports/globalwindreport; Business & Human Rights Resource Centre, 'Transition Minerals Tracker: 2025 Global Analysis', accessed 8 June 2025, https://www.business-humanrights.org/en/from-us/briefings/transition-minerals-tracker-2025-global-analysis; United Nations, 'The UN Secretary-General's Panel on Critical Energy Transition Minerals', accessed 8 June 2025, https://www.un.org/en/climatechange/critical-minerals; Indigenous Summit Just Transition, 'Indigenous Peoples Principles and Protocols for Just Transition', Geneva, 2024, https://www.indigenoussummit.org/summit-outcome; Indigenous Peoples' Rights International, 'Exploring Shared Prosperity: Indigenous Leadership and Partnerships for a Just Transition', accessed 8 June 2025, https://iprights.org/index.php/en/component/content/article/exploring-shared-prosperity-indigenous-leadership-and-partnerships-for-a-just-transition?catid=9&Itemid=102; The Nature Conservancy, 'Enabling a Community-Powered Energy Transition: Good Practices for Engaging Stakeholders, Fostering Collaboration, and Promoting Socioeconomic Benefits', March 2024, https://www.nature.org/content/dam/tnc/nature/en/documents/Enabling_a_Community-Powered_Energy_Transition.pdf; B. Jobson et al., 'Opportunities for Enhancing Biodiversity at Wind and Solar Energy Developments', The Biodiversity Consultancy, 2024,. https://portals.iucn.org/library/sites/library/files/documents/2024-037-En_0.pdf; Renewables Grid Initiative, 'Engage4Energy', accessed 8 June 2025, https://renewables-grid.eu/activities/engage4energy.html; James O'Connor, 'Briefing: Fairer and Faster Permitting for a Successful European Renewable Energy Transition', CAN Europe, 19 October 2023, https://caneurope.org/renewable-permitting-europe; SolarPower Europe, 'SolarPower Europe and The Nature Conservancy Release Landmark Policy Paper on Nature-Inclusive Solar', 15 October 2024, https://www.solarpowereurope.org/press-releases/solar-power-europe-and-the-nature-conservancy-release-landmark-policy-paper-on-nature-inclusive-solar; Reuters, 'Brazil's Lula Recognizes Three More Indigenous Territories', 4 December 2024, https://www.reuters.com/world/americas/brazils-lula-recognizes-three-more-indigenous-territories-2024-12-04; Government of Peru, 'Decreto Supremo N.° 008-2024-MINAM', 2024, https://www.gob.pe/institucion/minam/normas-legales/6124002-008-2024-minam; Government of Mexico, 'Ley Del Sector Eléctrico', 18 March 2025, https://www.diputados.gob.mx/LeyesBiblio/pdf/LSE.pdf; European Commission, 'Corporate Sustainability Due Diligence, accessed 8 June 2025, https://commission.europa.eu/business-economy-euro/doing-business-eu/sustainability-due-diligence-responsible-business/corporate-sustainability-due-diligence_en; Les Amis de La Terre, "OMNIBUS' Legislation – The European Union threatens to backtrack on its commitments to human, social, and environmental rights', 26 November 2024, https://www.amisdelaterre.org/communique-presse/omnibus-legislation-the-european-union-threatens-to-backtrack-on-its-commitments-to-human-social-and-environmental-rights; FAOLEX, 'Preservation and Development of Agricultural Land Act No. 39 of 2024', accessed 8 June 2025, https://www.fao.org/faolex/results/details/es/c/LEX-FAOC232598; Vietnam Briefing, 'Vietnam's New Electricity Law: Boosting Renewable Energy', 27 December 2024, https://www.vietnam-briefing.com/news/vietnams-new-electricity-law-legal-framework-renewable-energy.html; Tilleke & Gibbins, 'Potential Impact of Vietnam's New Land Law on the Energy Sector', 6 June 2024, https://www.tilleke.com/insights/potential-impact-of-vietnams-new-land-law-on-the-energy-sector; Légifrance, 'Article L314-36 – Code de l'énergie', accessed 8 June 2025, https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000047298015/2023-03-16; German Federal Ministry of Justice and Consumer Protection, '§ 12 GAPDZV – Individual Norm', accessed 8 June 2025, https://www.gesetze-im-internet.de/gapdzv/__12.html; Chambers and Partners, 'Renewable Energy 2024. Definitive Global Law Guides Offering Comparative Analysis From Top-Ranked Lawyers', 2024, https://www.morihamada.com/system/files/publications/2024/09/107681.pdf; Government of South Africa, 'ACT To Enable the Development of an Effective Climate Change Response and a Long-Term, Just Transition to a Low-Carbon and Climate-Resilient Economy and Society for South Africa in the Context of Sustainable Development; and to Provide for Matters Connected Therewith', 2024, https://www.gov.za/sites/default/files/gcis_document/202407/50966climatechangeact222024.pdf; Solar Stewardship Initiative, 'Supply Chain Traceability Standard', accessed 8 June 2025, https://www.solarstewardshipinitiative.org/ssi-standards/supply-chain-traceability-standard; Solar Stewardship Initiative, 'Certified Sites', accessed 8 June 2025, https://www.solarstewardshipinitiative.org/certified-sites; Hydropower Sustainability Alliance, 'Driving ESG Solutions', accessed 8 June 2025, https://www.hs-alliance.org/hs-standard.

63 International Energy Agency, 'World Extended Energy Balances', July 2024, https://www.iea.org/data-and-statistics/data-product/world-energy-balances. **Figure 21** from Ibid.

64 International Energy Agency, 'World Extended Energy Balances', July 2024, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

65 International Energy Agency, 'World Extended Energy Balances', July 2024, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

66 International Energy Agency, 'World Extended Energy Balances', July 2024, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

67 International Energy Agency, 'World Extended Energy Balances', July 2024, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

68 International Energy Agency, 'Renewables 2024', 9 October 2024, https://www.iea.org/reports/renewables-2024.

69 International Energy Agency, 'World Extended Energy Balances', July 2024, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

70 For solar thermal heating, barriers also include lack of awareness, competition with solar PV and heat pumps (which tend more to be the focus of government incentives). Sources for lack of awareness and imbalance in/lack of policies (and utility incentives): B. Epp, solrico, personal communication with REN21, 6 June 2025. Solar thermal challenges also from, for example: Mexico's National Solar Energy Association (ANES), cited in IWSolar, 'Mexico Solar Water Heater Market: Top Manufacturers and Trends', 4 June 2025, https://iwsolar.com/mexico-solar-water-heater-market-top-manufacturers-and-trends; P. Dias, Solar Heat Europe, personal communication with REN21, 17 March 2023; F. Stier, 'Producers Point to Forced Electrification and Cheap Natural Gas as Barriers for Solar Thermal in the US', Solar Thermal World, 30 August 2023, https://solarthermalworld.org/news/

producers-point-to-forced-electrification-and-cheap-natural-gas-as-barriers-for-solar-thermal-in-the-us.

