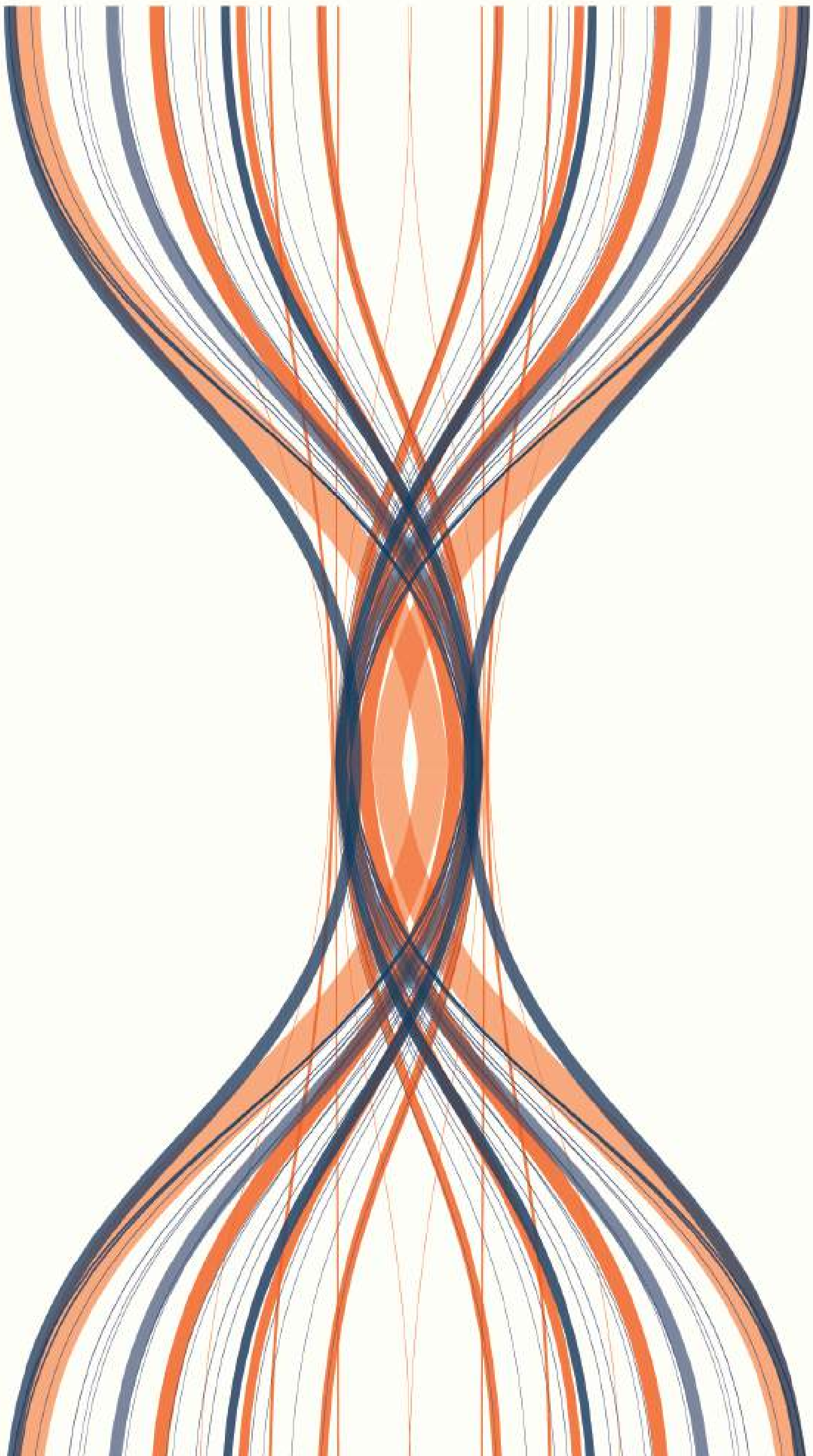
LOCAL GRIDS TO GLOBAL POWER

INDIA'S ENERGY TRANSITION

POOJIL TIWARI NEERA MAJUMDAR ARUNABHA GHOSH



15 CEEW THE COUNCIL

Local Grids to Global Power
India's Energy Transition

The first-of-its-kind data book on the world's largest clean energy transformation.

India's energy transition is reshaping the global growth story. Home to 1.45 billion people, it is the fastest-growing major economy and a nation aiming for net-zero emissions by 2070. This data-driven chronicle captures how India is electrifying every household, scaling renewables from megawatts to gigawatts, and pioneering fuels of the future such as green hydrogen.

From solar villages to smart grids, digital subsidies to global alliances, India is demonstrating that decarbonisation and development can advance together. Local Grids to Global Power reveals the numbers, the networks, and the new geopolitics of clean energy — and shows how one country's choices could determine the planet's climate future and provide a blueprint for the Global South.

Authors: Poojil Tiwari, Neera Majumdar, and Arunabha Ghosh.

Organisation: The Council on Energy, Environment and Water (CEEW) – **a homegrown institution** with headquarters in New Delhi – is among the **world's leading climate think tanks**. We use **data, integrated analysis, and strategic outreach** to support public policy, transform markets, shape technology, and nudge behaviour. CEEW seeks to explain – and change – the use, reuse, and misuse of resources. It addresses pressing global challenges through an **integrated and internationally focused** approach. approach. The Council prides itself on the **independence** of its high-quality research and strives to **impact sustainable development** at scale. In over 15 years of operation, CEEW has impacted over 400 million lives and engaged with over 20 state governments. Follow us on LinkedIn and X (formerly Twitter) for the latest updates.

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INTRODUCTION

The clean energy leap underway in India is not just a vulnerability or sustainability imperative but also a growth strategy.

With 1.45 billion people, India is the world's most populous country,[1] the fastest-growing major economy,[2] and currently, the third-largest emitter.[3] At the 26th Conference of Parties in Glasgow in 2021, India committed to achieving net-zero emissions by 2070. This transition could move over a billion people into a sustainable, low-emissions future and give the planet a fighting chance to limit global warming to below 2°C above pre-industrial levels.

In 2015, when the Sustainable Development Goals were adopted, India had the world's largest population without access to electricity.[4] Today, its household electrification programme has reached 28 million people in just 18 months since its launch in 2017.[5] Cleaner cooking fuels now reach almost all households, reducing both carbon emissions and indoor air pollution.[6] India's digital revolution – one of the cornerstones of its development strategy – is also cutting emissions. As hundreds of millions gained access to mobile phones and data, government services went online, including those delivering green energy subsidies directly to citizens. Smart meters now enable utilities to deliver electricity more efficiently and bill customers correctly, while green appliances such as super-efficient ceiling fans help households reduce consumption.[7] As a result, between 2005 and 2020, India cut its gross domestic product's (GDP) emissions intensity by 36 per cent.[8] All of this unfolded while the country simultaneously became the world's fourth-largest installer of renewable energy (RE) capacity.[9]

The scale of India's clean energy build-out has been remarkable. In 2010, the country had less than 20 megawatts (MW) of solar power capacity; today, it has over 127,000 MW.[10] Wind capacity has risen from 9,400 MW in 2008 to over 53,000 MW in 2025.[11] Nuclear power contributes another 8,700 MW.[12] India plans ramping up its ambitions with the announcement of a National Nuclear Mission in 2025, which aims to scale this up to 100,000 MW by 2047.[13] Collectively, non-fossil sources now account for more than 50 per cent of India's installed capacity.[14]

India is attempting what few countries have done: provide affordable clean energy to hundreds of millions, clean up one of the world's largest energy systems, and become an economic and industrial powerhouse – all at once. Yet, industries today receive less than 20 per cent[15] of their energy from electricity. Heavy industries still require fuels for high-intensity operations that cannot be met solely by electricity.[16] For this, the country is placing a strategic bet on fuels of the future such as green hydrogen. Approved in 2023 with an outlay of nearly USD 2.4 billion, the National Green Hydrogen Mission targets 5 million tonnes of green hydrogen production per year by 2030.[17]

India's ambitions extend beyond its borders. It helped found the International Solar Alliance, the Coalition for Disaster Resilient Infrastructure, and the Global Biofuels Alliance – global partnerships for clean energy and climate adaptation. Through the One Sun, One World, One Grid initiative, India envisions linking renewable-rich regions across Asia, the Middle East, and Africa through high-voltage transmission networks.[18] By 2040, 85 per cent of global energy demand will come from emerging economies in these regions.[19] However, in 2025, we are hard-pressed to find the world that signed the Paris Agreement a decade ago in 2015. Developed countries are projected to collectively emit around 3.7 gigatonnes more of carbon-dioxide-equivalent emissions in 2030 than their stated reduction goals.[20] At this rate, even if they achieve net-zero emissions by 2050, they will have consumed 40–50 per cent of the carbon budget left to limit the increase in global warming below 1.5°C of pre-industrial levels.[21]

India has an interest in ensuring that the technological and trade protectionism of the oil and gas era does not extend to the fuels of the future. Its spate of clean energy and climate action initiatives and a G20 presidency that saw the inclusion of African Union show that New Delhi has the record and reach to lead in shaping the rules in emerging fuels and clean technologies.

The world's largest energy transition can serve both as an example for, and a voice of, the Global South.

1.

INDIA NEEDS TO TRANSITION FOR THE WORLD TO TRANSITION

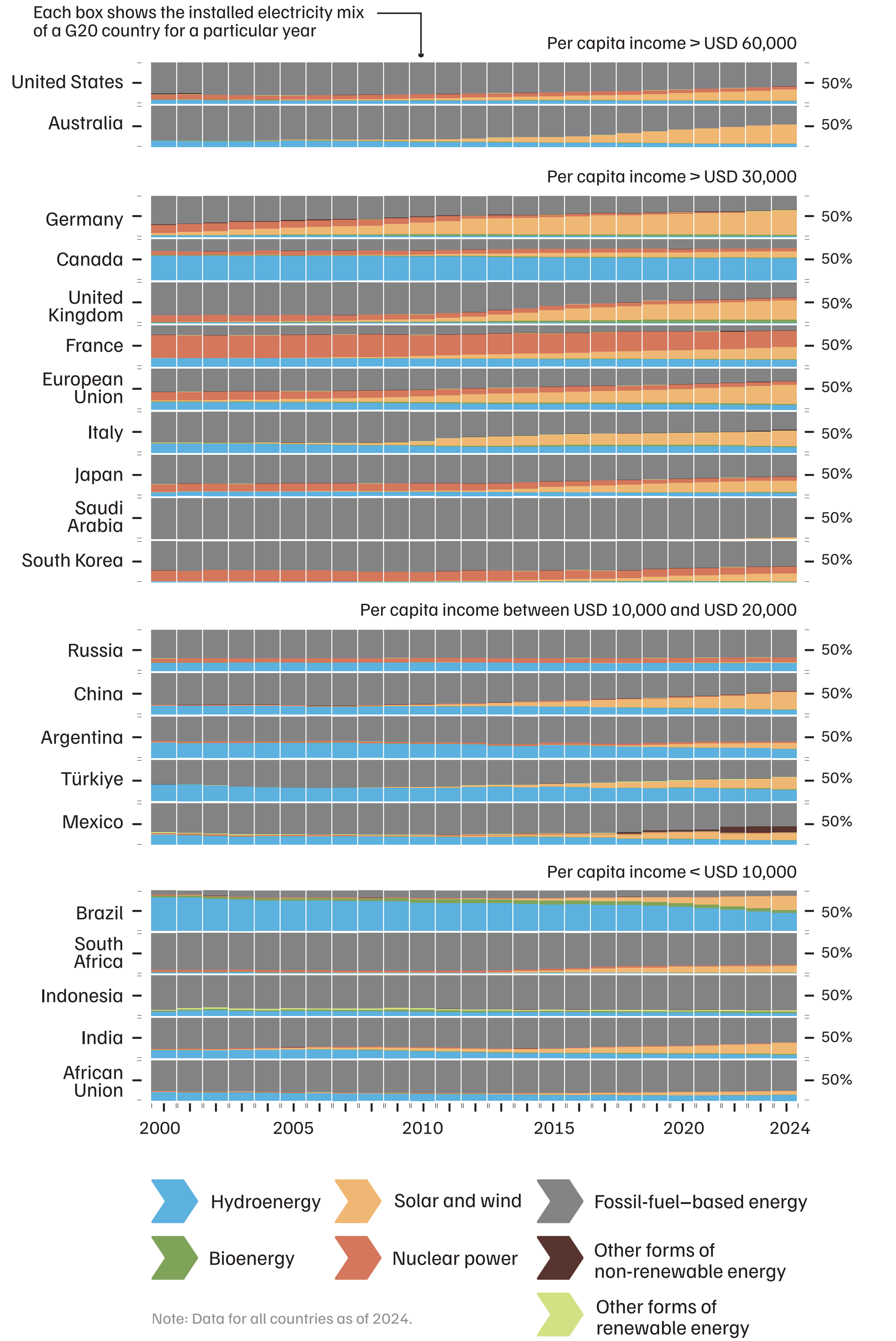
BIG TRANSITIONS ARE COMING IN EMERGING ECONOMIES

Usually, developed countries have achieved a certain level of economic prosperity before undergoing a transition to cleaner sources of energy.[1] Today, that story is being rewritten—from New Delhi to Ankara, São Paulo to Jakarta.

For instance, non-fossil fuels now make up 50 per cent of India's installed power capacity.[2] This is in tandem with near-universal household electrification[3] and liquefied petroleum gas (LPG) becoming the primary cooking fuel in nearly three-fourths of all households.[4] All of this has occurred at a per capita GDP of ~USD 2,800,[5] whereas countries such as the United States (US) and the United Kingdom (UK) began their dedicated clean energy efforts after achieving much higher GDPs.

South Africa, with ~USD 6,000 per capita GDP, is replacing coal with wind and solar as a solution to its energy crisis. In 2023, the country's solar PV installations grew by 33 per cent.[6] Brazil, with ~USD 10,000, has already achieved more than 80 per cent clean energy in its national power system.[7]

Looking at data from G20 countries, it is evident that the energy transition is being driven not only by advanced economies but also by emerging ones.



Note: Data for all countries as of 2024.

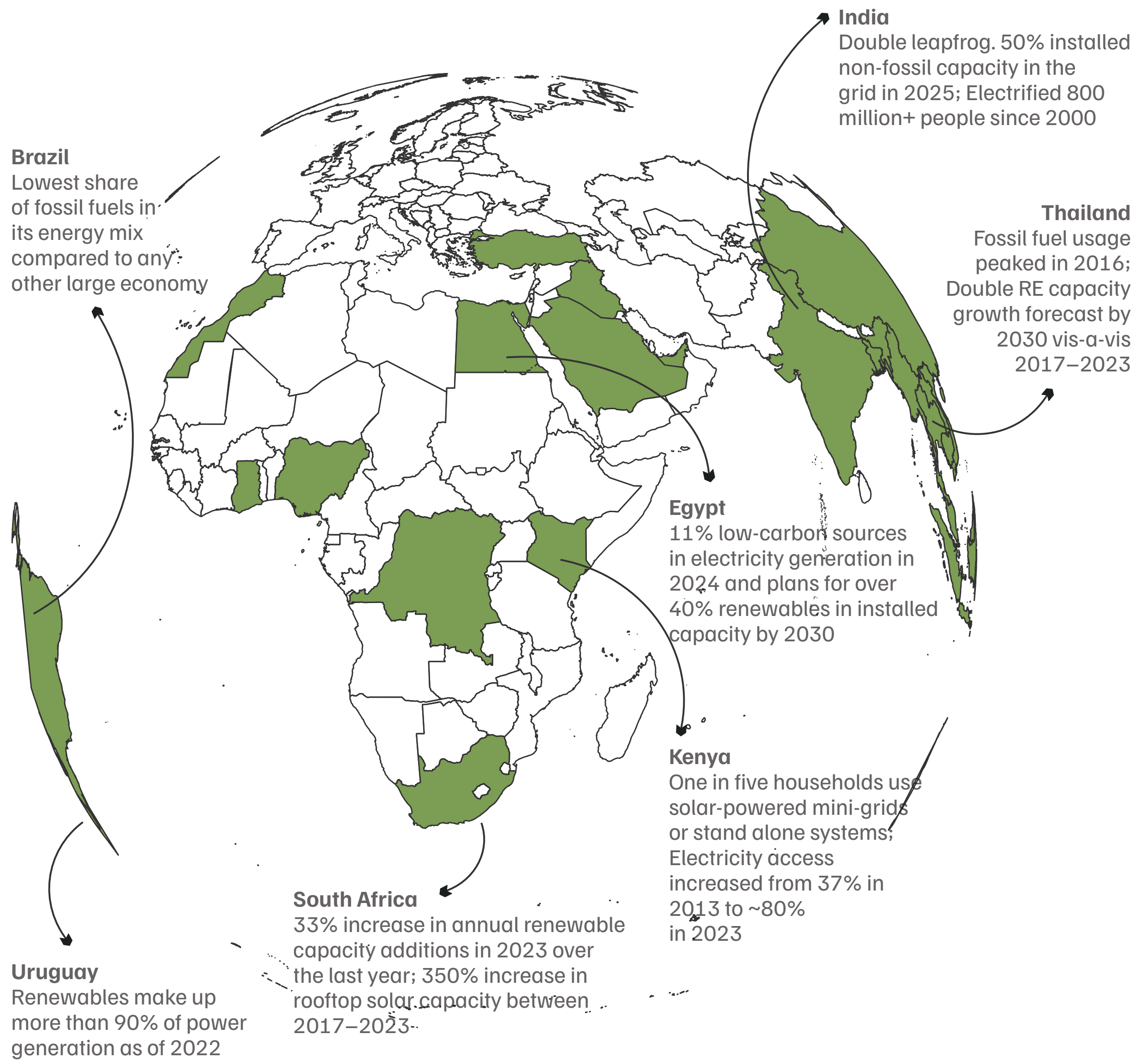
Source: Authors' analysis of data from International Renewable Energy Agency (IRENA). Renewable Capacity Statistics 2025. International Renewable Energy Agency, 2025 and The World Bank. GNI per capita, Atlas method (current US$)

EMERGING ECONOMIES ARE LEAPFROGGING INTO A CLEAN ENERGY PARADIGM

Over 80 per cent of the growth in global electricity demand between 2019 and 2040 is expected to come from emerging markets.[8] Unlike developed countries, they are not gradually transitioning towards clean energy. They are leapfrogging into clean energy to meet the rising demand from fast-growing economies.