71 REN21 GSR 2025 Geothermal Power and Heat Fact Sheet, available in July 2025.

72 REN21 GSR 2025 Geothermal Power and Heat Fact Sheet, available in July 2025.

73 REN21 GSR 2025 Geothermal Power and Heat Fact Sheet, available in July 2025.

74 Based on number of countries covered by Solarthermalworld.org, which has reported on solar thermal sales activities in at least 134 countries worldwide, from B. Epp, personal communication with REN21, 6 May 2024, and on B. Epp, personal communication with REN21, 6 June 2025.

75 Figure of 14.2% based on preliminary data of gross additions (17.8 GW_{th}, 25.4 million m^2) for 24 countries, from AEE – Institute for Sustainable Technologies (AEE INTEC), 'Solar Heat Worldwide, Global Market Development and Trends 2024, Detailed Market Figures 2023, 2025 Edition', International Energy Agency Solar Heating and Cooling Programme, 2025, https://www.iea-shc.org/solar-heat-worldwide, and from M. Spörk-Dür, AEE INTEC, personal communication with REN21, May 2025; China from AEE INTEC, op. cit. this note, 10.

76 **Snapshot China** from the following sources: Yu Wang, Xuchen Energy, personal communication with REN21, 20 May 2025; developer information and CNY 1.2 billion in corporate bonds from China Solar Thermal Alliance, '邯郸建投集团成功发行11.9亿元企业债，助力"光热+"更好更快建设', 24 September 2022, http://www.cnste.org/news/detail/8041.html; Bärbel Epp, 'Construction Imminent on 77 MW Solar Heat Plant for Leisure Resort', Solar Thermal World, accessed 9 May 2025, https://solarthermalworld.org/news/construction-imminent-on-77-mw-solar-heat-plant-for-leisure-resort.

77 AEE – Institute for Sustainable Technologies (AEE INTEC), 'Solar Heat Worldwide, Global Market Development and Trends 2024, Detailed Market Figures 2023, 2025 Edition', International Energy Agency Solar Heating and Cooling Programme, 2025, https://www.iea-shc.org/solar-heat-worldwide, and from M. Spörk-Dür, AEE INTEC, personal communication with REN21, May 2025; B. Epp, 'Global Expansion of Solar Industrial Heat: Key Insights from the Latest Outlook', Solar Thermal World, 1 April 2025, https://solarthermalworld.org/news/global-expansion-of-solar-industrial-heat-key-insights-from-the-latest-outlook; B. Epp, 'Global SHIP Market Reaches Five-Year High Despite National Fluctuations', Solar Thermal World, 17 March 2025, https://solarthermalworld.org/news/global-ship-market-reaches-five-year-high-despite-national-fluctuations.

78 B. Epp, solrico, personal communication with REN21, 6 June 2025. Solar thermal challenges also from, for example: Mexico's National Solar Energy Association (ANES), cited in IWSolar, 'Mexico Solar Water Heater Market: Top Manufacturers and Trends', 4 June 2025, https://iwsolar.com/mexico-solar-water-heater-market-top-manufacturers-and-trends; P. Dias, Solar Heat Europe, personal communication with REN21, 17 March 2023; F. Stier, 'Producers Point to Forced Electrification and Cheap Natural Gas as Barriers for Solar Thermal in the US', Solar Thermal World, 30 August 2023, https://solarthermalworld.org/news/producers-point-to-forced-electrification-and-cheap-natural-gas-as-barriers-for-solar-thermal-in-the-us.

79 US Department of Agriculture, 'Biofuels Annual: Brazil', 31 August 2024, https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Biofuels%20Annual_Brasilia_Brazil_BR2024-0022. **Figure 22** from Ibid.

80 US Department of Agriculture, 'Biofuels Annual: Indonesia', 2024, https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Biofuels%20Annual_Jakarta_Indonesia_ID2024-0018.

81 RISE, 'What You Need to Know about the Swedish Biofuel Reduction Mandate', 22 November 2023, https://www.ri.se/en/news/blog/what-you-need-to-know-about-the-swedish-biofuel-reduction-mandate.

82 Government of Brazil, 'Lula Enacts Fuel of the Future Law: Brazil Will Drive the World's Largest Energy Revolution', October 2024, https://www.gov.br/planalto/en/latest-news/2024/10/lula-enacts-fuel-of-the-future-law-201cbrazil-will-drive-the-worlds-largest-energy-revolution201d.

83 International Renewable Energy Agency, 'Sustainable Aviation Fuel South East Asia', 2024, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Dec/IRENA_Sustainable_aviation_fuel_Southeast_asia_2024.pdf; Argus Media, 'Indonesia to Require SAF for Flights from 2027', 19 September 2024, https://www.argusmedia.com/en/news-and-insights/latest-market-news/2609725-indonesia-to-require-saf-for-flights-from-2027; Kim Michelle, 'Can South Korea's Aviation Industry Pivot to Green Skies?', Institute for Energy Economics and Financial Analysis, 10 December 2024, https://ieefa.org/resources/can-south-koreas-aviation-industry-pivot-green-skies.

84 **Table 1** from REN21, 'REN21 Capacity Database', 2025.

85 **Table 2** from REN21, 'REN21 Capacity Database', 2025; World Bank, 'Population, total [Data set]', World Development Indicators, accessed 12 May 2025, https://data.worldbank.org/indicator/SP.POP.TOTL.

ENDNOTES | ENERGY SYSTEMS AND INFRASTRUCTURE

1 **Figure 23** from Ember, 'Yearly Electricity Data', accessed 6 May 2025, https://ember-energy.org/data/yearly-electricity-data; Uruguay from Sladjana Djunisic, 2025, 'Uruguay's Power Generation 99% Renewable in 2024 – Preliminary Data', Renewables Now, April 30, 2025, https://renewablesnow.com/news/uruguays-power-generation-99-percent-renewable-in-2024-preliminary-data-1274551/.

2 Nina Chestney, 'EU Power Grid Needs Trillion-Dollar Upgrade to Avert Spain-Style Blackouts', *Reuters*, 6 May 2025, https://www.reuters.com/sustainability/climate-energy/eu-power-grid-needs-trillion-dollar-upgrade-avert-spain-style-blackouts-2025-05-05.

3 COP29, 'COP29 Global Energy Storage and Grids Pledge', accessed 24 April 2025, https://cop29.az/en/pages/cop29-global-energy-storage-and-grids-pledge; Lola Hughes, 'Global BESS Deployments Soared 53% in 2024', Energy Storage News, 14 January 2025, https://www.energy-storage.news/global-bess-deployments-soared-53-in-2024; European Commission, 'Digitalisation of the Energy Systems', accessed 6 May 2025, https://energy.ec.europa.eu/topics/eus-energy-system/digitalisation-energy-system_en.

4 BloombergNEF, 'Global Cost of Renewables to Continue Falling in 2025 as China Extends Manufacturing Lead: BloombergNEF', 6 February 2025, https://about.bnef.com/blog/global-cost-of-renewables-to-continue-falling-in-2025-as-china-extends-manufacturing-lead-bloombergnef.