In Asia Pacific (excluding China), renewable capacity is expected to grow by more than 680 GW between 2024–2030, which is double the capacity added over the past six years.[9] In the Middle East and North Africa (MENA), RE expansion is expected to triple from 53 GW in 2023 to almost 150 GW in 2030. This is spurred by growing domestic demand, coupled with population and economic growth.[10] Latin America, long dominated by hydropower, is pivoting decisively to solar and wind. Brazil leads RE expansion with over half of Latin America's planned capacity additions, followed by Chile, Mexico, and Colombia.[11]

In countries such as South Africa, Chile, Thailand, and Türkiye, the demand for fossil fuels in electricity generation has already peaked,[12] while India is advancing clean energy deployment and improving electricity access for its citizens.[13]



Source: Bond, Kingsmill, Arunabha Ghosh, Ed Vaughan, and Harry Benham. 2021. Reach for the sun: The emerging market electricity leapfrog. A Carbon Tracker-CEEW report. London: Carbon Tracker, Ferris, Nick; IRENA. Renewable Capacity Statistics 2025. International Renewable Energy Agency, 2025; "Weekly Data: South Africa's Unprecedented Rooftop Solar Boom." Energy Monitor, 14 August 2023; "Uruguay." International Energy Agency (IEA); "Kenya's energy sector is making strides toward universal electricity access, clean cooking solutions and renewable energy development." IEA News, 14 April 2025; "Egypt." Ember, 11 April 2025.

CLEAN ENERGY NOW POWERS HALF OF INDIA'S INSTALLED ELECTRICITY CAPACITY

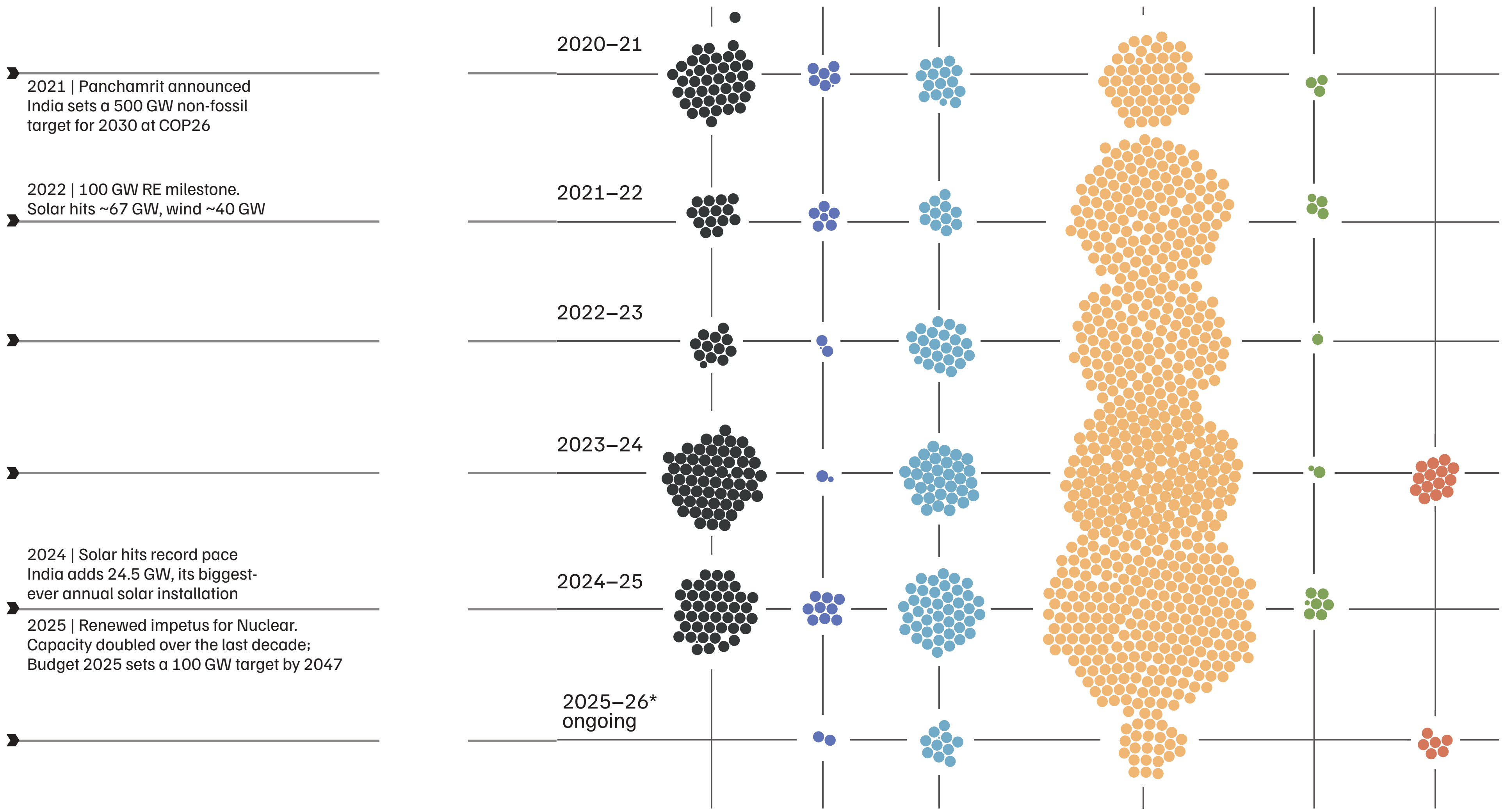
In 2010, India had about 20 MW of solar capacity.[14] Today, the country has added more solar in the last four years than in all the years prior.[15]

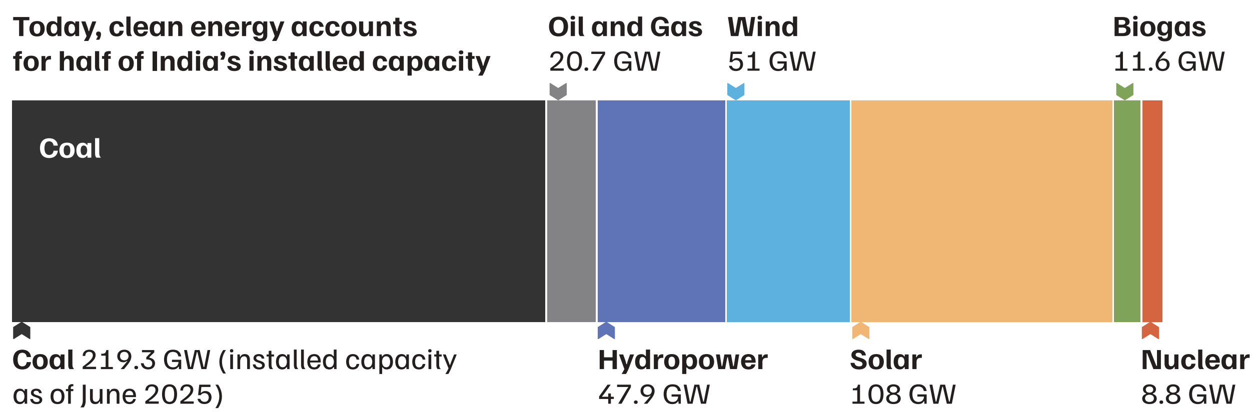
Similarly, India's wind and hydropower sectors have matured. Its grid is nationally integrated, and for the first time, annual RE additions are outpacing those from fossil fuels.[16] New Delhi is already in the middle of one of the most ambitious clean energy transitions the world has seen. Between 2020 and 2024, it was exceeded only by China and the USA in RE installations. However, in percentage terms, India's grid already has more installed renewable capacity than the USA.[17] Further, the International Energy Agency (IEA) reports that while China is the largest builder of renewable capacity in net volume, India is installing renewables at the fastest rate among major economies.[18]

India has met its 2030 nationally determined contribution – ensuring that non-fossil sources make up 50 per cent of its installed power capacity – five years ahead of schedule.[19] While the road ahead may not remain linear, New Delhi is well on track.

In 2020, coal made up 55% of India's total installed capacity. Since then, India has dramatically scaled up its clean energy deployment

Each circle represents approx. 100 MW of additional installed capacity





Source: Authors' analysis of data from NITI Aayog and Vasudha Foundation. Taken from NITI Aayog. n.d. "India Climate & Energy Dashboard." (ICED)

Note: India has not added new oil and gas capacity since 2020. Hydro includes small-hydro. Data for 2025–26 is as of June 2025.

INDIA SHOULD AIM FOR 600 GW OF CLEAN ENERGY BY 2030

New Delhi's commitment to install 500 GW of non-fossil-fuel energy capacity by 2030 will be enough to meet India's future power demand in 2030.

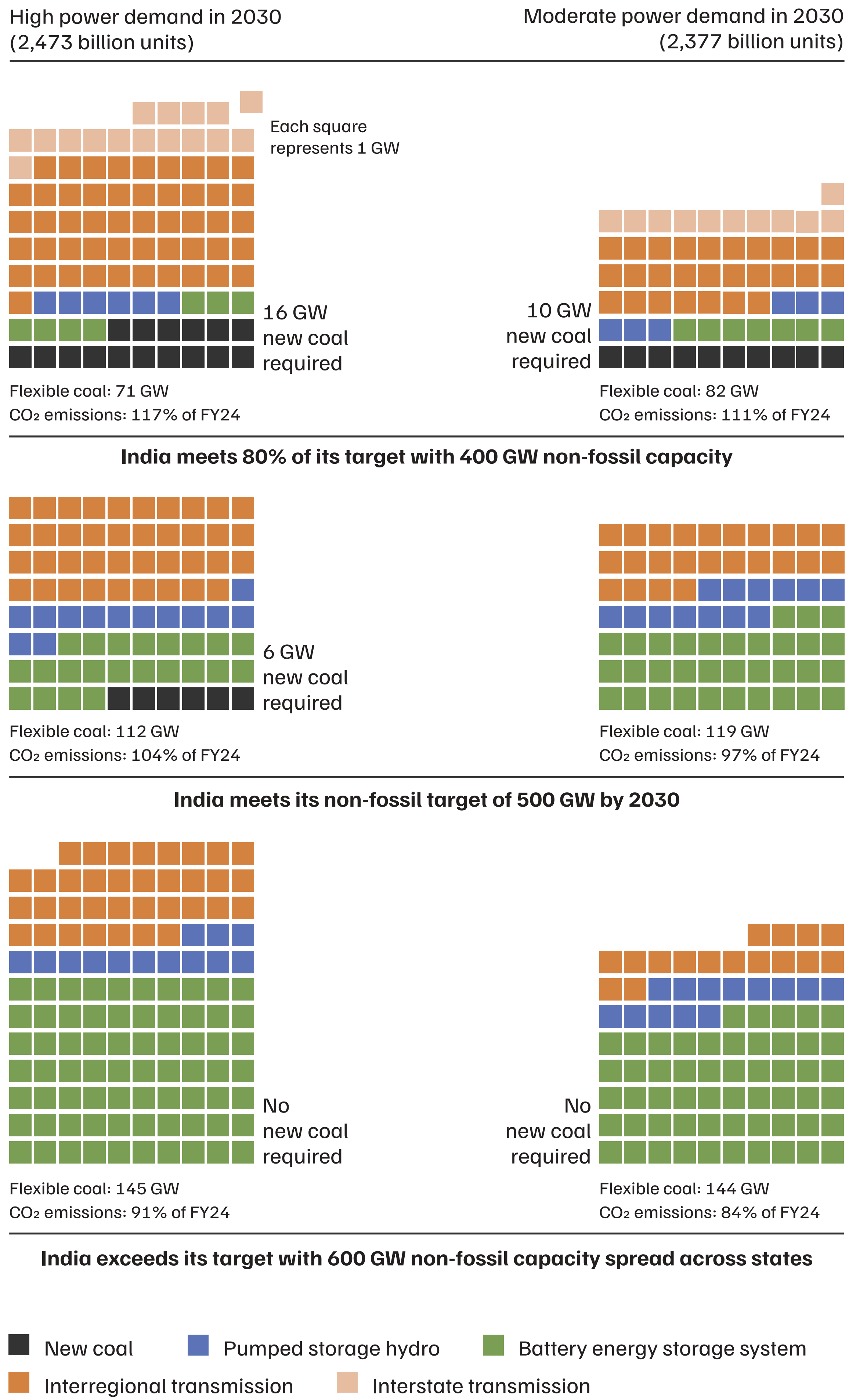
This is in a moderate-demand scenario, where electricity demand is expected to grow by 5.8 per cent annually from 2022, according to the country's Central Electricity Authority.[20] The Council's analysis shows that existing, under-construction, and planned projects can meet this demand without adding new coal capacity to the grid.[21]

A more compelling and ambitious case isfor going further. India's energy demand is estimated to grow by more than any other country in the coming decades.[22] If demand outpaces economic growth – driven by the need for cooling or data centres – India will require an extra 100 GW of clean power by 2030 to avoid adding new coal to the grid.[23] Each square in the figure represents one GW of additional resources – storage, hydro, or new coal – needed over and above the installed RE capacity across moderate and high power-demand scenarios.

Deploying 600 GW of clean energy across states by 2030 offers a more reliable and cost-effective path to energy security. We estimate this could save up to INR 42,400 crore in power procurement costs, while creating as many as 2,40,000 additional full-time-equivalent jobs and cutting carbon emissions by ~16 per cent from FY24 levels.[24]

Source: Agarwal, Disha, Arushi Relan, Rudhi Pradhan, Sanyogita Satpute, Karthik Ganesan, Shalu Agrawal. 2025. How can India Meet its Rising Power Demand? Council on Energy, Environment and Water.

Note: CO2 emissions in FY24 were 1,260 MtCO2.



A 2070 NET-ZERO WILL COME WITH PEOPLE, LAND, AND CLIMATE CHALLENGES

To meet its net-zero goal by 2070, India could need around 7,000 GW of renewable energy.

But each additional GW comes with greater constraints on land, population density, climate risk, and availability of sunlight.