5 COP29, 'COP29 Global Energy Storage and Grids Pledge', accessed 9 May 2025, https://cop29.az/en/pages/cop29-global-energy-storage-and-grids-pledge.

6 COP29, 'COP29 Green Energy Pledge: Green Energy Zones and Corridors', accessed 9 May 2025, https://cop29.az/en/pages/cop29-green-energy-pledge-green-energy-zones-and-corridors.

7 International Energy Agency, 'Executive Summary – Renewables 2024 – Analysis', 2024, https://www.iea.org/reports/renewables-2024/executive-summary.

8 Joseph Rand et al., 'Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2023', Lawrence Berkeley National Laboratory, 2024, https://emp.lbl.gov/sites/default/files/2024-04/Queued%20Up%20 2024%20Edition_R2.pdf.

9 Wenjie Ding and Edward White, 'Gridlock in China: Huge Spending on Network in Shift to Green Energy', *Financial Times*, 9 July 2024, https://www.ft.com/content/2c0fa0d1-2902-440e-8677-d9f087c2e943.

10 Vincent Shaw, 'Digging into China's Solar Capacity Numbers', pv magazine International, 28 March 2025, https://www.pv-magazine.com/2025/03/28/digging-into-chinas-solar-capacity-numbers; Wenjie Ding and Edward White, 'Gridlock in China: Huge Spending on Network in Shift to Green Energy', *Financial Times*, 9 July 2024, https://www.ft.com/content/2c0fa0d1-2902-440e-8677-d9f087c2e943.

11 European Union Agency for the Cooperation of Energy Regulators (ACER), 'Transmission Capacities for Cross-Zonal Trade of Electricity and Congestion Management in the EU: 2024 Market Monitoring Report', 3 July 2024, https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER_2024_MMR_Crosszonal_electricity_trade_capacities.pdf; "Regulation – 2015/1222 – EN – EUR-Lex," n.d. https://eur-lex.europa.eu/eli/reg/2015/1222/oj/eng.

12 European Union Agency for the Cooperation of Energy Regulators (ACER), 'Unlocking Flexibility: No-Regret Actions to Remove Barriers to Demand Response: 2025 Monitoring Report', 9 April 2025, https://www.acer.europa.eu/sites/default/files/documents/Publications/2025-ACER-Unlocking-flexibility-demand-response-barriers.pdf.

13 REN21, 'REN21 Policy Database', 2025.

14 REN21, 'REN21 Policy Database', 2025; UK Electricity System Operator, 'Innovation Strategy', 2024, https://www.neso.energy/document/315646/download. **Snapshot United Kingdom** from the following sources: UK Electricity System Operator, 'Balancing Services', accessed 10 May 2025, https://www.neso.energy/industry-information/balancing-services; UK Electricity System Operator, 'Constraints Collaboration Project', accessed 10 May 2025, https://www.neso.energy/industry-information/balancing-services/constraints-collaboration-project; UK Electricity System Operator, 'World-First for Constraints Market', accessed 10 May 2025, https://www.neso.energy/news/world-first-constraints-market; Johnny Gowdy, 'Toxic Constraint Coverage Could Damage Clean Power Plan', Regen, 12 December 2024, https://www.regen.co.uk/insights/toxic-constraint-coverage-could-damage-clean-power-plan; UK Electricity System Operator, 'Procurement Guidelines, Published in Accordance with Standard Condition C9 of National Energy System Operator, Electricity System Operator Licence', April 2025, https://www.neso.energy/document/352156/download; Daniel Lewis and Josh Oxby, 'Energy Security and AI', UK Parliament Post, Postnote 735, December 2024, https://researchbriefings.files.parliament.uk/documents/POST-PN-0735/POST-PN-0735.pdf.

15 Minnesota Legislature, 'SF 3683 as Introduced – 93rd Legislature (2023-2024)', 10 June 2024, https://www.revisor.mn.gov/bills/text.php?number=SF3683&version=0&session=ls93&session_year=2024&session_number=0; US Federal Energy Regulatory Commission, 'E-1 | RM24-6-000', 27 June 2024, https://www.ferc.gov/media/e-1-rm24-6-000.

16 Maeve Allsup, 'Behind the Scenes of the Country's Largest Dynamic Line Rating Deployment', Latitude Media, 5 August 2024, https://www.latitudemedia.com/news/behind-the-scenes-of-the-countrys-largest-dynamic-line-rating-deployment; Yusuf Latief, 'Red Eléctrica Instals over 750 Dynamic Line Rating Devices on Overheads', Smart Energy International, 12 July 2024, https://www.smart-energy.com/industry-sectors/energy-grid-management/red-electrica-instals-over-750-dynamic-line-rating-devices-on-overheads; TenneT, 'TenneT Invests 30 Percent More in Electricity Grid Expansions', 2 January 2025, https://www.tennet.eu/de-en/news/tennet-invests-30-percent-more-electricity-grid-expansions; Roberto Castro, 'Smart Wires, ISA CTEEP Announce Brazil's First SmartValve Project', Smart Wires Inc., 26 September 2024, https://www.smartwires.com/2024/09/26/smart-wires-and-isa-cteep-announce-first-advanced-power-flow-control-project-in-brazil; Roberto Castro, 'Smart Wires Announces Delivery of Second Project with ISA', Smart Wires Inc., 5 September 2024, https://www.smartwires.com/2024/09/05/smart-wires-announces-delivery-of-second-project-with-isa-transelca-to-accelerate-connection-of-renewable-energy.

17 US Department of Energy, 'Grid Modernization Strategy 2024', 2024, https://www.energy.gov/sites/default/files/2024-12/Grid%20Modernization%20Strategy%202024.pdf; Australian Energy Market Operator, '2024 Inertia Report', December 2024, https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system_security_planning/2024-inertia-report; RWE, 'RWE Builds Ultra-Fast, Innovative Battery Storage System in the Netherlands to Help Safeguard the Grid', 9 September 2024, https://www.rwe.com/en/press/rwe-generation/2024-09-09-rwe-builds-ultra-fast-innovative-battery-storage-system-in-the-netherlands; UK Electricity System Operator, 'Innovation Strategy', 2024, https://www.neso.energy/document/315646/download; US National Energy Regulatory Commission, 'An Introduction to Inverter-Based Resources on the Bulk Power System', 2023, https://www.nerc.com/pa/Documents/2023_NERC_Guide_Inverter-Based-Resources.pdf.

18 Australian Energy Market Operator, '2024 Inertia Report', December 2024, https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system_security_planning/2024-inertia-report; Coordinador Eléctrico Nacional, 'Hoja de Ruta Para Una Transición Energética Acelerada: Visión Del Coordinador Eléctrico Nacional', 2024, https://www.coordinador.cl/wp-content/uploads/2024/12/HOJA-DE-RUTA-12-2024-V1.pdf; Grid Controller of India Limited, 'Report on Events Involving Transmission Grid Connected Wind and Solar Plants', November 2023, https://posoco.in/wp-content/uploads/2024/01/Report-on-Events-Involving-Transmission-Grid-Connected-Wind-Solar-Plants.pdf; Global Power System Transformation Consortium (G-PST), 'South Africa', accessed 6 May 2025, https://globalpst.org/where-we-work/south-africa.

19 Nile Basin Initiative, 'Power Grids of Burundi, Rwanda, and Tanzania Interconnected and Synchronized Through Rusumo Project, in March 2024', 16 August 2024, https://nilebasin.org/content/power-grids-burundi-rwanda-and-tanzania-interconnected-and-synchronized-through-rusumo; African Development Bank, 'South Sudan – Uganda Power Interconnection Project (P-Z1-FA0-192 and P-Z1-FA0-194)', accessed 7 May 2025, https://www.afdb.org/en/documents/south-sudan-uganda-power-interconnection-project-p-z1-fa0-192-and-p-z1-fa0-194; Energy Capital & Power, 'East African Power Market to Start Trading by December 2024', 1 August 2024, https://energycapitalpower.com/east-african-power-market-start-trading-december-2024.

20 Nadja Skopljak, 'First DC Connection Between Europe and North Africa Gets €45 Million from EIB', Offshore Energy, 4 January 2024, https://www.offshore-energy.biz/first-dc-connection-between-europe-and-north-africa-gets-e45-million-from-eib; Patrick Jowett, 'Azerbaijan, Kazakhstan, Uzbekistan Plan Energy Interconnection', pv magazine International, 6 May 2024, https://www.pv-magazine.com/2024/05/06/azerbaijan-kazakhstan-uzbekistan-plan-energy-interconnection.

21 CorralRosales, 'Ecuadorian Government Launches Tender for Electrical Interconnection with Peru', 5 September 2024, https://corralrosales.com/en/ecuadorian-government-launches-tender-for-electrical-interconnection-with-peru. Patrick Jowett, 'Azerbaijan, Kazakhstan, Uzbekistan Plan Energy Interconnection', pv magazine International, 6 May 2024, https://www.pv-magazine.com/2024/05/06/azerbaijan-kazakhstan-uzbekistan-plan-energy-interconnection.

22 Volta Foundation, '2024 Battery Report', 2024, https://volta.foundation/battery-report-2024.

23 **Figure 24** from Volta Foundation, '2024 Battery Report', 2024, https://volta.foundation/battery-report-2024; Lola Hughes, 'Global BESS Deployments Soared 53% in 2024', Energy Storage News, 14 January 2025, https://www.energy-storage.news/global-bess-deployments-soared-53-in-2024; International Hydropower Association, personal communications with REN21, June 2024 and May 2025

24 Lola Hughes, 'Global BESS Deployments Soared 53% in 2024', Energy Storage News, 14 January 2025, https://www.energy-storage.news/global-bess-deployments-soared-53-in-2024.

25 US Energy Information Administration, 'U.S. Battery Capacity Increased 66% in 2024', 12 March 2025, https://www.eia.gov/todayinenergy/detail.php?id=64705; Lola Hughes, 'Global BESS Deployments Soared 53% in 2024', Energy Storage News, 14 January 2025, https://www.energy-storage.news/global-bess-deployments-soared-53-in-2024.

26 Lola Hughes, 'Global BESS Deployments Soared 53% in 2024', Energy Storage News, 14 January 2025, https://www.energy-storage.news/global-bess-deployments-soared-53-in-2024.

27 Lola Hughes, 'Global BESS Deployments Soared 53% in 2024', Energy Storage News, 14 January 2025, https://www.energy-storage.news/global-bess-deployments-soared-53-in-2024.

28 Lola Hughes, 'Global BESS Deployments Soared 53% in 2024', Energy Storage News, 14 January 2025, https://www.energy-storage.news/global-bess-deployments-soared-53-in-2024.

29 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

30 BloombergNEF, 'Global Cost of Renewables to Continue Falling in 2025 as China Extends Manufacturing Lead: BloombergNEF', 6 February 2025, https://about.bnef.com/blog/global-cost-of-renewables-to-continue-falling-in-2025-as-china-extends-manufacturing-lead-bloombergnef.

31 International Hydropower Association, personal communication with REN21, May 2025.

32 International Hydropower Association, personal communication with REN21, May 2025.

33 Global Market Insights Inc., 'Thermal Energy Storage Systems Market Size, 2025-2034 Forecast', February 2025, https://www.gminsights.com/industry-analysis/thermal-energy-storage-market.

34 **Figure 25** from REN21, 'REN21 Policy Database', 2025.

35 REN21, 'REN21 Policy Database', 2025.

36 REN21, 'REN21 Policy Database', 2025.

37 Ofgem, 'Long Duration Electricity Storage: Cap and Floor Application Window 1', 8 April 2025, https://www.ofgem.gov.uk/decision/long-duration-electricity-storage-cap-and-floor-application-window-1; AEMO Services, 'AEMO Services' NSW Long Duration Storage Tender Awards More than 1GW and 13GWh', 27 February 2025, https://aemoservices.com.au/news/media-release/250227-asl-nsw-long-duration-storage-tender-awards-more-than-1gw-and-13gwh.

38 International Energy Agency, 'Global Hydrogen Review 2024 – Analysis', 2024, https://www.iea.org/reports/global-hydrogen-review-2024.

39 BloombergNEF, 'Energy Transition Investment Trends 2025', 30 January 2025, https://about.bnef.com/energy-transition-investment.

40 David R. Baker, 'Why Almost Nobody Is Buying Green Hydrogen', Bloomberg, 12 August 2024, https://www.bloomberg.com/news/articles/2024-08-12/why-almost-nobody-is-buying-hydrogen-dashing-green-power-hopes; Bloomberg, 'Green Hydrogen Will Be Far Costlier Than Estimated, Harvard Scientists Find', SupplyChainBrain, 9 October 2024, https://www.supplychainbrain.com/articles/40463-green-hydrogen-will-be-far-costlier-than-estimated-harvard-scientists-find.

41 **Figure 26** from REN21, 'REN21 Policy Database', 2025.

42 REN21, 'REN21 Policy Database', 2025.

43 Hellenic Republic Ministry of Environment and Energy, 'National Energy and Climate Plan', 2024, https://commission.europa.eu/publications/greece-final-updated-necp-2021-2030-submitted-2025_en; Sergio Goncalves, 'Portugal Plans to Raise Share of Renewables in Electricity Consumption to 93% by 2030', *Reuters*, 22 July 2024, https://www.reuters.com/business/energy/portugal-plans-raise-share-renewables-electricity-consumption-93-by-2030-2024-07-22.