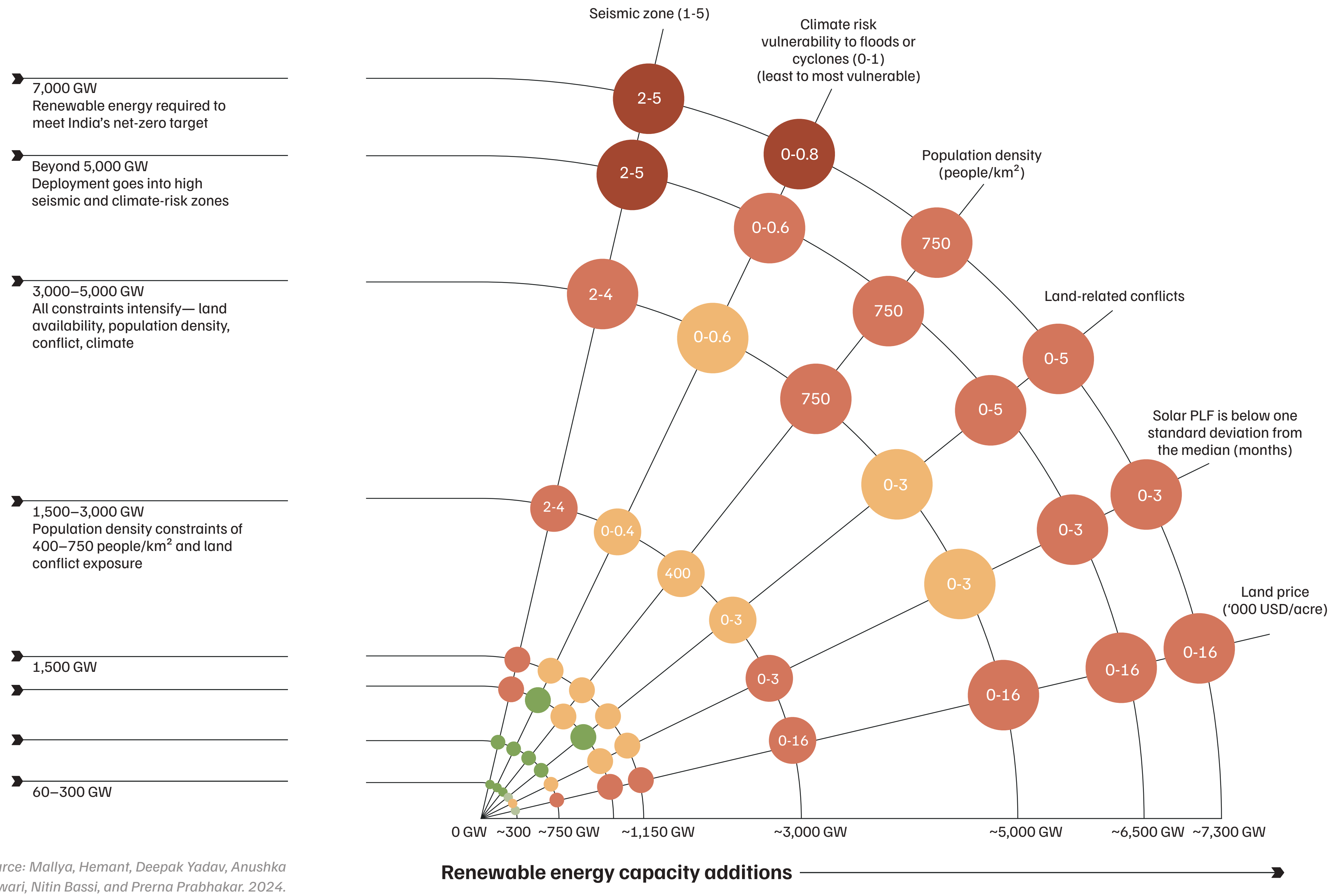
Each circle represents the levels of difficulty to building more RE in India

Easier to do — Harder to do

On the very first day of the 2021 United Nations Climate Change Conference (COP26) in Glasgow, India's prime minister announced the country's aim to reach net-zero emissions by 2070.[25]

By one estimate, India's achievement of this target alone could reduce global warming by 0.2°C.[26] Achieving this target requires the country to install around 7,000 GW of wind and solar capacity.[27] Currently, it has an installed capacity of ~180 GW.[28] On the ground, deploying RE beyond 300 GW will require making realistic trade-offs, such as choosing between deploying RE on highly priced land and highly populated land.[29] Beyond 750 GW, India will need to deploy RE in areas that are either prone to earthquakes or have higher seasonality, which impacts solar availability.[30] Beyond 1,500 GW, India will also need to tap into areas with higher population density – up to 750 people per square kilometre. Finally, unlocking RE potential beyond 3,000 GW will require exploring areas with high climate risks and land-related social conflicts.[31]

Policy reforms, infrastructure investment, and real-time data that enable smarter site selection and faster project approvals will be critical. Each additional gigawatt will help keep the 1.5°C target within reach. The next phase of India's energy transition will be shaped not just by how much the country builds, but where and how it chooses to build it.



Source: Mallya, Hemant, Deepak Yadav, Anushka Maheshwari, Nitin Bassi, and Prerna Prabhakar. 2024. Unlocking India's RE and Green Hydrogen Potential: An Assessment of Land, Water, and Climate Nexus. Council on Energy, Environment and Water

2.

GREENING THE INDIAN ELEPHANT

INDIA'S CLIMATE POLICIES ARE ALREADY PAYING OFF

Between 2015 and 2020, India's climate policies helped avoid 440 million tonnes of carbon dioxide emissions.[1]

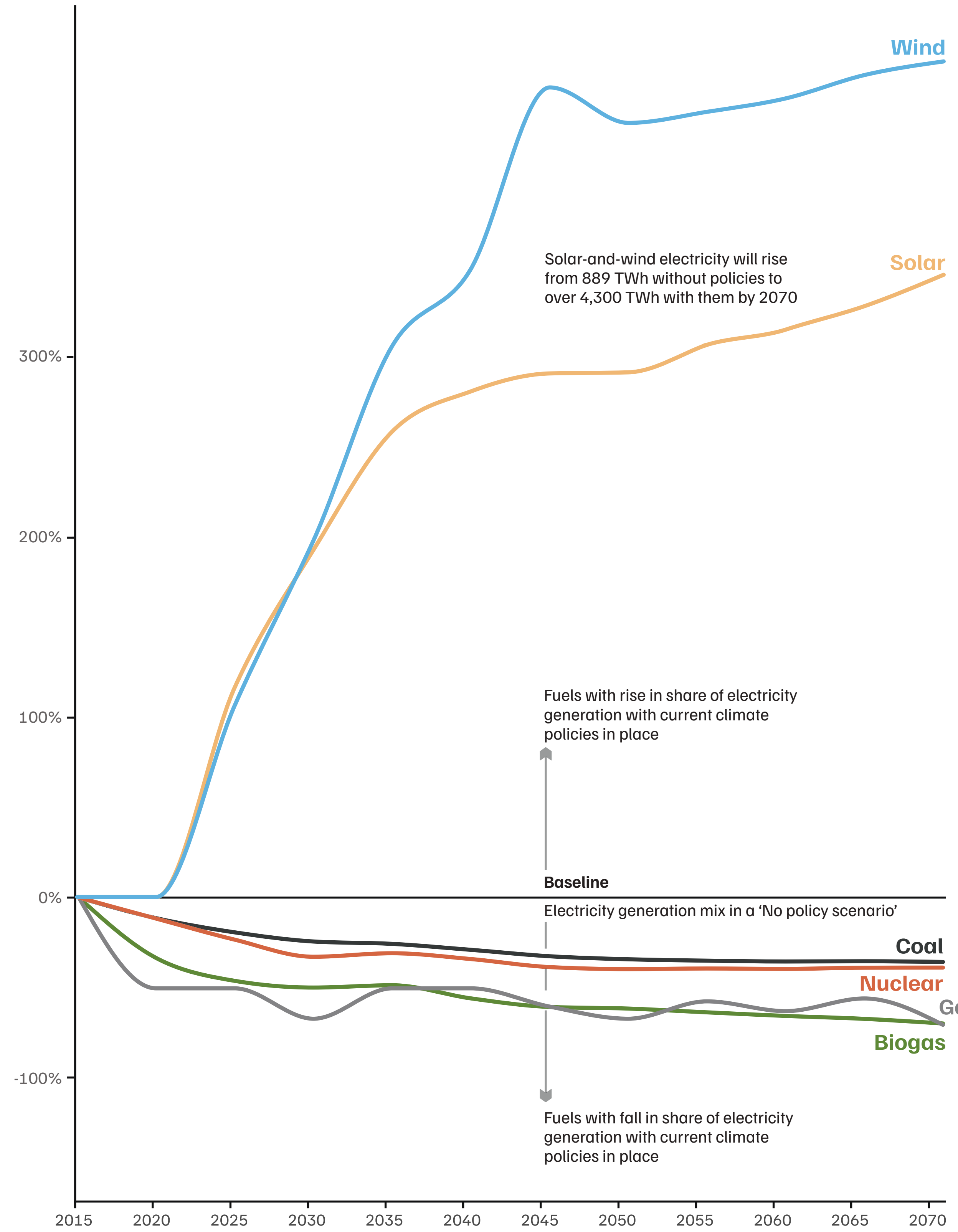
India's policies across power, transport, and residential sectors are further projected to reduce emissions by four billion tonnes between 2020 and 2030, well beyond the one billion tonne reduction India promised at COP26 in 2021.[2]

CEEW has modelled India's energy mix till 2070 under two policy scenarios. The 'current policy' scenario reflects interventions such as the National Solar Mission, RE auctions, light-emitting diode (LED) adoption, and the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) and FAME II schemes for incentivising electric vehicle (EV) sales—and a No Policy Scenario. Stronger policies for solar and wind have helped avoid the addition of 80 GW of new coal-based power plants, otherwise needed to meet the country's growing demand.[3]

Without these policies—and even with the current climate policies—coal would remain important for India's energy security and affordability, especially in the near term. While current policies are bending the long-term emissions curve, they will fall short of achieving net-zero by 2070, making the case stronger for India to develop a more ambitious long-term energy transition plan.[4]

Source: Chaturvedi, Vaibhav, Anurag Dey, and Ritik Anand. 2024. Impact of Select Climate Policies on India's Emissions Pathway. Council on Energy, Environment and Water

With climate policies, electricity generation from renewables surges as that from fossil fuels declines



Note: The percentage increase in wind is higher due to a relatively lower base.

INDIA IS CHAMPIONING DOORSTEP DELIVERY OF SUSTAINABILITY

The energy transition is increasingly becoming visible in India's economy, policies, and homes.

Between 2005 and 2020, the emissions intensity of India's GDP – the amount of emissions generated for each dollar added to national income – fell by 31.5 per cent.[5] Increased energy efficiency and green energy deployment brought about this reduction, driving economic growth. Since 2017, the Saubhagya (or 'good fortune') scheme has connected ~28 million homes to electricity, bringing household electrification rates to at least 98 per cent.6 India is also the largest procurer of LED light bulbs under the Unnat Jyoti by Affordable LEDs for All scheme. New Delhi's large-scale purchases brought down the price of a single light bulb by 85 per cent between 2015 and 2019, further lowering the cost of energy-efficient lighting for ordinary households.[7] Another priority has been providing Indian homes with cleaner cooking fuels, reducing reliance on firewood and other plant materials that release large amounts of carbon dioxide. The 2016 Pradhan Mantri Ujjwala (or 'bright') scheme brought LPG cylinders to four-fifths of the country's households by 2020, up from half just a few years earlier.[8] More recently, the country has made a significant push for decentralised energy with the Pradhan Mantri Surya Ghar: Muft Bijli (or 'solar-powered homes: free electricity') scheme, promising to deploy rooftop solar systems in 10 million homes by 2026–27.[9]

When citizens experience the benefits of green growth – fairer and cheaper billing; cleaner cooking and indoor air quality; and energy-efficient homes – sustainability gains public momentum.

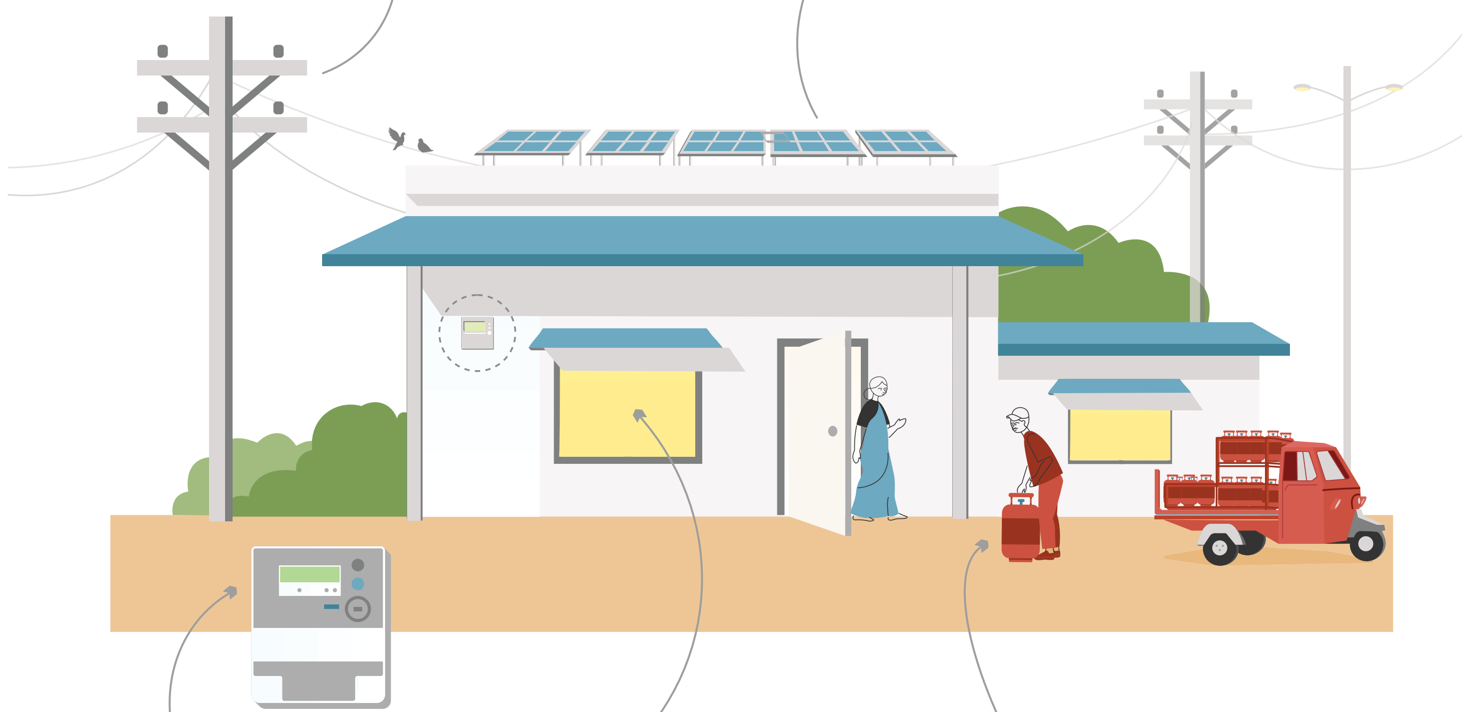
Sources: Ministry of Power. 2023. "Saubhagya Electrification Scheme – A Total 2.86 crore Households Have Been Electrified." Press Information Bureau, March 16, 2023; Zachariah, Sachin, Bhawna Tyagi, and Neeraj Kuldeep. 2023. Mapping India's Residential Rooftop Solar Potential: A Bottom-Up Assessment Using Primary Data. Council on Energy, Environment and Water (CEEW); Mani, Sunil, Shalu Agrawal, Abhishek Jain, and Karthik Ganesan. 2021. State of Clean Cooking Energy Access in India: Insights from the India Residential Energy Survey (IRES) 2020. CEEW; Shalu Agrawal, Sunil Mani, Simran Kalra, Bharat Sharma, and Kanika Balani. 2023. Enabling A Consumer-Centric Smart Metering Transition in India: Insights from A Survey of Six States. CEEW, and Press Information Bureau, Government of India. "PM Surya Ghar: India's Solar Revolution — Muft Bijli Yojana Crosses Milestone of 10 Lakh Installations." Press Information Bureau, March 13, 2025

~28 million

households connected to electricity in 18 months. Every urban home now has access to power

102 GW

of economic potential exists for solar rooftops across Indian households



60%

of smart meter users said they were satisfied with billing/ payments in the technology and would recommend prepaid meters to others

~370 million

LEDs (bulbs + streetlights) deployed till April 2023, abating 38.7 million tonnes of carbon emissions each year

71%

households use LPG as their primary cooking fuel—95% in urban and 60% in rural areas. ~8 in 10 households now have access to LPG