44 REN21, 'REN21 Policy Database', 2025.

ENDNOTES | RENEWABLES IN ENERGY DEMAND SECTORS

1 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
2 International Energy Agency (IEA), 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025; IEA, 'Growth in Global Energy Demand Surged in 2024 to Almost Twice Its Recent Average', 24 March 2025, https://www.iea.org/news/growth-in-global-energy-demand-surged-in-2024-to-almost-twice-its-recent-average.
3 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances. **Figure 27** from Ibid.
4 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
5 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
6 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
7 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
8 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
9 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
10 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
11 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
12 United Nations Environment Programme, 'Global Status Report for Buildings and Construction 2024/2025', 2025, https://wedocs.unep.org/20.500.11822/47214.
13 Ember, 'Global Electricity Review 2025', 8 April 2025, https://ember-energy.org/latest-insights/global-electricity-review-2025; International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
14 United Nations Environment Programme, 'Global Status Report for Buildings and Construction 2024/2025', 2025, https://wedocs.unep.org/20.500.11822/47214.
15 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025.
16 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025. **Box 1** from the following sources: electricity consumption of data centres and data transmission networks from International Energy Agency, 'Data Centres & Networks', accessed 28 April 2025, https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks; data for global electricity demand increases and data centres' electricity demand from Ember, 'Global Electricity Review 2025', 8 April 2025, https://ember-energy.org/latest-insights/global-electricity-review-2025; efficiency analysis of AI models from Alex Wilkins, 'Does DeepSeek Show a Way to Slash the Energy Demands of AI?', New Scientist, 29 January 2025, https://www.newscientist.com/article/2466138-does-deepseek-show-a-way-to-slash-the-energy-demands-of-ai; major data centre hubs and an estimated 160-165% increase from Goldman Sachs Research, 'AI to Drive 165% Increase in Data Center Power Demand by 2030', 4 February 2025, https://www.goldmansachs.com/insights/articles/ai-to-drive-165-increase-in-data-center-power-demand-by-2030; total electricity demand of Ireland from Central Statistics Office, Republic of Ireland, 'Data Centres Metered Electricity Consumption 2023', 23 July 2024, https://www.cso.ie/en/releasesandpublications/ep/p-dcmec/datacentresmeteredelectricityconsumption2023; jurisdictions with restrictions from Kenza Bryan, 'Data Centres Curbed as Pressure Grows on Electricity Grids', *Financial Times*, 12 February 2024, https://www.ft.com/content/53accefd-eca7-47f2-a51e-c32f3ab51ad5; up to 30% increase in electricity consumption in Europe from Goldman Sachs Research, 'Data Centers Could Boost European Power Demand by 30%', 7 February 2025, https://www.goldmansachs.com/insights/articles/data-centers-could-boost-european-power-demand-by-30-percent.
17 International Energy Agency, 'Energy Efficiency 2024', 7 November 2024, https://www.iea.org/reports/energy-efficiency-2024/executive-summary.
18 International Energy Agency, 'Energy Efficiency 2024', 7 November 2024, https://www.iea.org/reports/energy-efficiency-2024/executive-summary.
19 International Energy Agency, 'Energy Efficiency 2024', 7 November 2024, https://www.iea.org/reports/energy-efficiency-2024/executive-summary.
20 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
21 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
22 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
23 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
24 International Renewable Energy Agency and United Nations Food and Agriculture Organization, 'Renewable Energy for Agri-Food Systems: Towards the Sustainable Development Goals and the Paris Agreement', 2021, https://www.fao.org/documents/card/en/c/cb7433en; International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
25 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
26 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
27 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
28 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
29 International Renewable Energy Agency, 'How to Decarbonise End Use Sectors with Renewable Power', 2023, https://www.irena.org/Digital-content/Digital-Story/2023/Jun/How-to-decarbonise-end-use-sectors-with-renewable-power/detail.
30 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances. **Figure 28** from International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances
31 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
32 International Energy Agency, 'World Energy Outlook 2024', 16 October 2024, https://www.iea.org/reports/world-energy-outlook-2024.
33 International Energy Agency, 'World Energy Outlook 2024', 16 October 2024, https://www.iea.org/reports/world-energy-outlook-2024.
34 US National Renewable Energy Laboratory, 'Overview of Building Electrification Technologies and Market Opportunities', November 2024, https://docs.nrel.gov/docs/fy25osti/88309.pdf; International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
35 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025.
36 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025.
37 International Energy Agency, 'Global Energy Review 2025', 24 March 2025, https://www.iea.org/reports/global-energy-review-2025.
38 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.
39 US National Renewable Energy Laboratory, 'Agricultural Decarbonization | Energy Analysis', accessed 31 May 2025, https://www.nrel.gov/analysis/agricultural-decarbonization; Arash Farokhi Soofi, Saeed D. Manshadi and Araceli Saucedo, 'Farm Electrification: A Road-Map to Decarbonize the Agriculture Sector', *The Electricity Journal* 35, no. 2 (2022): 107076, https://doi.org/10.1016/j.tej.2022.107076.
40 International Renewable Energy Agency, 'Off-Grid Renewable Energy Statistics 2024', 2024, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Dec/Off-grid_Renewable_Energy_Statistics_2024.pdf.
41 International Renewable Energy Agency, 'Off-Grid Renewable Energy Statistics 2024', 2024, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Dec/Off-grid_Renewable_Energy_Statistics_2024.pdf.

42 Jingxiu Qin et al., 'Global Energy Use and Carbon Emissions from Irrigated Agriculture', *Nature Communications* 15 (10 April 2024): 3084, https://doi.org/10.1038/s41467-024-47383-5; CLASP, 'Spotlight on Solar Water Pumps', 2024, https://www.clasp.ngo/report/net-zero-heroes/spotlights/spotlight-on-solar-water-pumps.

43 Data Insights Market, 'Exploring Barriers in Agricultural Electric Tractor Market: Trends and Analysis 2025-2033', 19 March 2025, https://www.datainsightsmarket.com/reports/agricultural-electric-tractor-55449.

44 International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

45 International Energy Agency, 'Executive Summary – Global EV Outlook 2025', 2025, https://www.iea.org/reports/global-ev-outlook-2025/executive-summary.

46 BloombergNEF, 'Electric Vehicle Outlook 2024', 2024, https://assets.bbhub.io/professional/sites/24/847354_BNEF_EVO2024_ExecutiveSummary.pdf.

47 International Energy Agency, 'Executive Summary – Global EV Outlook 2025', 2025, https://www.iea.org/reports/global-ev-outlook-2025/executive-summary.

48 International Energy Agency, 'Rail', accessed 2 June 2025, https://www.iea.org/energy-system/transport/rail.

49 Subhash Narayan, 'Railway Chugs Slowly on Electrification Drive, to Cover Final 811 Km Electrification by Year End', mint, 28 April 2025, https://www.livemint.com/news/india/indian-railways-electrification-plan-broad-gauge-network-north-east-south-last-mile-connections-11745581921014.html; Government of China, 'National Data', accessed 2 June 2025, https://data.stats.gov.cn/easyquery.htm?cn=C01.