HOW INDIA ELECTRIFIED ALL HOMES

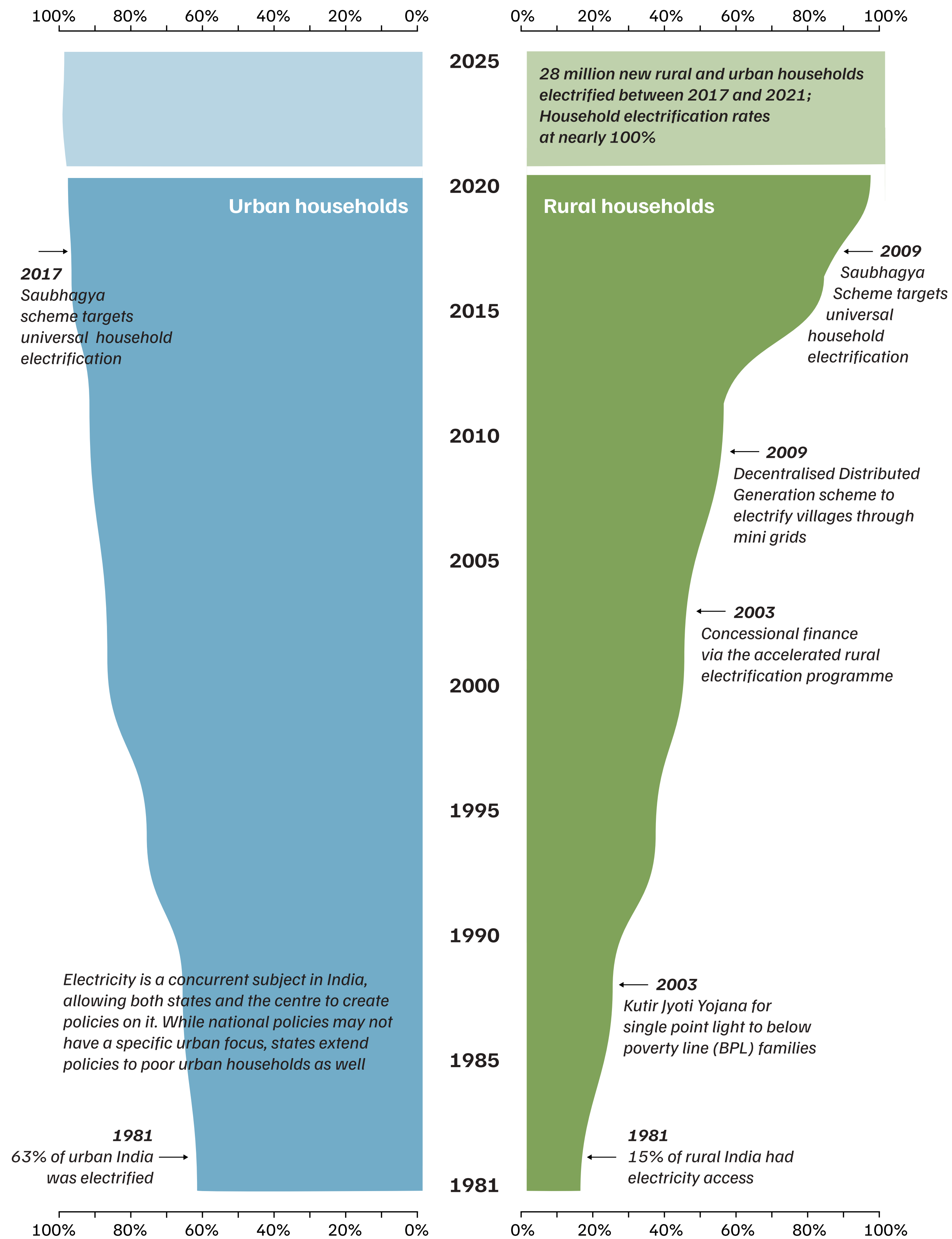
In the 18 months after the launch of India's universal household electrification scheme, the *Pradhan Mantri Sahaj Bijli Har Ghar Yojana* (Saubhagya) in 2017, 26 million new households had been electrified[10] and household electrification rates reached nearly 99 per cent.[11]

If the world had mirrored the rate of India's expansion, an additional 430 million people could have gained electricity access between 2015 and 2020. However, per capita electricity consumption remains low in India—about one-third of the global average[12]—implying that demand will rise with rising incomes, urbanisation and temperatures.

Electricity access is just one of the multiple, simultaneous transitions that India—and much of the developing world—is undertaking. Energy demand is shifting rapidly from rural to urban areas. These countries are also moving from weak bargaining positions in global energy markets to deeper integration into them. Power systems are moving from centralised to more decentralised and digitally enabled grids. India's experience—delivering electricity access to nearly 800 million people over two decades[13] offers lessons that can be adapted across the world where nearly 700 million people still lack electricity.[14]

What comes next are skills to manage complex grids, technologies such as smart meters that can turn consumers into active participants in grid balancing, and electricity access that supports cooling, heating, mobility, and livelihoods.

Households using electricity as primary source of lighting (%)



Source: Agrawal, Shalu, Sunil Mani, Abhishek Jain, and Karthik Ganesan. 2020. State of Electricity Access in India: Insights from the India Residential Energy consumption Survey (IRES) 2020. Council on Energy, Environment and Water.

A DECADE OF ACTION ON CLEAN COOKING ACCESS

In 2011, three out of ten Indian households used LPG as their primary cooking fuel. By 2020, this number had increased to seven in ten.[15] Globally in the same time, clean cooking access increased from 58 per cent to 71 per cent of the population.[16]

If the world had increased access to clean cooking at the same rate as India, it could have provided access to 2.28 billion additional people by 2020.

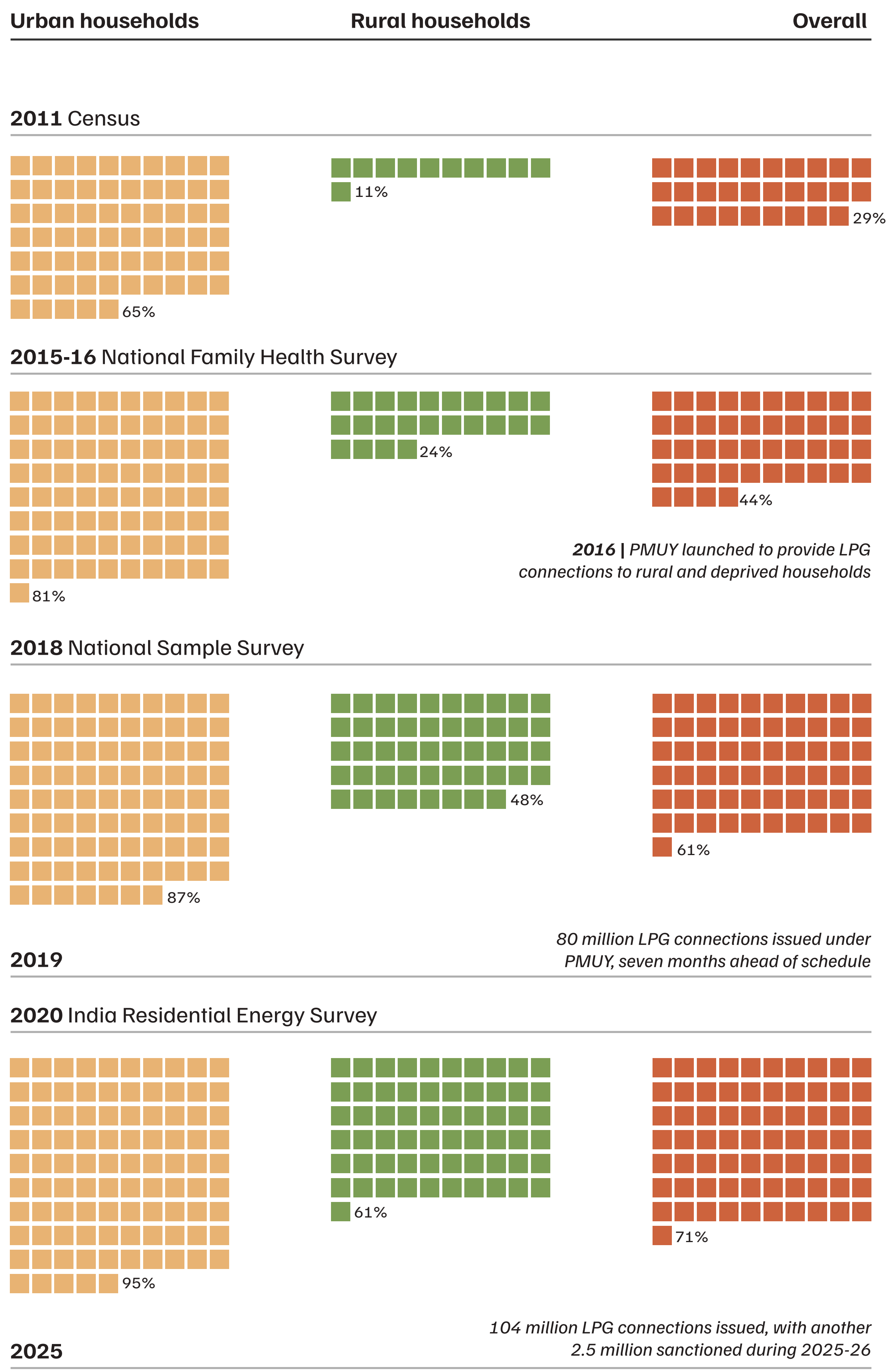
For decades before, millions of Indian households relied on firewood, dung cakes, and coal for daily cooking—fuels that impose a heavy cost on health for the most vulnerable in India.[17] A major turning point came with the launch of the *Pradhan Mantri Ujjwala Yojana (PMUY)* in 2016, which removed upfront cost barriers by providing deposit-free LPG connections to women from BPL households. Subsequent policy refinements—simplified eligibility norms, targeted subsidies on refills—reinforced the policy push for clean cooking.[18] However, energy access does not end with a connection.

With PMUY turning 10 in 2026, clean fuels—LPG and electricity—must be the sole source of cooking energy. This should be further supported by restrictions on firewood sales, winter subsidies on clean fuels, and behaviour change campaigns.[19] When clean cooking reaches households, it delivers cleaner air, lower public health burdens, and better quality of life for the country.

Source: *Mani, Sunil, Shalu Agrawal, Abhishek Jain and Karthik Ganesan. 2021. State of Clean Cooking Energy Access in India:Insights from the India Residential Energy Survey (IRES) 2020. New Delhi: Council on Energy, Environment and Water. Government of India. Pradhan Mantri Ujjwala Yojana (PMUY): About the Scheme. Ministry of Petroleum and Natural Gas.*

Note: The government surveys and census exercise capture information on households' use of LPG as the primary cooking fuel but not on whether the household has an LPG connection. Thus, actual LPG penetration at any point of time would be equal to or greater than the estimates of LPG use as the primary cooking fuel.

Indian households cooking primarily with LPG (in%)



THE ENERGY TRANSITION IS POWERING NEW RURAL ENTERPRISES IN INDIA

India's clean energy transition is not just about increasing access; it is also about powering livelihoods.

Neither is it just an urban India story. With the near-universal electrification of villages and households, energy demand patterns will shift. Electricity use will rise in homes and across rural enterprises seeking higher productivity. Decentralised RE technologies (DRE) could sustainably meet this rising demand and steer growth in rural economies.[20] In 2022, India adopted a first-of-its-kind national policy to enable DRE technologies to support livelihoods.[21] These clean energy technologies draw power from the sun and other renewables such as biomass to supply electricity locally. Decentralised RE technologies can run appliances and power small enterprises, reducing reliance on the central power grid. For instance, a portable solar dryer can extend the shelf life of farm produce (such as dry flowers, mangoes, and tomatoes), reducing food loss and increasing farmers' incomes.[22] A CEEW survey of DRE users found that six in ten are engaged in farming,[23] underscoring DRE's importance for agriculture – India's largest employer. Notably, while the sector accounts for three-fourths of rural women's jobs,[24] 62 per cent of DRE users are women.[25]

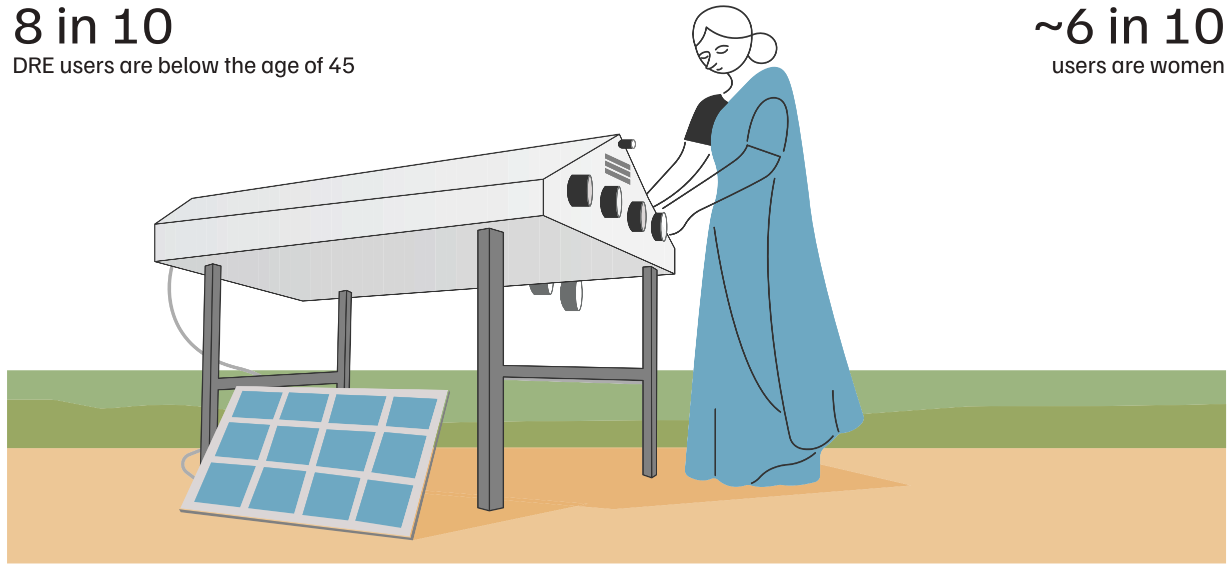
Distributed clean tech also represents a massive economic opportunity. The Council further estimates that mature technologies could support 37 million livelihoods and create a USD ~50 billion market for deploying enterprises.[26] Unlocking this will require financing across the value chain – from innovators designing solutions and rural enterprises scaling production to end-users adopting DRE to power their livelihoods.

Source: Yasaswi, Priyatam, Divya Gaur, and Abhishek Jain. 2025. How Decentralised Renewable Energy-Powered Technologies Impact Sustainable Livelihoods: Findings from the Ground. Council on Energy, Environment and Water; Jain, Abhishek, Wase Khalid, and Shruti Jindal. 2023. Decentralised Renewable Energy Technologies for Sustainable Livelihoods: Market, Viability, and Impact Potential in India. Council on Energy, Environment and Water

Who is using distributed clean tech in India?

8 in 10
DRE users are below the age of 45

~6 in 10
users are women

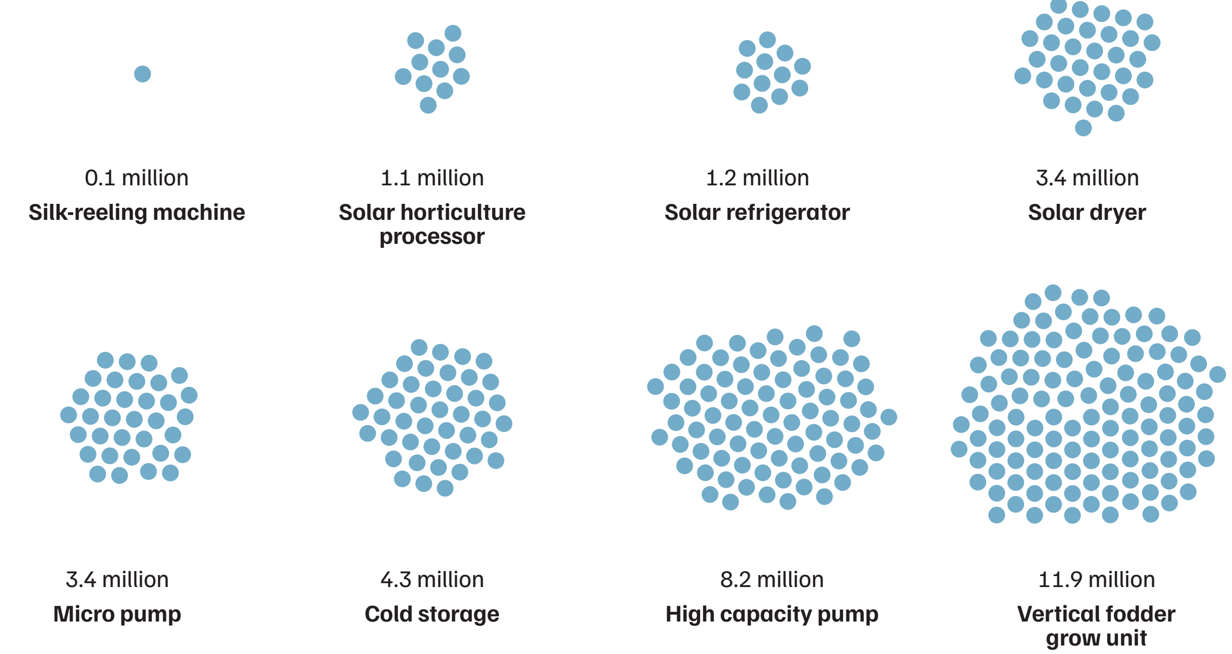


4 in 10
DRE users belong to Scheduled Castes and Scheduled Tribes: historically marginalised communities that have faced social exclusion and limited economic mobility

~6 in 10
users have a household income below USD 1,800 per year

DRE clean tech has the potential to support 37 million livelihoods, further catalysing a ~USD 50 billion market

Every dot corresponds to 100,000 future livelihoods



Note: Selected technologies shown have deployment scales between 100 and 100,000+ users.