50 International Energy Agency, `World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

51 International Energy Agency, 'Electricity 2025', 14 February 2025, https://www.iea.org/reports/electricity-2025.

52 International Energy Agency, 'Executive Summary – Electricity 2025', 2025, https://www.iea.org/reports/electricity-2025/executive-summary; Ember, 'Global Electricity Review 2025', 8 April 2025, https://ember-energy.org/latest-insights/global-electricity-review-2025.

53 Ember, 'Global Electricity Review 2025', 8 April 2025, https://ember-energy.org/latest-insights/global-electricity-review-2025.

54 **Figure 29** from International Energy Agency, 'World Energy Balances', 2025, https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

55 Solar Power Europe, 'Global Market Outlook for Solar Power 2025-2029', May 2025, https://api.solarpowereurope.org/uploads/Global_Market_Outlook_2025_v1_aaebd9698b.pdf; Malcolm Moore, 'Big Businesses Step Up to Buy Energy from New Wind and Solar Farms', *Financial Times*, 3 March 2025, https://www.ft.com/content/f2901ca4-438c-45f2-a53f-32e86ab387bb.

56 S&P Global Commodity Insights, 'Data Centers Drive Surge in Clean Energy Procurement in 2024', 28 February 2025, https://www.spglobal.com/commodity-insights/en/news-research/blog/energy-transition/022825-data-centers-drive-surge-in-clean-energy-procurement-in-2024.

57 Malcolm Moore, 'Big Businesses Step up to Buy Energy from New Wind and Solar Farms', *Financial Times*, 3 March 2025, https://www.ft.com/content/f2901ca4-438c-45f2-a53f-32e86ab387bb. **Sidebar 6** from the following sources: Malcolm Moore, 'Big Businesses Step Up to Buy Energy from New Wind and Solar Farms', *Financial Times*, 3 March 2025, https://www.ft.com/content/f2901ca4-438c-45f2-a53f-32e86ab387bb; S&P Global Commodity Insights, 'Data Centers Drive Surge in Clean Energy Procurement in 2024', 28 February 2025, https://www.spglobal.com/commodity-insights/en/news-research/blog/energy-transition/022825-data-centers-drive-surge-in-clean-energy-procurement-in-2024; Forrest Crellin, 'Engie Still Sees Strong US Appetite for Renewables', Reuters, 3 February 2025, https://www.reuters.com/business/energy/engie-still-sees-strong-us-appetite-renewables-2025-02-03; Tony Lenoir, 'Nuclear Bolsters Top US Hyperscalers' Clean Energy Portfolio, Now over 84 GW', S&P Global, 5 May 2025, https://www.spglobal.com/market-intelligence/en/news-insights/research/nuclear-bolsters-top-us-hyperscalers-clean-energy-portfolio-now-over-84-gw; La Redazione, 'European PPA Market: 19 GW Contracted Capacity in One Year', Rinnovabili, 24 April 2025, https://www.rinnovabili.net/business/markets/european-ppa-market-2024-growth-spain-germany-lead; Anu Bhambhani, 'Europe Signed 19 GW of Renewable Energy Deals in 2024, Wood Mackenzie', Taiyang News, 16 April 2025, https://taiyangnews.info/markets/europe-signed-19-gw-re-ppa-2024; North American Clean Energy, 'Negative Prices Drive Crucial Innovations in Europe's PPA Market – Pexapark Renewables Market Outlook 2025', 30 January 2025, https://www.nacleanenergy.com/alternative-energies/negative-prices-drive-crucial-innovations-in-europe-s-ppa-market-pexapark-renewables-market-outlook-2025; Amy Chiang, 'Emerging Corporate Renewable Energy Opportunities in Asia-Pacific', 3Degrees, 14 November 2024, https://3degreesinc.com/insights/emerging-corporate-renewable-energy-opportunities-in-apac; Japan Energy Hub, 'Corporate PPAs', accessed 25 May 2025, https://japanenergyhub.com/corporate-ppas; Renewable Energy Institute, '[Information-Package] Corporate PPA: Latest Trends in Japan (2024 Edition), accessed 25 May 2025, https://www.renewable-ei.org/en/activities/reports/20240423.php; Veselina Ilieva Petrova, 'PFO Signs Concession Deal for 52-MWp PV Project in Cote d'Ivoire', Renewables Now, 26 January 2024, https://renewablesnow.com/news/pfo-signs-concession-deal-for-52-mwp-pv-project-in-cote-divoire-846668; Renew Africa, 'AMEA Power Signs PPA with Eskom for 120MW Solar Plant', 3 May 2024, https://renewafrica.biz/news/solar/amea-power-signs-ppa-with-eskom-for-120mw-solar-plant; *Reuters*, 'Glencore Agrees to Solar Plant Deal with Pele Green Energy', 28 November 2024, https://www.reuters.com/business/energy/glencore-agrees-solar-plant-deal-with-pele-green-energy-2024-11-28; MIGA, 'Corporación Nacional Del Cobre de Chile – CODELCO Renewable Energy PPAs | World Bank Group Guarantees', accessed 25 May 2025, https://www.miga.org/project/corporacion-nacional-del-cobre-de-chile-codelco-renewable-energy-ppas-1; Energía Estratégica, 'Grenergy Firma Un PPA En Chile Para Su Planta Solar Gran Teno de 241 MW', 30 June 2023, https://www.energiaestrategica.com/grenergy-firma-un-ppa-en-chile-para-su-planta-solar-gran-teno-de-241-mw; Gob.cl. "President Inaugurates Gran Teno Photovoltaic Plant That Will Supply 136,000 Homes," March 13, 2024. Accessed June 16, 2025. https://www.gob.cl/en/news/president-inaugurates-gran-teno-photovoltaic-plant-that-will-supply-136000-homes; Leticia Fucuchima, 'Brazil's Eletrobras Partners with GEP on Green Hydrogen', *Reuters*, 14 May 2024, https://www.reuters.com/business/energy/brazils-eletrobras-partners-with-gep-green-hydrogen-2024-05-14; Aboli More, 'Power Purchase Agreement Market Size | USD 444.3 Bn by 2033', Market.us, 13 December 2024, https://www.news.market.us/power-purchase-agreement-market-news-2024; Research and Markets, 'Renewable Energy Certificates Industry Research 2024-2033 – Introduction of Innovative Certification Programs to Boost Consumer Confidence in Domestic Renewables', Yahoo News, 5 December 2024, https://finance.yahoo.com/news/renewable-energy-certificates-industry-research-122300454.html; AltEnergyMag, 'Renewable Energy Certificates Market: Driving Global Sustainability and Market Growth', 16 January 2025, https://www.altenergymag.com/news/2025/01/16/renewable-energy-certificates-market-driving-global-sustainability-and-market-growth/44238; Government of China, 'China's Green Electricity Trading Pilot Officially Launched', China Government Network', 7 September 2021, https://www.gov.cn/xinwen/2021-09/07/content_5636072.htm; Government of China, '"Basic Rules for Medium- and Long-Term Electricity Transactions – Special Chapter on Green Electricity Transactions" Released – Promoting the Active Participation of Business Entities in Green Electricity Transactions – Policy Interpretation', China Government Network', August 2024, https://www.gov.cn/zhengce/202408/content_6970517.htm. **Figure 30** from the following sources: Moore, op. cit. this note; S&P Global Commodity Insights, op. cit. this note; BloombergNEF, 'Corporate Clean Power Buying Grew 12% to New Record in 2023, According to BloombergNEF,' 13 February 2024, https://about.bnef.com/blog/corporate-clean-power-buying-grew-12-to-new-record-in-2023-according-to-bloombergnef.