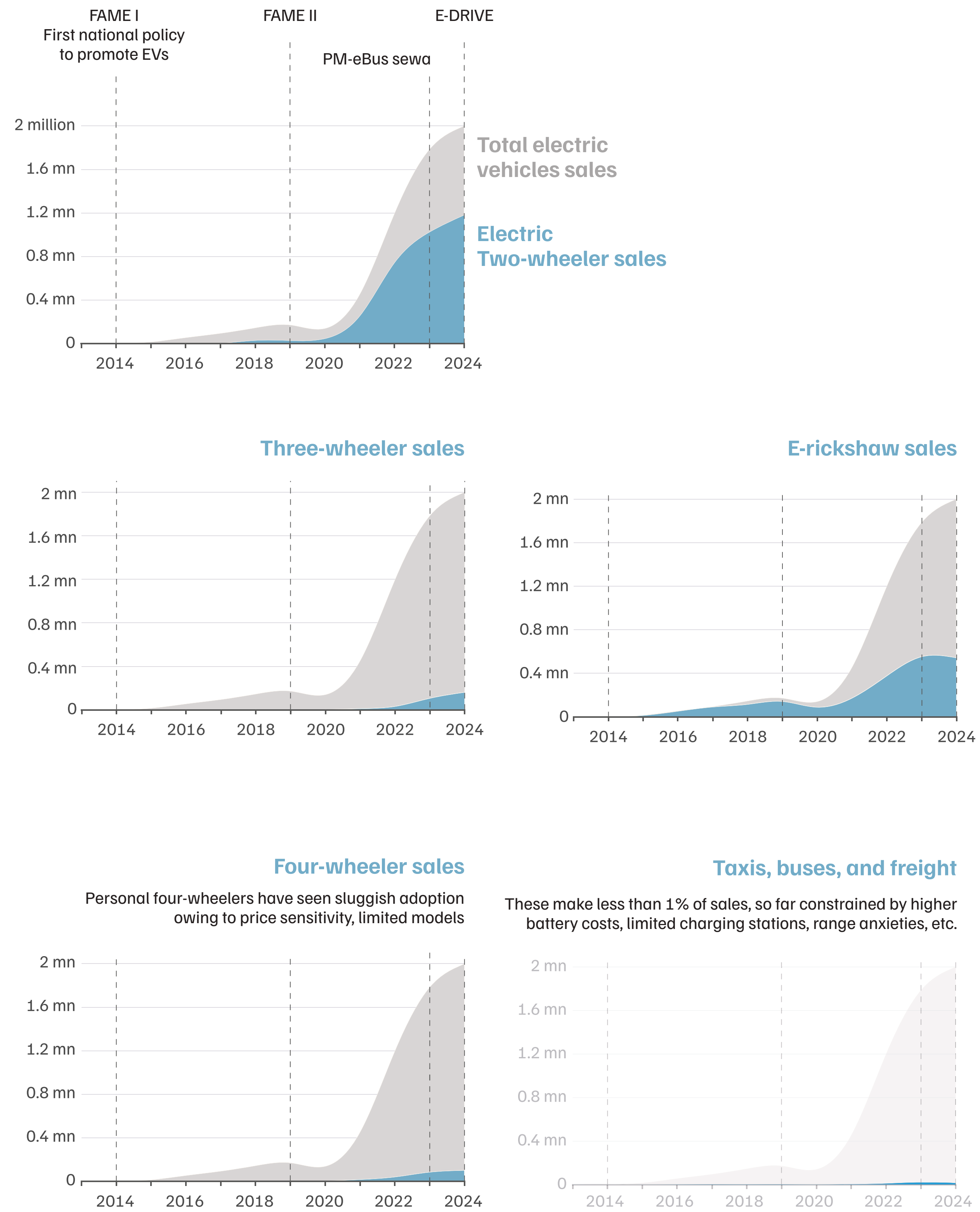
POLICIES ARE BUILDING MOMENTUM FOR THE EV STORY

Much like clean cooking and household electrification, India's approach to transport must balance two goals – expanding public transport access and ensuring clean mobility.

On the latter, India is on the right track. In 2024–25, EV sales neared 2 million units[27] and are projected to reach about 6 million units combined by 2026, driven by supportive policies and subsidies.[28] The inflexion point came in 2019 with FAME II, a USD 1.4 billion (2019 prices) scheme offering subsidies for electric two-, three-, and four-wheelers and public buses.[29] This was followed by the Pradhan Mantri-eBus Sewa initiative in 2023 to deploy 10,000 electric buses[30]. The following year, the Pradhan Mantri e-Drive scheme extended incentives for 2.9 million EVs, with two-fifths of its financial outlay dedicated to e-buses.[31]

The push for public transport is relevant because 94 per cent of EVs sold in 2024–25 were two- and three-wheelers.[32] Both remain cheaper to own and operate – at a total cost of ownership of less than INR 1.5/km – across their entire life cycle.[33] Yet, while these lighter EVs meet rising-income aspirations and last-mile mobility needs, their rapid growth risks adding to the congestion and pressure on urban roads.[34]

India's EV sales neared 2 million in 2024–25



Source: CEEW. n.d. "EV National Volume Monitor & Performance." New Delhi: Council on Energy, Environment and Water. https://www.ceew.in/gfc/tools_and_dashboards/electric-mobility/national-volume-monitor.

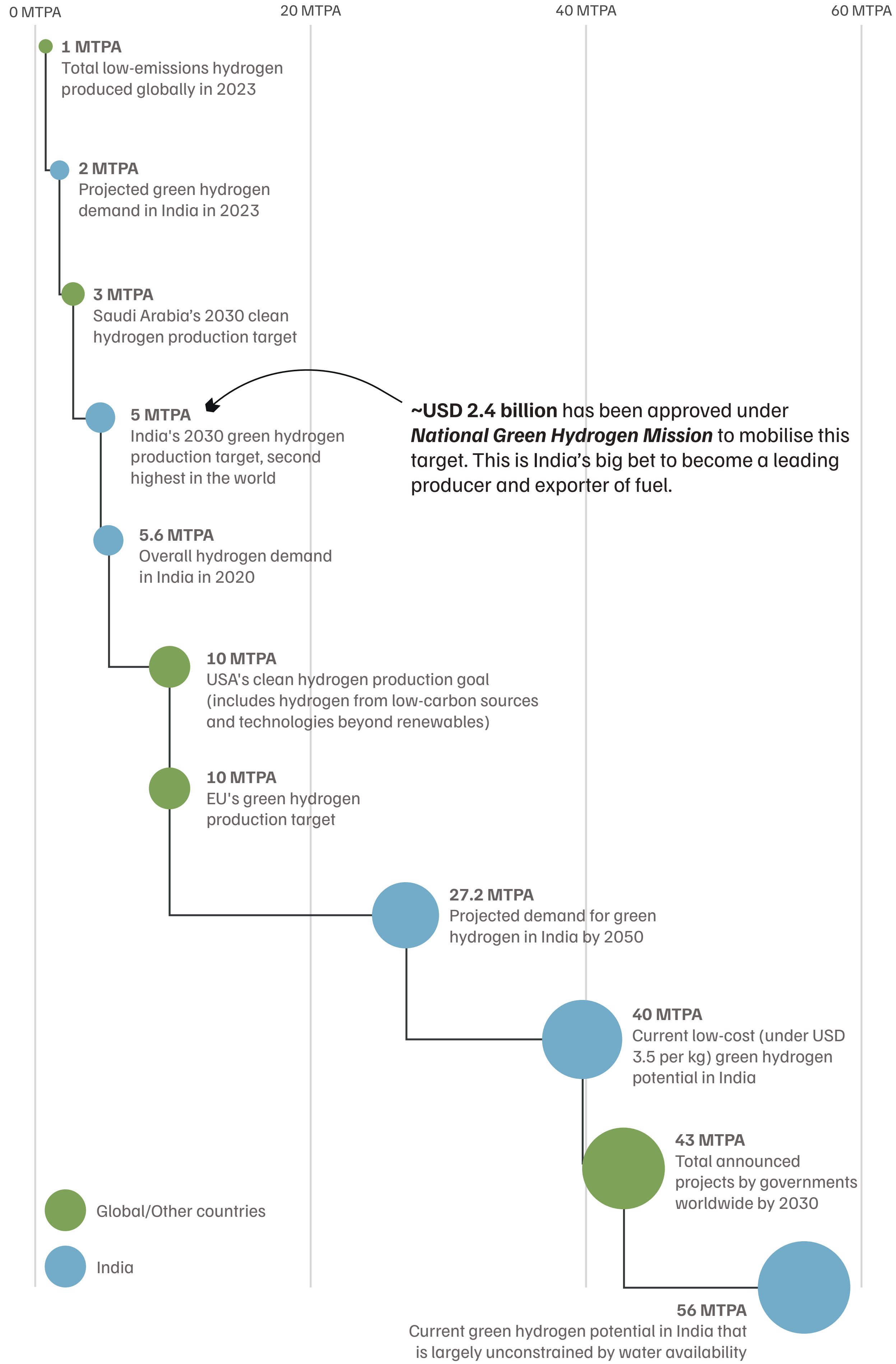
INDIA IS BETTING BIG ON GREEN HYDROGEN

New Delhi has set one of the world's most ambitious green hydrogen production targets for a single economy – 5 million metric tonnes per annum (MTPA) by 2030.[35]

Further, over 10 times this production potential exists in areas without major water availability issues.[36] Producing hydrogen involves splitting water into hydrogen and oxygen, a process requiring significant energy. When that energy comes from renewable or non-fossil sources, the result is green hydrogen. India will need to add about 135 GW of new RE capacity to supply the 310 billion units of electricity required to generate 5 MTPA of green hydrogen by 2030.[37] This is nearly 13 per cent of the current projected electricity demand in 2030,[38] an indication of how significantly the fuel could reshape the way India consumes power. For hard-to-abate sectors such as steel, freight transport, and petrochemicals, this fuel-of-the-future could be a game-changer, advancing industrial growth while simultaneously reducing industrial emissions.

Early signs show that six states – Gujarat, Maharashtra, Tamil Nadu, Andhra Pradesh, Odisha, and Uttar Pradesh – could deliver nearly 90 per cent of India's 2030 target. Gujarat alone may produce 2 MTPA, driven by its ports, industries, and strong wind and solar base.[39] India is showing leadership in production targets. Now, it must also lead in promoting a global, rules-based framework to avoid protectionist barriers in green hydrogen trade and technology.

Source: IEA. 2024. "Global Hydrogen Review 2024 – Analysis."; Mallya, Hemant, Deepak Yadav, Anushka Maheshwari, Nitin Bassi, and Prerna Prabhakar. 2024. Unlocking India's RE and Green Hydrogen Potential: An Assessment of Land, Water, and Climate Nexus. Council on Energy, Environment and Water; CFLI India and CEEW. 2024. Financing Green Hydrogen in India: Private Sector Considerations to Strengthen India's Enabling Environment for a Competitive Green Hydrogen Economy. Council on Energy, Environment and Water; Ghosh, Arunabha, Tulika Gupta, Shuva Raha, Hemant Mallya, Deepak Yadav, and Nandini Harihar. 2022. Rules for an Energy-Secure Global Green Hydrogen Economy. Council on Energy, Environment and Water.



3.
THE ENERGY TRANSITION IS STILL AN UPHILL TASK

MONEY DOESN'T FLOW WHERE THE SUN SHINES THE MOST – THE GLOBAL SOUTH

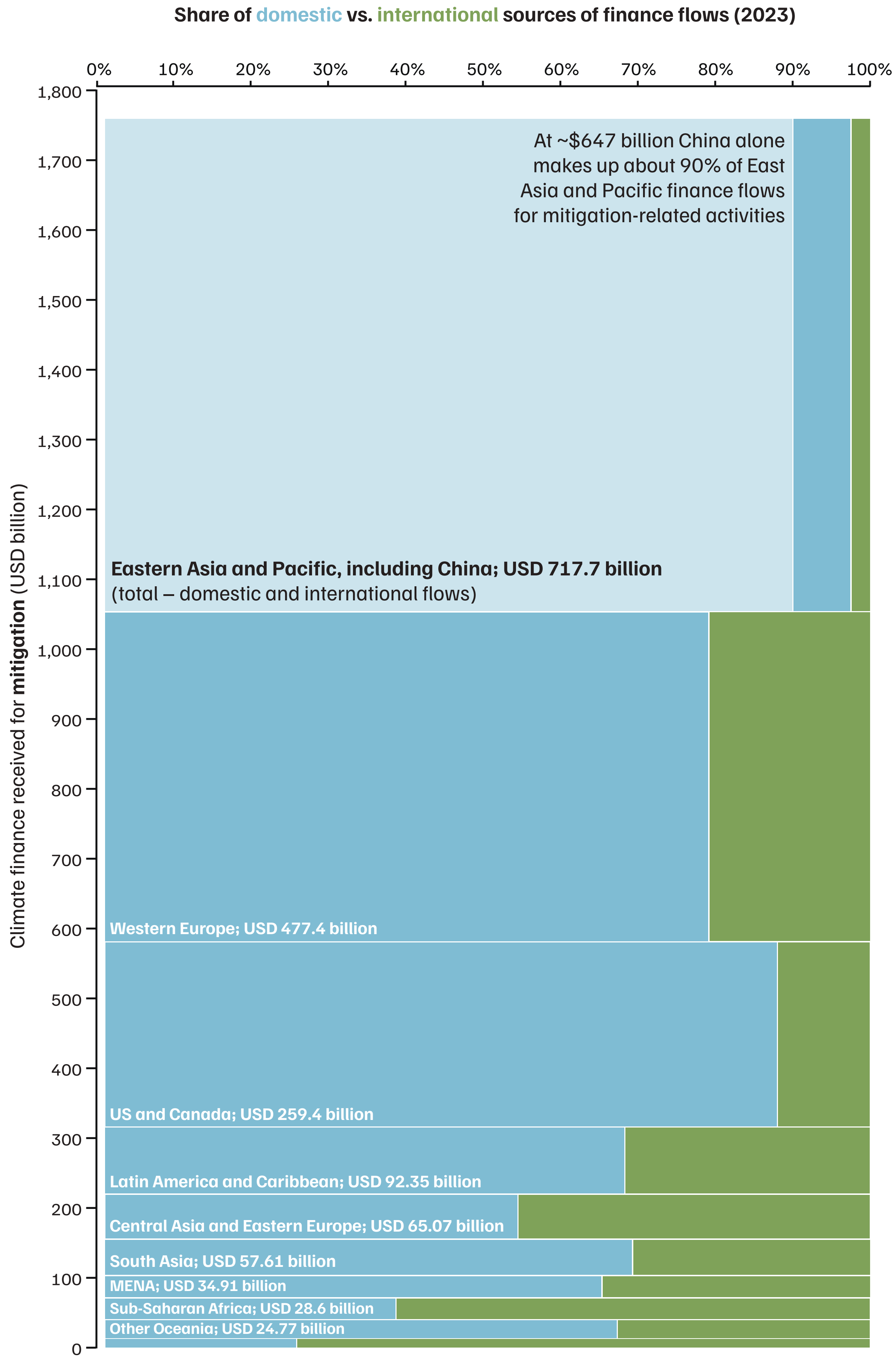
No conversation on exponential climate action can happen without one on exponential climate finance.[1]

Global climate finance reached USD 1.9 trillion in 2023[2] – less than two per cent of the global GDP. Over 90 per cent of this went to mitigation,[3] financing clean energy, transport, and industrial efforts to reduce or prevent emissions. For context, the Independent High-Level Expert Group on Climate Finance estimated in 2024 that developing countries (excluding China) will need USD 3.2 trillion annually by 2035 for climate and nature investments. Of this, USD 1.3 trillion must come from international sources.[4]

International investors often overestimate risks in emerging markets, partly due to information gaps. As a result, they either avoid clean energy projects or demand returns so high that capital becomes prohibitively expensive.[5] Simultaneously, developing countries must balance climate ambition with economic growth. Around 3.4 billion people live in countries that currently spend more on interest payments than on health or education.[6]

At the 29th Conference of the Parties in Baku, developed countries committed to 'taking the lead' in mobilising USD 300 billion annually by 2035 – far below what is needed. The Council estimates that India alone will require about USD 202 billion each year until 2070 to meet its net-zero target.[7] Therefore, mitigation finance in the Global South must be de-risked. One of CEEW's proposals – the Global Clean Investment Risk Mitigation Mechanism – seeks to do this by pooling risk across projects and countries and safeguarding investors against political, currency, and utility-related risks.[8]

Source: Climate Policy Initiative. n.d. "Global Landscape of Climate Finance: Data Dashboard".



MINERALS CRITICAL TO THE CLEAN ENERGY TRANSITION ARE HELD BY A FEW COUNTRIES

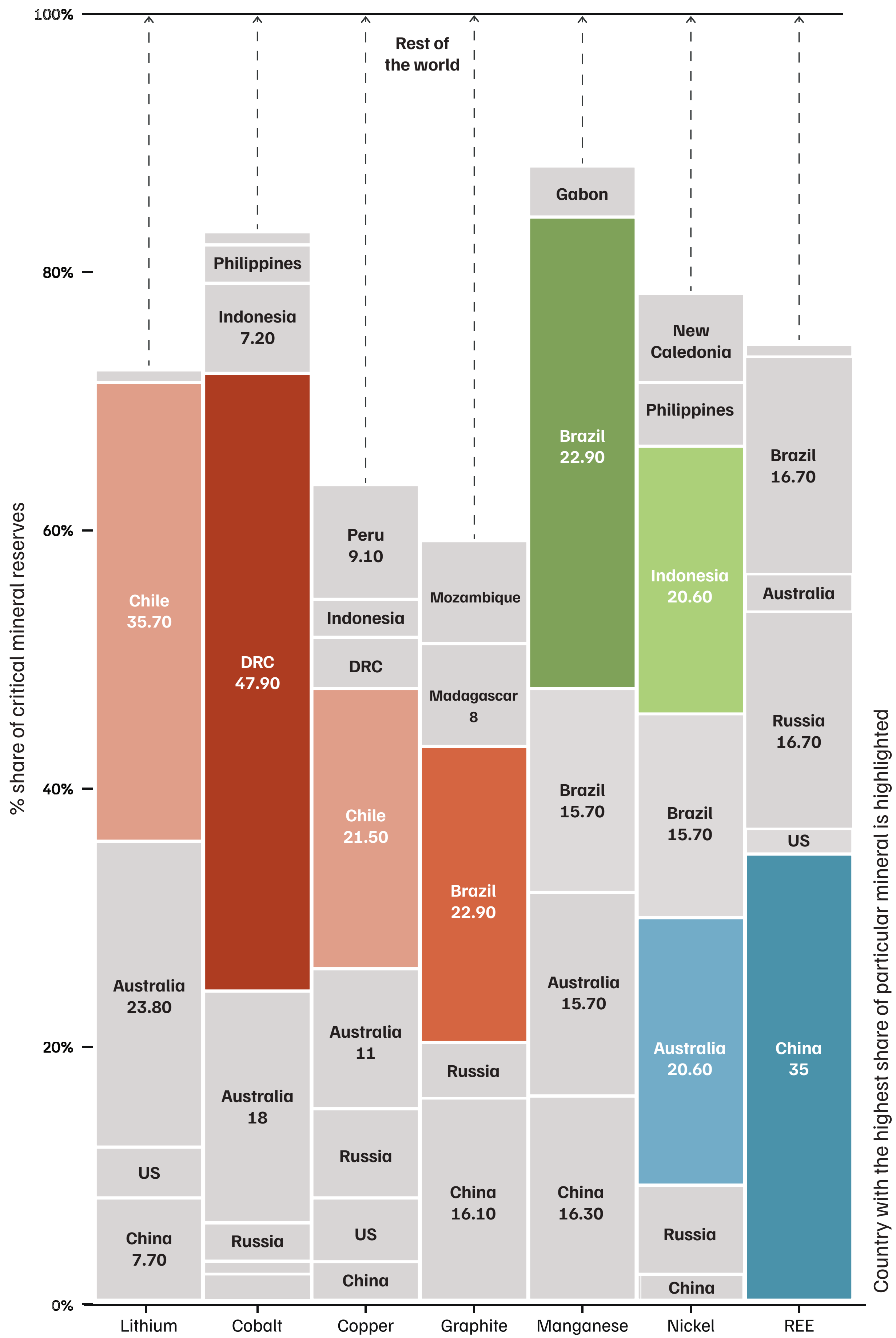
In 2023, India discovered 5.9 million tonnes of lithium reserves in the northernmost region of Jammu and Kashmir.[9] This discovery made it the seventh-largest holder of global lithium reserves at the time.[10] However, reserves alone do not make a battery industry.

Building capacity to extract lithium from reserves can take 12 years; manufacturing batteries from it can take 4 years more.[11] The fastest route will need diversified supply chains and rules-based global collaboration. Fifteen countries host 55–90 per cent of the critical minerals – such as copper, lithium, nickel, cobalt, and rare earths – needed for the clean tech transition.[12] These minerals find applications in solar panels, wind turbines, EVs, standalone batteries, and semiconductors. Further, the same countries produced 75–90 per cent of these critical minerals in 2022.[13]

India possesses commercial-scale reserves of seven critical minerals. Further, it has decades of experience processing base metals, such as iron and aluminium, which can be extended to critical minerals through scaling research, workforce upskilling, and the development of processing hubs.[14]

Oil has shaped the geopolitics of energy security over the past decades. The emerging energy transition paradigm should leave no one behind. We need global guardrails for mining and the use of critical minerals while recognising national sovereignty and environmental and social imperatives.[15]

Source: CEEW, IEA, UC Davis, and WRI India. 2023. Addressing Vulnerabilities in the Supply Chain of Critical Minerals. Council on Energy, Environment and Water.



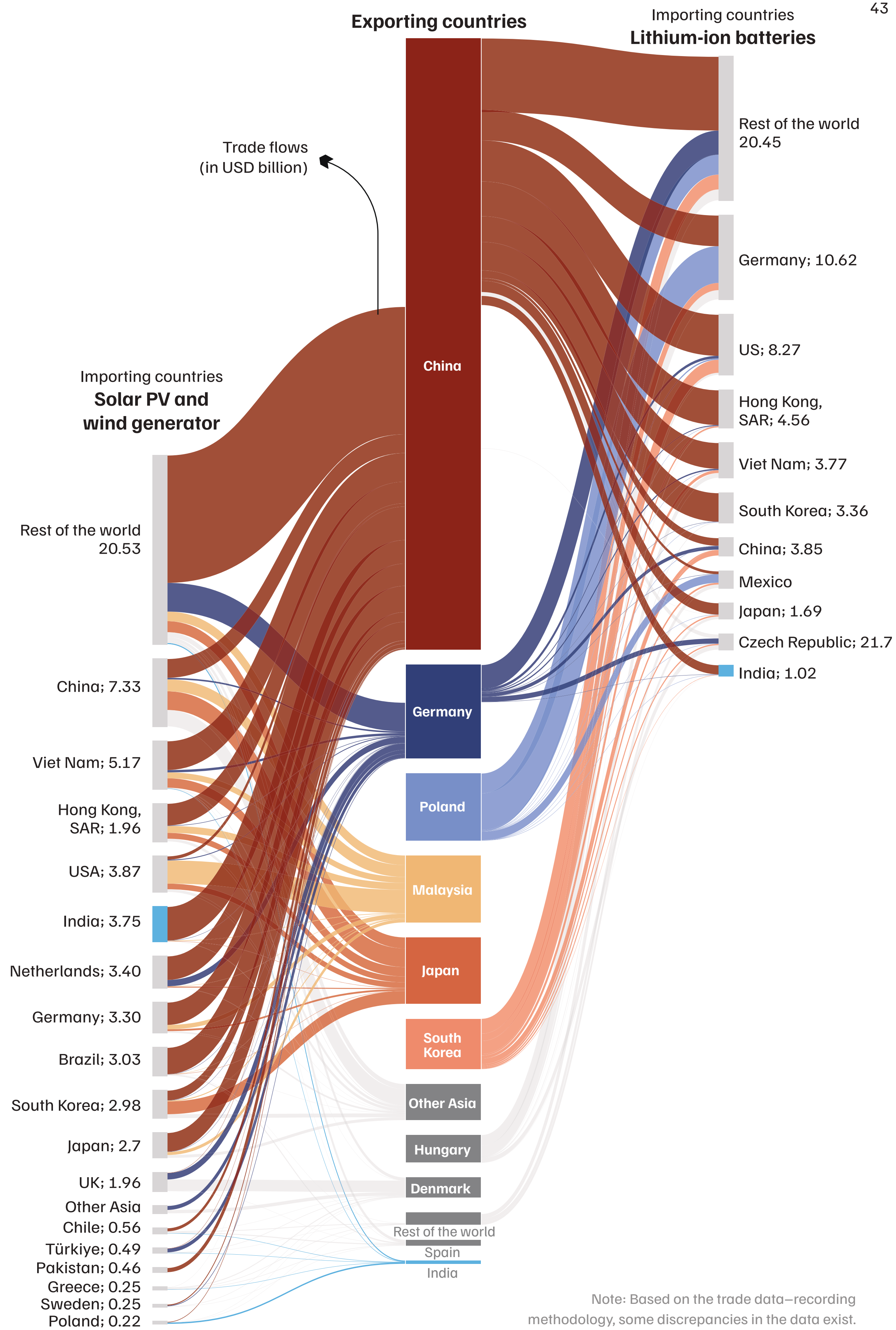
Note: DRC = Democratic Republic of the Congo; REEs = rare earth elements.

THE CLEAN TECHNOLOGY BOOM IS CURRENTLY RUNNING ON CONCENTRATED IMPORTS

Concentration in clean energy isn't just about minerals. It extends down the value chain to the very technologies built on them.

Four countries – China, Malaysia, Japan, and Germany – made up 70 per cent of global solar photovoltaic exports between 2012 and 2021.[16] Similarly, China, Germany, Denmark, and Spain made up more than 80 per cent of global wind generator exports in the same period.[17] Lithium-ion batteries are even more skewed. China now accounts for nearly half of the global battery trade, even as the shares of other major exporters, such as South Korea and Japan, have declined between 2012 and 2021.[18]

This is happening alongside falling technology costs and a sharp rise in global trade in these technologies since 2017. For instance, global trade in solar cells and modules reached around USD 70 billion as of 2021, even as per-unit prices have fallen sharply.[19] The number of countries importing more than USD 10 million worth of these products has risen by nearly 30 per cent between 2012 and 2021. Yet, a G20 report finds that nearly 70 per cent of importers continue to have a concentrated import mix, a trend that has only intensified with time.[20]



Source: Tyagi, Akanksha, Dhruv Warrior, Disha Agarwal, Hemant Mallya, Karthik Ganesan, Rishab Jain, et al. 2023. Developing Resilient Renewable Energy Supply Chains for Global Clean Energy Transition. Council on Energy, Environment and Water.

Note: Based on the trade data–recording methodology, some discrepancies in the data exist.

THE FINAL FRONTIER OF THE ENERGY TRANSITION - CLEANING UP HEAVY INDUSTRIES

India is the second-largest producer of steel and cement in the world, together responsible for over 500 million tonnes of carbon dioxide emissions each year.[21,22]

Rising incomes, rapid urbanisation, and expanding infrastructure mean that much of India is still being built. Steel and cement remain critical to this story. However, to achieve net-zero emissions, they must be manufactured far more sustainably. The steel industry alone emitted nearly 300 million tonnes in 2021–22. These emissions were largely generated by coal-based reduction, a complex process the industry is locked into.[23] CEEW estimates that decarbonising existing steel plants will need USD 283 billion in capital investment (CAPEX) and USD 8.8 billion in operating costs (OPEX) every year.[24]

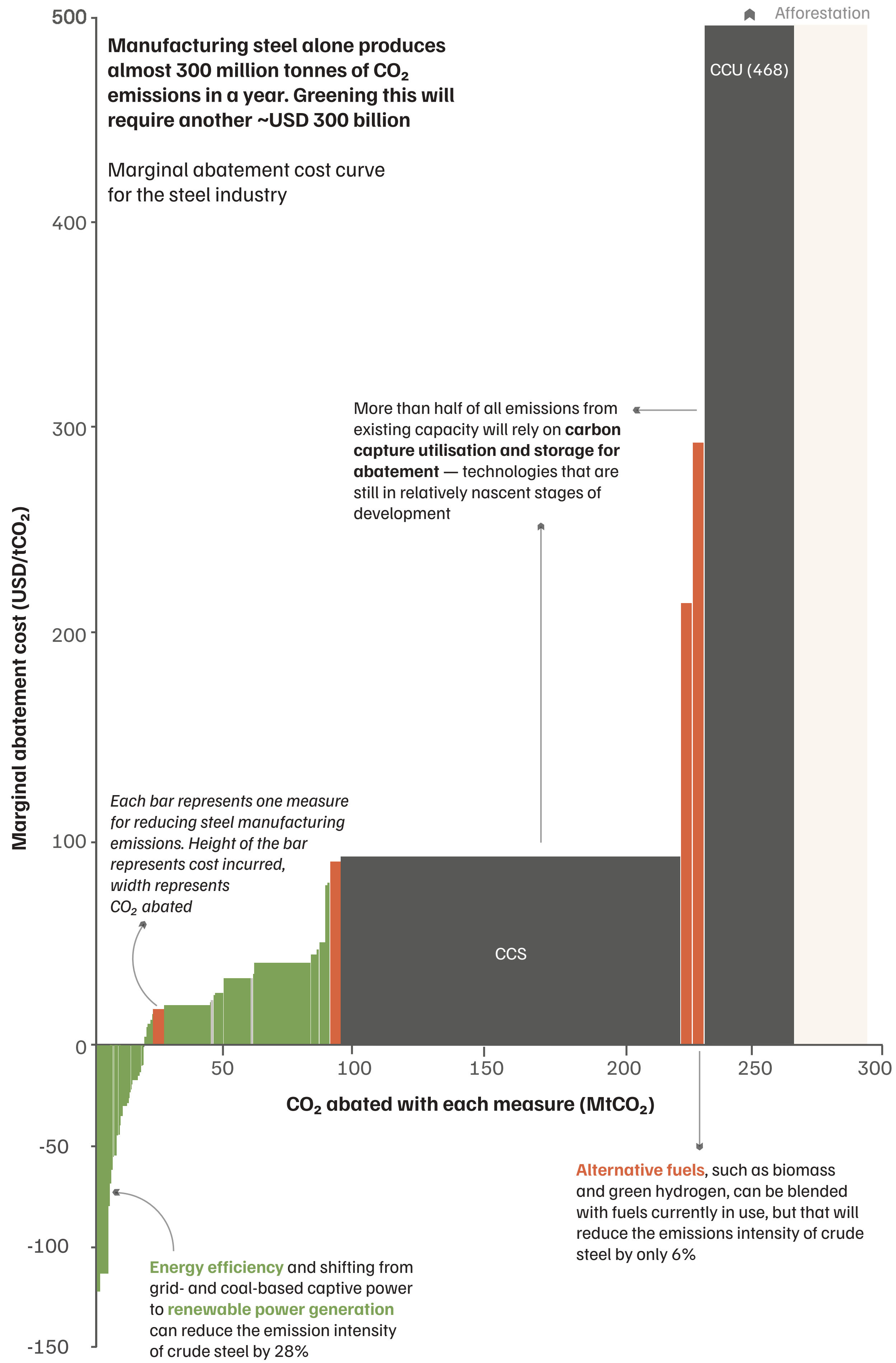
Cement is no easier. Its decarbonisation will require USD 334 billion in CAPEX and an additional USD 3 billion in OPEX annually.[25] Over half of these emission cuts depend on technologies that are not mature, such as carbon capture, utilisation, and storage (CCUS), making near-net-zero steel up to 70 per cent[26] and cement up to 107 per cent[27] costlier than today's prices.

Cleaning up heavy industries also demands concessional international finance, round-the-clock renewable power,[28, 29] and affordable factory-floor logistics. Without this, India risks being locked into carbon-intensive growth. With it, the country can prove that even the hardest-to-abate sectors could be the green backbone of India's industrial future.