58 Solar Power Europe, 'Global Market Outlook for Solar Power 2025-2029', May 2025, https://api.solarpowereurope.org/uploads/Global_Market_Outlook_2025_v1_aaebd9698b.pdf.

59 Renewables First & Herald Analytics, 'The Great Solar Rush in Pakistan', 2024, https://uploads.renewablesfirst.org/The_Great_Solar_Rush_in_Pakistan_38157451a3.pdf.

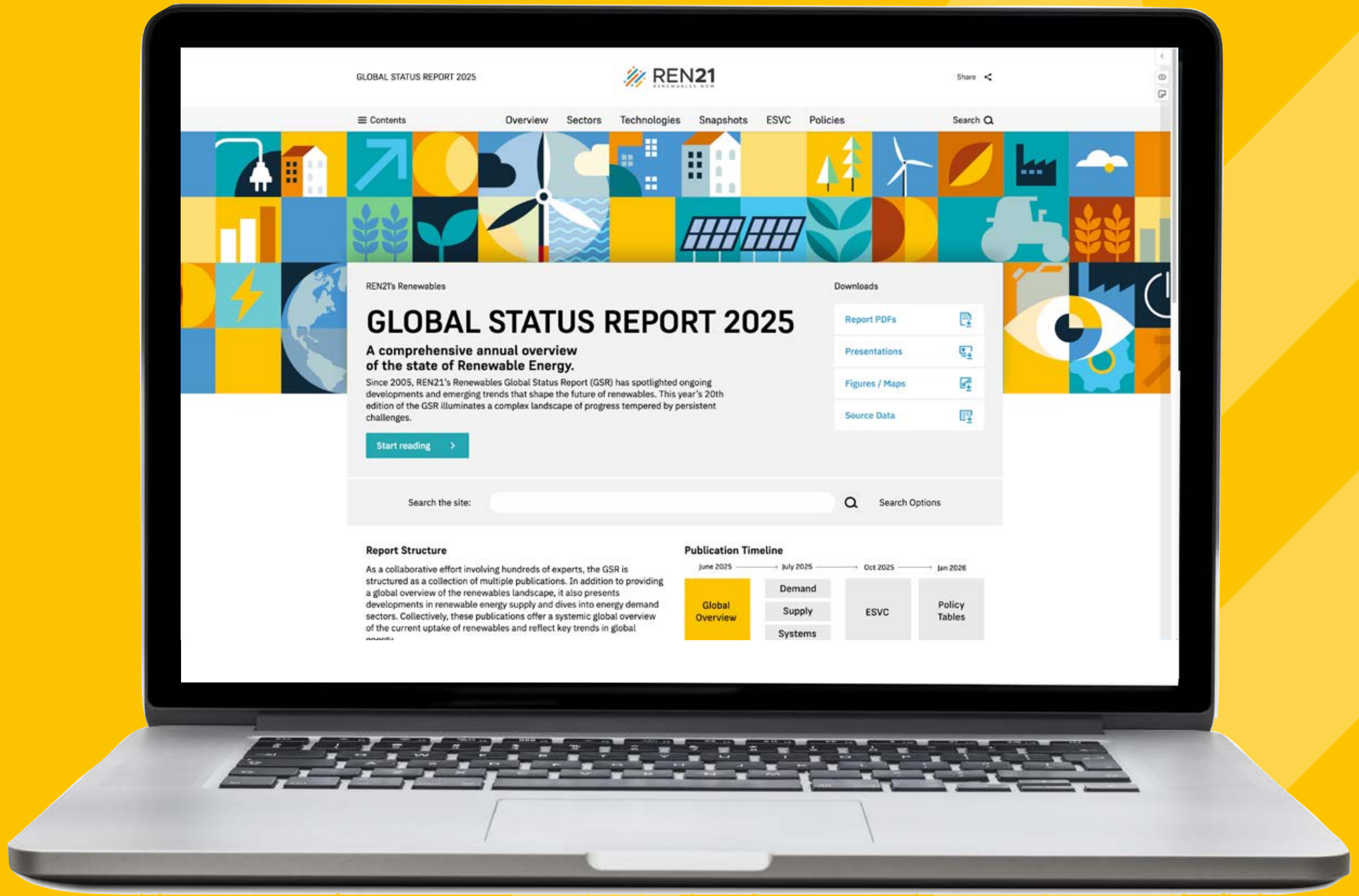
60 Renewables First & Herald Analytics, 'The Great Solar Rush in Pakistan', 2024, https://uploads.renewablesfirst.org/The_Great_Solar_Rush_in_Pakistan_38157451a3.pdf; Solar Power Europe, 'Global Market Outlook for Solar Power 2025-2029', May 2025, https://api.solarpowereurope.org/uploads/Global_Market_Outlook_2025_v1_aaebd9698b.pdf.

61 L'Orient Today, 'Experts Weigh in: Why Is Lebanon's Solar "Boom" No Longer Booming?', 13 May 2024, https://today.lorientlejour.com/article/1413635/experts-weigh-in-why-is-lebanons-solar-boom-no-longer-booming.html.

62 South African Local Government Association, 'Status of Embedded Generation in South African Municipalities', 2023, https://www.sseg.org.za/wp-content/uploads/2024/02/Status-of-EG-in-South-African-Municipalities-2023-FINAL-2.pdf.

63 Solar Power Europe, 'Global Market Outlook for Solar Power 2025-2029', May 2025, https://api.solarpowereurope.org/uploads/Global_Market_Outlook_2025_v1_aaebd9698b.pdf.