Source: Nitturu, Kartheek, Pratheek Sripathy, Deepak Yadav, Rishabh Patidar, and Hemant Mallya. 2023. Evaluating Net-Zero for the Indian Steel Industry: Marginal Abatement Cost Curves of Carbon Mitigation Technologies. Council on Energy, Environment and Water.

Manufacturing steel alone produces almost 300 million tonnes of CO_2 emissions in a year. Greening this will require another ~USD 300 billion

Marginal abatement cost curve for the steel industry



BETWEEN HEAT AND RAIN, CLIMATE RISKS ARE COMPOUNDING THE DECARBONISATION CHALLENGE

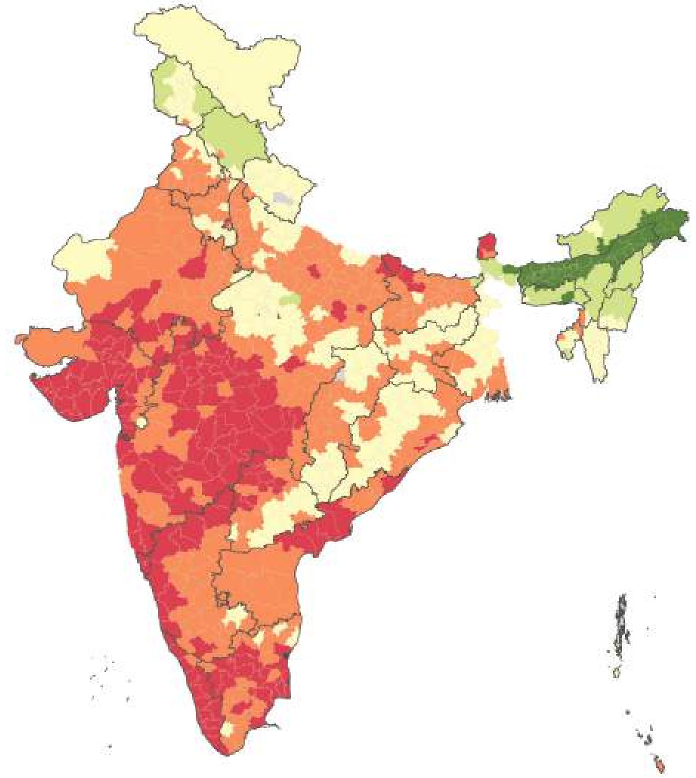
Three-fourths of India's districts are vulnerable to extreme climate events, including floods, cyclones, and droughts. More than 80 per cent of the country's population lives in these districts.[30]

CEEW's heat-risk index – based on four decades of data across 734 districts and 35+ indicators – shows that 57 per cent of the country's districts, which are home to ~1.1 billion people, face high to very high heat risk.[31] This is the context in which India's energy transition is unfolding. Dense urban districts such as Mumbai and Delhi, and those across the agriculturally important Indo-Gangetic Plains, face the greatest exposure.[32]

For outdoor workers – especially those in agriculture, construction, and the gig economy – rising heat and humidity impair the body's natural cooling mechanism, compounding health risks.[33] The International Labour Organization estimates that by 2030, India could lose the equivalent of 35 million full-time jobs to heat stress,[34] turning it into a productivity crisis. Rainfall patterns are also shifting. Nearly a quarter of districts, including Bengaluru, Jaipur, and Indore, saw both deficient and excessive rainfall between 2012 and 2022, compared to the previous four decades.[35] When this happens matters even more. Almost all sub-districts that saw rainfall declines did so during June and July – the start of the summer sowing season.[36]

As climate risks rise, India's path to growth must also build resilience through data-driven, locally grounded plans that make cities ready for heat, floods, and the future.[37]

Sources: Prabhu, Shravan, Keerthana Anthikat Sukesh, Srishti Mandal, Divyanshu Sharma, and Vishwas Chitale. 2025. How Extreme Heat is Impacting India: Assessing District-Level Heat Risk. Council on Energy, Environment and Water; Prabhu, Shravan and Vishwas Chitale. 2024. Decoding India's Changing Monsoon Patterns: A Tehsil-Level Assessment. Council on Energy, Environment and Water



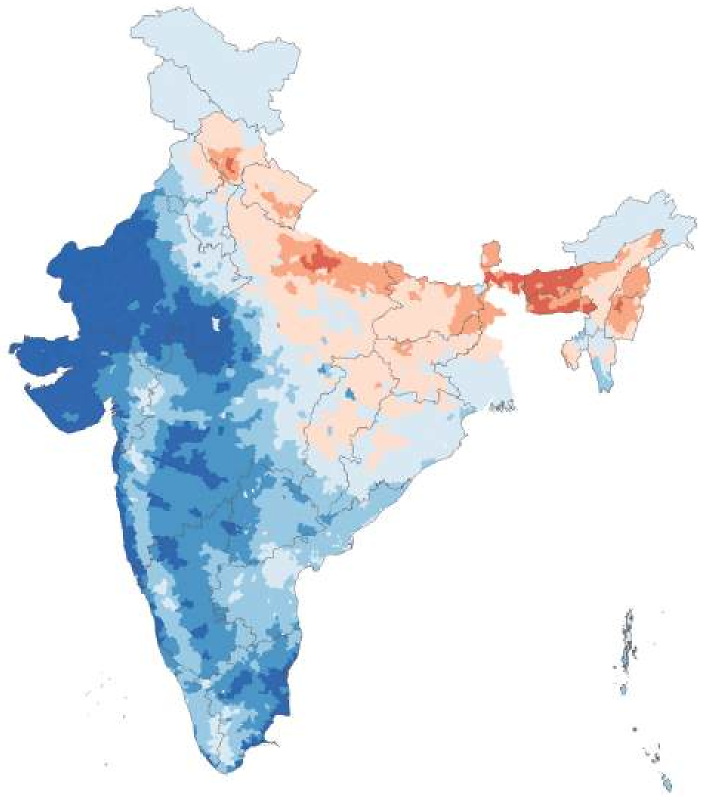
57% of Indian districts, home to three-fourths of the population, now face high to very high heat risk

Many districts in the agriculturally important Indo-Gangetic plains of Uttar Pradesh and Bihar face high to very high risk

On the western coast, Gujarat, Maharashtra, Goa and Kerala are facing the heat with more than 75% of their districts under very high risk

Heat risk index

- Very low risk
- Low risk
- Moderate risk
- High risk
- Very high risk



55% of sub-districts recorded more than a 10% rise in southwest monsoon rainfall between 2012 and 2022

Heavy rainfall days have become more frequent in 64% of sub-districts, especially in Maharashtra, Gujarat, Tamil Nadu, and Karnataka

11% of sub-districts saw a >10% decline in rainfall, mainly in the Indo-Gangetic Plains, northeast, and Himalayas

Changes in southwest monsoon rainfall (%)

- > -30%
- -10% to 0%
- 0% to 10%
- > 30%

4.

WHERE DO WE GO FROM HERE?

WHERE WILL 500 GW OF NON-FOSSIL CAPACITY BY 2030 COME FROM?

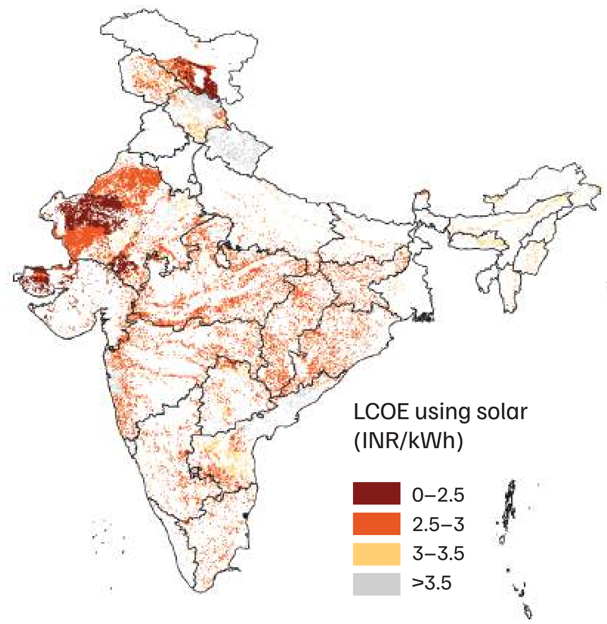
At COP26 in 2021, India announced the *Panchamrit* – five commitments to decouple growth from emissions – including a pledge to go net-zero by 2070.[1]

By 2025, it had achieved half of its installed power capacity from non-fossil sources,[2] reduced the emissions intensity of its GDP,[3] and launched Mission LiFE (Lifestyle for Environment) to advance pro-planet lifestyles.[4] The next milestone is to install 500 GW of non-fossil capacity by 2030.[5] Achieving this will hinge on economics as much as ambition. Analysis of the levelised cost of electricity (LCOE) – the yearly cost of building and operating a power plant per unit of electricity generated – shows where renewables can be deployed most cost-effectively. Rajasthan, Madhya Pradesh, and Maharashtra together hold around 11,000 GW of solar potential below INR 2.8 per kWh.[6] Tamil Nadu has the cheapest wind power up to 50 GW at less than INR 2.65 per kWh, with Karnataka, Gujarat, and Maharashtra offering another 700 GW of low-cost potential.[7]

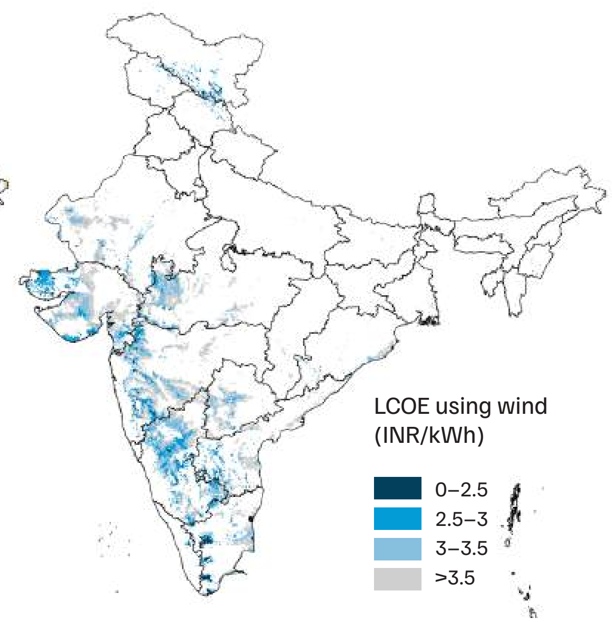
Nuclear power will also play a larger role, with plans to nearly triple capacity to 22.5 GW by 2032. The Indian government has approved expansions of existing and new projects in Andhra Pradesh, Gujarat, Rajasthan, Tamil Nadu, Haryana, Karnataka, and Madhya Pradesh.[8] To meet its 2030 target, India will need to find space for renewables in deserts, croplands, on rooftops, and in its policies – all within the next five years.

Source: Mallya, Hemant, Deepak Yadav, Anushka Maheshwari, Nitin Bassi, and Prerna Prabhakar. 2024. Unlocking India's RE and Green Hydrogen Potential: An Assessment of Land, Water, and Climate Nexus. Council on Energy, Environment and Water and authors' analysis of data from Global Energy Monitor. 2025. "Global Nuclear Power Tracker.

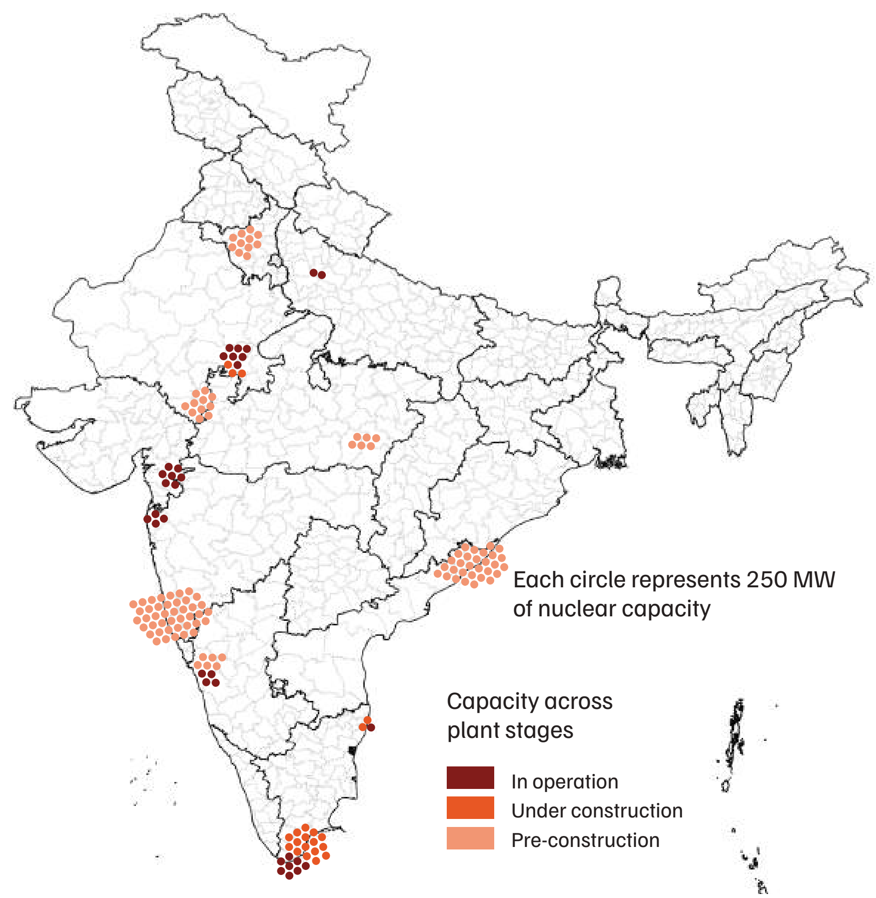
Optimal solar sites
based on levelised cost of electricity (LCOE)



Optimal wind sites
based on LCOE



Nuclear capacity
proposed and operating



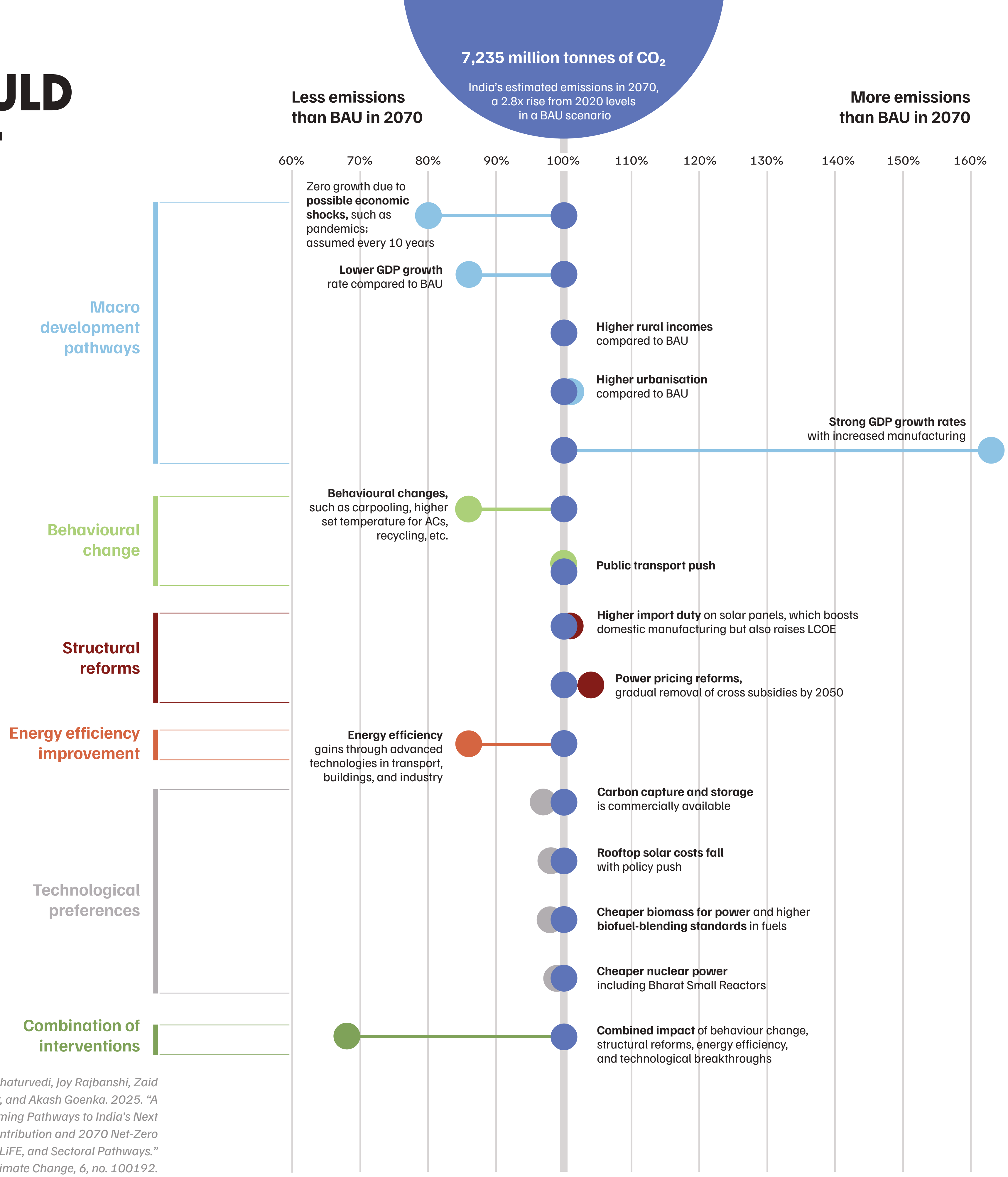
AFTER 2030, WHAT COULD GIVE INDIA THE BIGGEST CUTS IN EMISSIONS?

India is on track to meet its nationally determined contribution of reducing its GDP's emissions intensity by 45 per cent by 2030.[9]

Between 2005 and 2019, it cut its emissions intensity by a third[10]. Further climate emissions modelling suggests a 48–57 per cent decline from 2005 levels by 2030.[11] This reaffirms what India has shown since the Paris Agreement: that growth and emissions reductions can go hand in hand. It also poses the question: What comes after 2030? Researchers modelled 18 scenarios for India's net-zero target, identifying actions delivering the largest emissions cuts. This includes a business-as-usual (BAU) scenario that reflects the country's trajectory under current policies.

Behavioural and lifestyle changes – such as using fewer private vehicles and adopting energy-efficient appliances under the Mission LiFE framework – could deliver more than 10 per cent lower emissions by 2070 compared to BAU, while easing pressure on land resources.[12] Similarly, rationalised lower tariffs for industrial and commercial users could accelerate electrification and clean energy uptake, while higher tariffs for households coupled with targeted support could make rooftop solar more attractive. Even a high-growth scenario would see India's emissions intensity of GDP fall by 3 per cent compared to BAU.[13]

India's current climate policies are expected to cut nearly 4 billion tonnes of carbon dioxide emissions in this decade.[14] After 2030, the question is not just whether India can reduce emissions, but which pathways it ought to take to achieve net-zero emissions.



Source: Das, P., Vaibhav Chaturvedi, Joy Rajbanshi, Zaid A. Khan, Satish Kumar, and Akash Goenka. 2025. "A New Scenario Set for Informing Pathways to India's Next Nationally Determined Contribution and 2070 Net-Zero Target: Structural Reforms, LiFE, and Sectoral Pathways." Energy and Climate Change, 6, no. 100192.

5.

INDIA AND THE WORLD NEED EACH OTHER

WHY INDIA'S TRANSITION MATTERS FOR THE WORLD

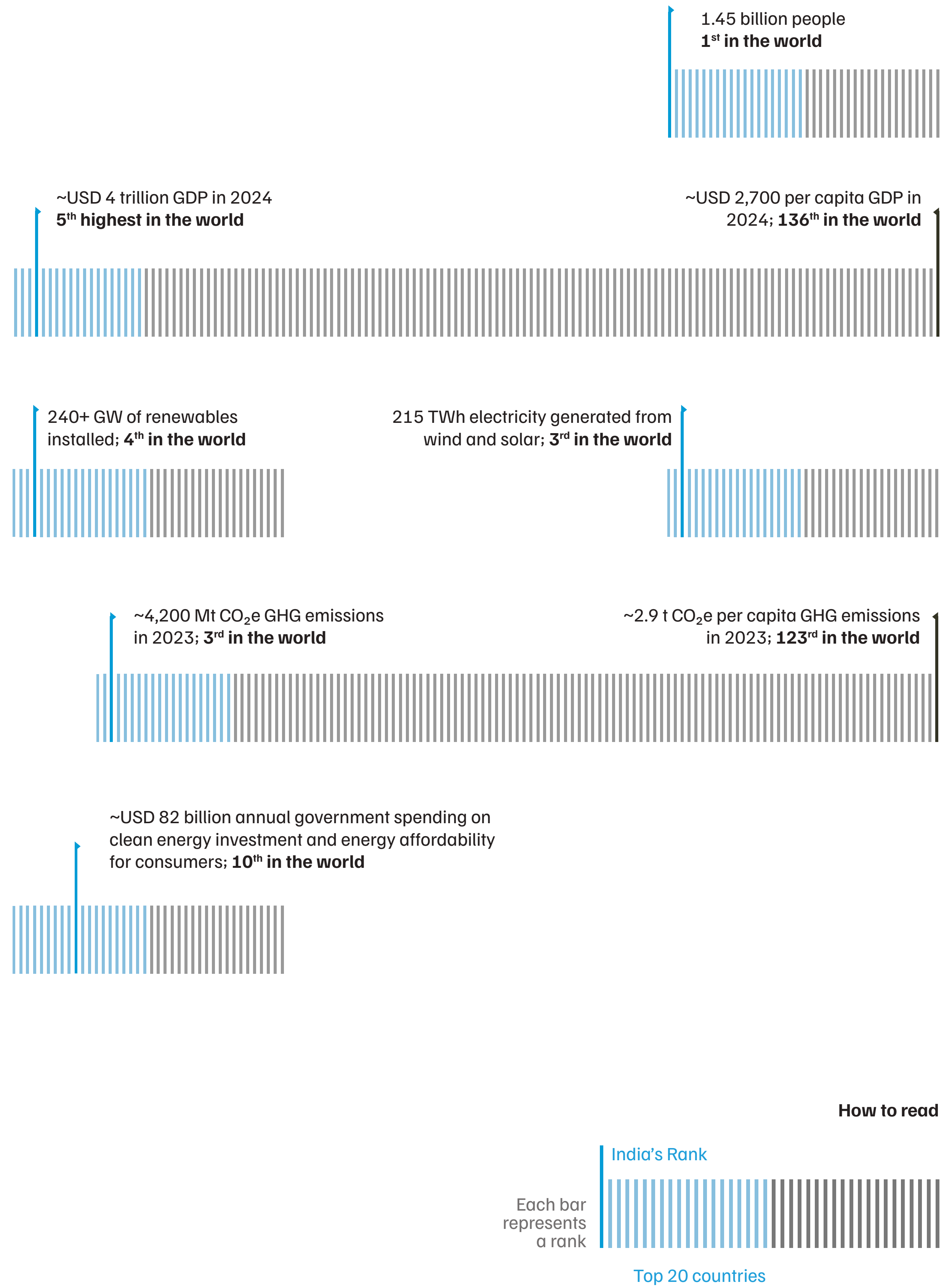
There are many parallel realities in India.

Home to 1.45 billion people, it is the world's largest country[1] and its third-largest emitter, yet it ranks around 123rd in per capita greenhouse gas emissions.[2] For context, the US ranks around 15th and China 25th. By the end of this decade, India is projected to become the world's third-largest economy.[3] This is the backdrop for its energy transition.

However, in India, multiple transitions are unfolding at once: from rural to urban, from traditional to modern energy sources, from growth to sustainable growth, and towards deeper integration into energy markets.[4]

Further, achieving net-zero emissions by 2070 will require average investments of USD 202 billion every year for the next five decades.[5] Few countries are undertaking an exercise of this scale and multitudes. This is the energy transition that can shift 1.45 billion people into a sustainable, low-emissions future. The world has an interest in making sure India succeeds.

Sources: Authors' compilation of data from the World Bank. World Bank Open Data and International Energy Agency. 2024. "Government Energy Spending Tracker: Policy Database." International Energy Agency.



IT'S A PLURILATERAL WORLD AND INDIA COULD LEAD IN IT

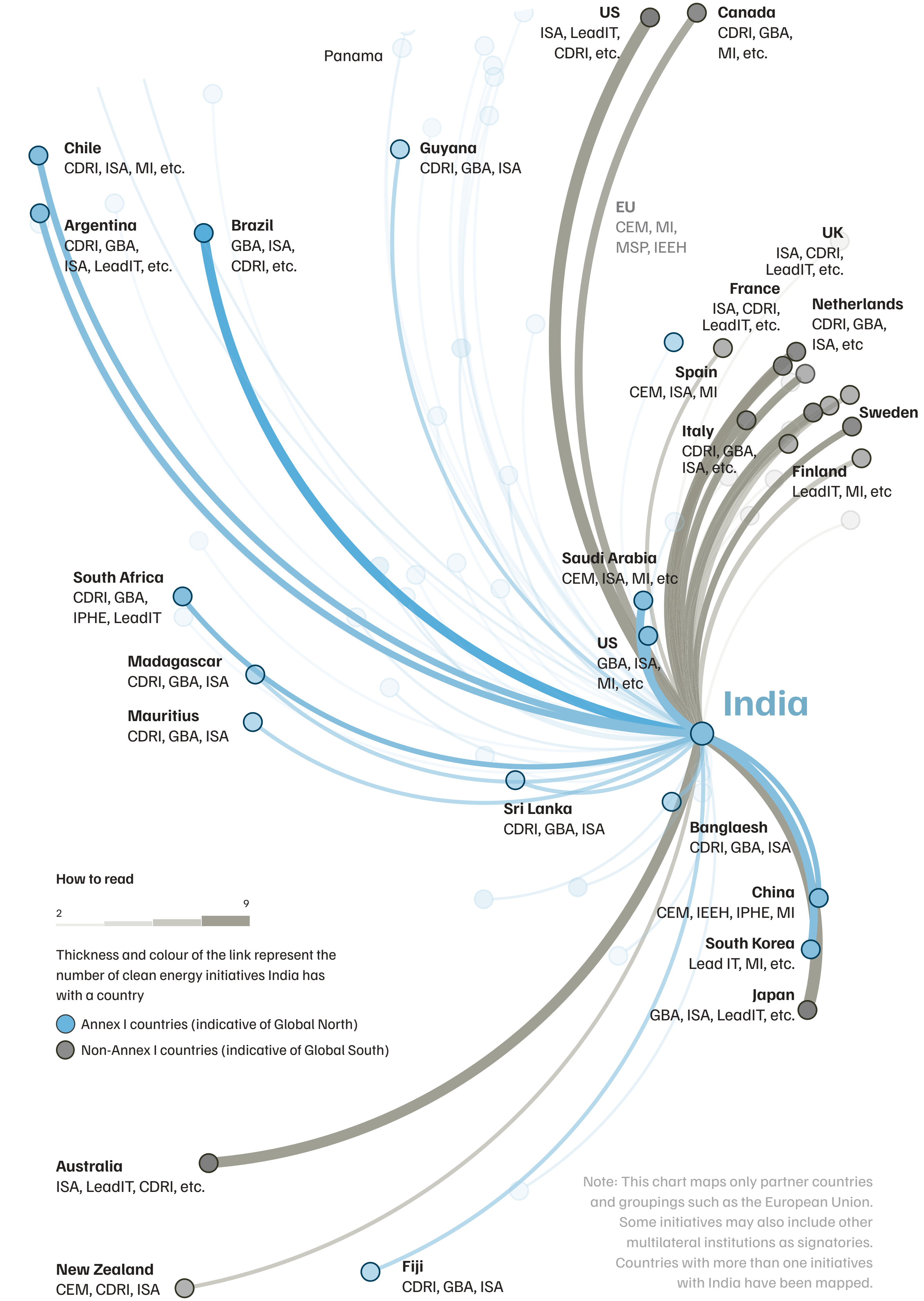
Ten years on, the multilateral world that signed the Paris Agreement is under threat. Economic protectionism, rising debt burdens, and political and geopolitical upheavals have contributed to diluting climate ambitions. Strategic bilateralism and smart plurilateralism could show us the way out.[6]

India has already proven that it is up to the task. From the International Solar Alliance with 120+ signatories[7] launched at the Paris COP in 2015 to the Global Biofuels Alliance announced during India's G20 presidency,[8] the country is providing a litmus test for how the Global South can build and scale durable plurilateral platforms worldwide.

Selected clean energy initatives

Clean Energy Ministerial (CEM)
Coalition for Disaster Resilient Infrastructure (CDRI)
Global Biofuels Alliance (GBA)
International Energy Efficiency Hub (IEEH)
International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)
International Solar Alliance (ISA)
Leadership Group for Industry Transition (LeadIT)
Minerals Security Partnership (MSP)
Mission Innovation (MI)

Initiatives co-launched by India



Source: Authors' compilation based on information from the official websites of the clean energy initiatives mentioned in the visualisation

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1. India needs to transition for the world to transition

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The Council on Energy, Environment and Water (CEEW)—**a homegrown institution** with headquarters in New Delhi—is **among the world's leading climate think tanks**. We use **data, integrated analysis**, and **strategic outreach** to support public policy, transform markets, shape technology, and nudge behaviour. CEEW seeks to explain—and change—the use, reuse and misuse of resources. CEEW addresses pressing global challenges through an **integrated** and **internationally focused** approach. It prides itself on the **independence** of its high-quality research and strives to **impact sustainable development at scale**.

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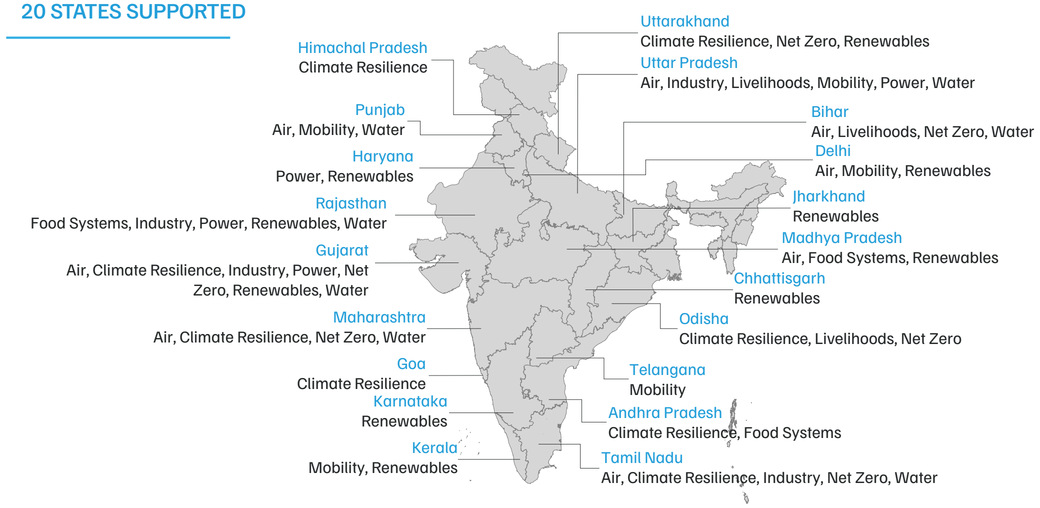
Fuels of the future
Sustainable livelihoods & green economy
Quality of life of citizens
India's story to the world

SELECT POLICY ENGAGEMENTS

NATIONAL/INTERNATIONAL
2011 | National Water Resources Framework
2014 | 175 GW renewables target
2015 | International Solar Alliance
2016 | PM *Ujjwala Yojana*
2017 | *Saubhagya* Schemes
2019 | Climate Vulnerability Index
2021 | Net Zero by 2070
2022 | Mission LiFE
2022 | National Bioenergy Programme
2022 | E-waste (Management) Rules
2023 | G20 Green Development Pact
2023 | National Green Hydrogen Mission
2024 | Green Steel Taxonomy
2024 | PM *Surya Ghar Yojana*
2025 | National Critical Mineral Mission
2025 | Rajya Sabha guidelines on crop residue burning
2025 | National Adaptation Plan

STATE
2022 | Rajasthan Organic Farming Mission
2022 | Jharkhand Solar Policy
2022 | Uttar Pradesh *Vidyut Sakhi* programme
2023 | Rajasthan Green Hydrogen Policy
2023 | Uttarakhand Solar Policy
2024 | Net-zero roadmaps for Bihar & Tamil Nadu
2025 | Green Odisha Initiative
2025 | Maharashtra Climate Action Plan 2.0
2025 | 50 Heat Action Plans (GJ, OD, MH, TN)
2025 | Delhi Clean Air Action Plan
2025 | Delhi EV Policy 2.0

20 STATES SUPPORTED



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