64 **Figure 31** from REN21, 'REN21 Policy Database', 2025.
65 REN21, 'REN21 Policy Database', 2025. The data in this section draw from the REN21 Policy Database. Developed and regularly updated by REN21, the database tracks renewable energy targets and policies across sectors and policy types, primarily at the national level, to support the analysis of ambition and implementation. The REN21 Policy Database is currently being expanded to enhance coverage across governance levels (including sub-national levels) and end-use sectors.
66 REN21, 'REN21 Policy Database', 2025.
67 REN21, 'REN21 Policy Database', 2025.
68 European Commission, Representation in Italy, 'La Commissione approva un regime italiano di aiuti di Stato da 1,7 miliardi di € nell'ambito del dispositivo per la ripresa e la resilienza a sostegno di impianti agrivol', 10 November 2023, https://italy.representation.ec.europa.eu/notizie-ed-eventi/notizie/la-commissione-approva-un-regime-italiano-da-17-miliardi-di-eu-sostegno-di-impianti-agrivoltaici-2023-11-10_it; Telquel, 'Agriculture: le Maroc mise sur l'énergie solaire pour révolutionner le secteur', accessed 1 June 2025, https://telquel.ma/2024/05/21/agriculture-le-maroc-mise-sur-lenergie-solaire-pour-revolutionner-le-secteur_1873394; Portail Sud Maroc, 'Pompage Solaire pour l'Irrigation au Maroc: Une Subvention de l'État pour Promouvoir l'Économie d'Eau et l'Énergie Verte', 21 November 2024, https://portailsudmaroc.com/actualite/26876/pompage-solaire-pour-lirrigation-au-maroc-une-subvention-de-ltat-pour-; UK Government, 'Funding for Farmers, Growers and Land Managers', 12 May 2025, https://www.gov.uk/guidance/funding-for-farmers.
69 AFIR, 'Detalii Și Anexe Schemă ENERGIE – Portalul AFIR – Informații PS 2027 Și Depunere Proiecte Online', accessed 1 June 2025, https://www.afir.ro/domenii-de-interventie/detalii-si-anexe-schema-energie; Agricultura E. Pescas, 'Portaria 274/2024/1, de 21 de Outubro', Diários da República, 21 October 2024, https://dre.tretas.org/dre/5936139/portaria-274-2024-1-de-21-de-outubro.
70 REN21, 'REN21 Policy Database', 2025.
71 Österreichs digitales Amt, 'Erneuerbare-Wärme-Gesetz', 2024, https://www.oesterreich.gv.at/Gesetzliche-Neuerungen/archiv-bgbl-2024/Erneuerbare-Waerme-Gesetz-EWG.html.
72 Republika Slovenija, 'Energetski Zakon (EZ-2) (PISRS)', 2024, https://pisrs.si/pregledPredpisa?id=ZAKO8855; Scottisch Government, 'New Build Heat Standard', 1 January 2025, https://www.gov.scot/publications/new-build-heat-standard-factsheet; Government of the Czech Republic, 'The Government Approved the National Reform Programme 2024', 2024, https://vlada.gov.cz/en/evropske-zalezitosti/aktualne/the-government-approved-the-national-reform-programme-2024-213144.
73 United Nations Environment Programme, 'Global Status Report for Buildings and Construction 2024/2025', 2025, https://wedocs.unep.org/20.500.11822/47214.
74 International Energy Agency, 'Energy Efficiency 2024', 7 November 2024, https://www.iea.org/reports/energy-efficiency-2024/executive-summary.
75 International Energy Agency, 'World Energy Investment 2024', 6 June 2024, https://www.iea.org/reports/world-energy-investment-2024.
76 International Energy Agency, 'World Energy Investment 2024', 6 June 2024, https://www.iea.org/reports/world-energy-investment-2024.
77 International Energy Agency, 'Energy Efficiency 2024', 7 November 2024, https://www.iea.org/reports/energy-efficiency-2024/executive-summary.
78 International Energy Agency, 'Energy Efficiency 2024', 7 November 2024, https://www.iea.org/reports/energy-efficiency-2024/executive-summary.
79 **Sidebar 7** from the following sources: International Energy Agency (IEA), 'Space Cooling', 12 July 2023, https://www.iea.org/energy-system/buildings/space-cooling; IEA, 'Keeping Cool in a Hotter World Is Using More Energy, Making Efficiency More Important Than Ever', 23 July 2023, https://www.iea.org/commentaries/keeping-cool-in-a-hotter-world-is-using-more-energy-making-efficiency-more-important-than-ever; IEA, 'Sustainable, Affordable Cooling Can Save Tens of Thousands of Lives Each Year', March 2023, https://www.iea.org/reports/sustainable-affordable-cooling-can-save-tens-of-thousands-of-lives-each-year; Sustainable Energy for All, 'Chilling Prospects: Tracking Sustainable Cooling for All', 2021, https://www.seforall.org/system/files/2021-05/Chilling-Prospects-21-SEforALL.pdf; United Nations Development Programme, 'Summary of National Cooling Action Plans (NCAPs)', 2023, https://www.undp.org/sites/g/files/zskgke326/files/2023-11/undp-summary-of-national-cooling-action-plans_0.pdf; Etienne Gonin, 'Integrated Policy Approach National Cooling Action Plans, Lessons Learned Way Forward', Workshop on Energy Efficiency, United Nations Environment Programme (UNEP), 22 October 2023, https://ozone.unep.org/system/files/documents/4.1_Integrated%20policy%20approach%20National%20Cooling%20Action%20Plans%2C%20lessons%20learned%20way%20forward%20.pdf; UNEP and Cool Coalition, 'Global Cooling Pledge for COP28', 6 December 2023, https://wedocs.unep.org/bitstream/handle/20.500.11822/44310/Global-Cooling-Pledge-final_231206_145613.pdf; Green Climate Fund, 'FP177: Cooling Facility', 7 October 2021, https://www.greenclimate.fund/project/fp177.
80 REN21, 'REN21 Policy Database', 2025.
81 David Stanway, 'China Sets Low Bar for Firms in New Carbon Market Expansion Plan', *Reuters*, 11 September 2024, https://www.reuters.com/sustainability/climate-energy/china-sets-low-bar-firms-new-carbon-market-expansion-plan-2024-09-10; BMWE, 'First Round of Carbon Contracts for Difference Launched', 2024, https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2024/03/20240312-first-round-of-carbon-contracts-for-difference-launched.html.
82 European Commission, 'Carbon Border Adjustment Mechanism', accessed 1 June 2025, https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en.
83 International Energy Agency, 'Industry – Energy System', accessed 1 June 2025, https://www.iea.org/energy-system/industry.
84 IEA, 'Amendment to the Energy Conservation Act – Policies', 8 May 2023, https://www.iea.org/policies/17441-amendment-to-the-energy-conservation-act.
85 REN21, 'REN21 Policy Database', 2025.
86 International Energy Agency, 'Bioenergy: Countries' Report – Update 2024', December 2024, https://www.ieabioenergy.com/wp-content/uploads/2025/01/CountriesReport2024_final.pdf.
87 International Energy Agency, 'Policy Database – Data & Statistics', 2025, https://www.iea.org/policies.
88 REN21, 'REN21 Policy Database', 2025.
89 International Energy Agency, 'World Energy Outlook 2024', 16 October 2024, https://www.iea.org/reports/world-energy-outlook-2024.
90 Joe Boyland and Elena Talalasova, 'Annual Progress Report on Green Shipping Corridors 2024', 19 November 2024, https://globalmaritimeforum.org/report/annual-progress-report-on-green-shipping-corridors-2024.



RENEWABLES GLOBAL STATUS REPORT
2025 COLLECTION

For more information, please visit our website. There you will find all the details and get a comprehensive overview of all the different modules and factsheets.

www.ren21.gsr2025.net

ISBN 978-3-948393-19-9

REN21 Secretariat
158 ter rue du Temple
75003 Paris
France

www.ren21.net