Crossing the tipping point

Solar and Storage Case Study

University of Exeter

EEIST

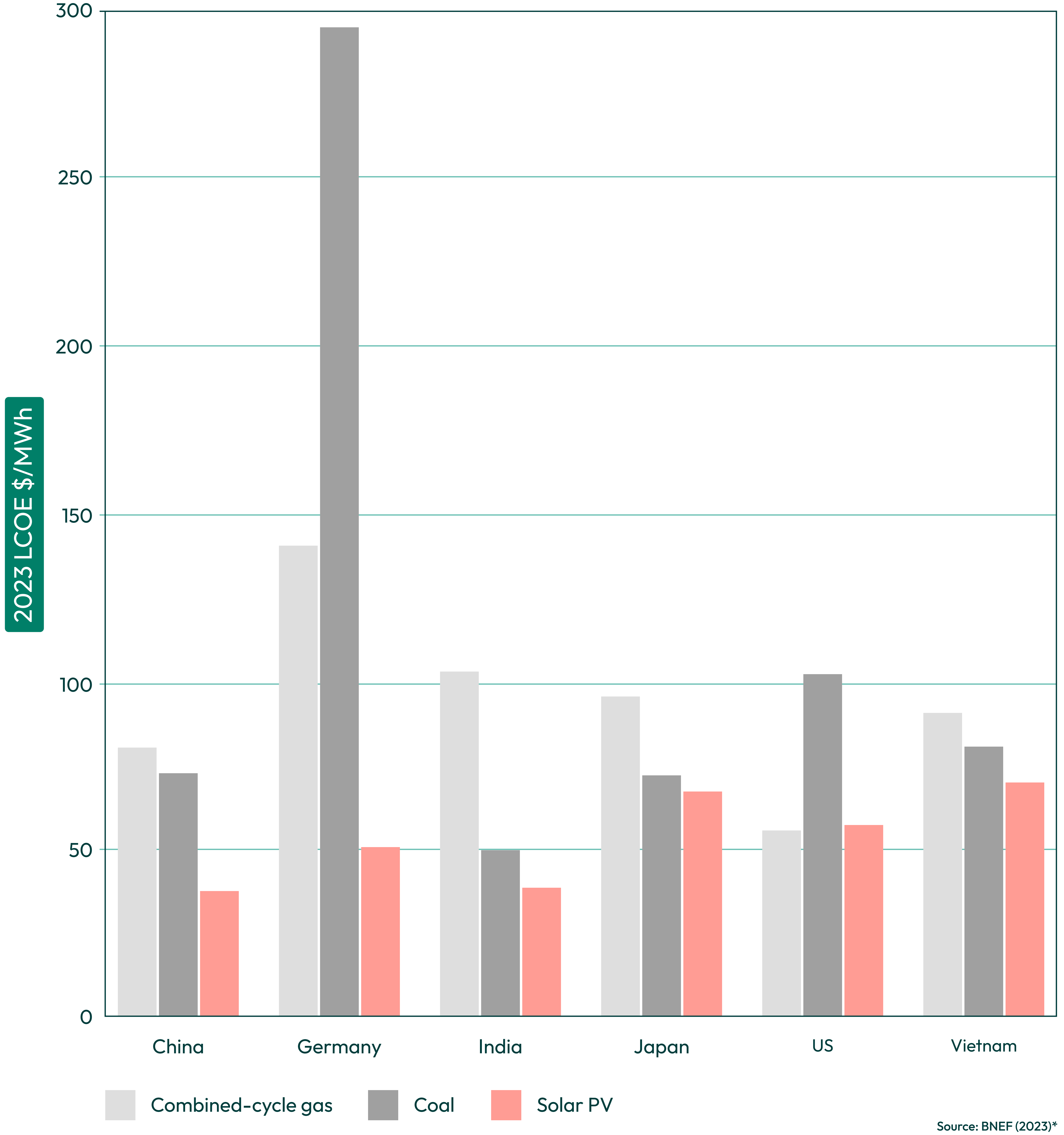
In partnership with

BEZOS EARTH FUND

Tipping point: current status

For five years, new solar PV has been cheaper than new coal and gas in most of the world

- **Electricity from new solar PV is already cheaper than electricity from new coal and gas plants in markets including China, Germany, India, US, Japan and Vietnam.** Solar has a levelised cost of electricity (LCOE)* approximately 1.5 to 2.5 times lower than gas and 2 to 3 times less expensive than coal on average [1].
- **A rapid shift to renewables, with a prominent role for solar, is the most cost-effective way to decarbonise the power system [2].** As a result, solar PV is expected to dominate the mix, reaching 50% of global electricity generation by 2050 [3].
- **The cost gap is widening in renewables' favour,** with the cost of solar falling by 80-90% persistently each decade since 1960, while the costs of fossil-fuels are highly volatile, show no long-term decrease, and may increase in future as depletion is driving extraction from easy to harder-to-reach sources [4].



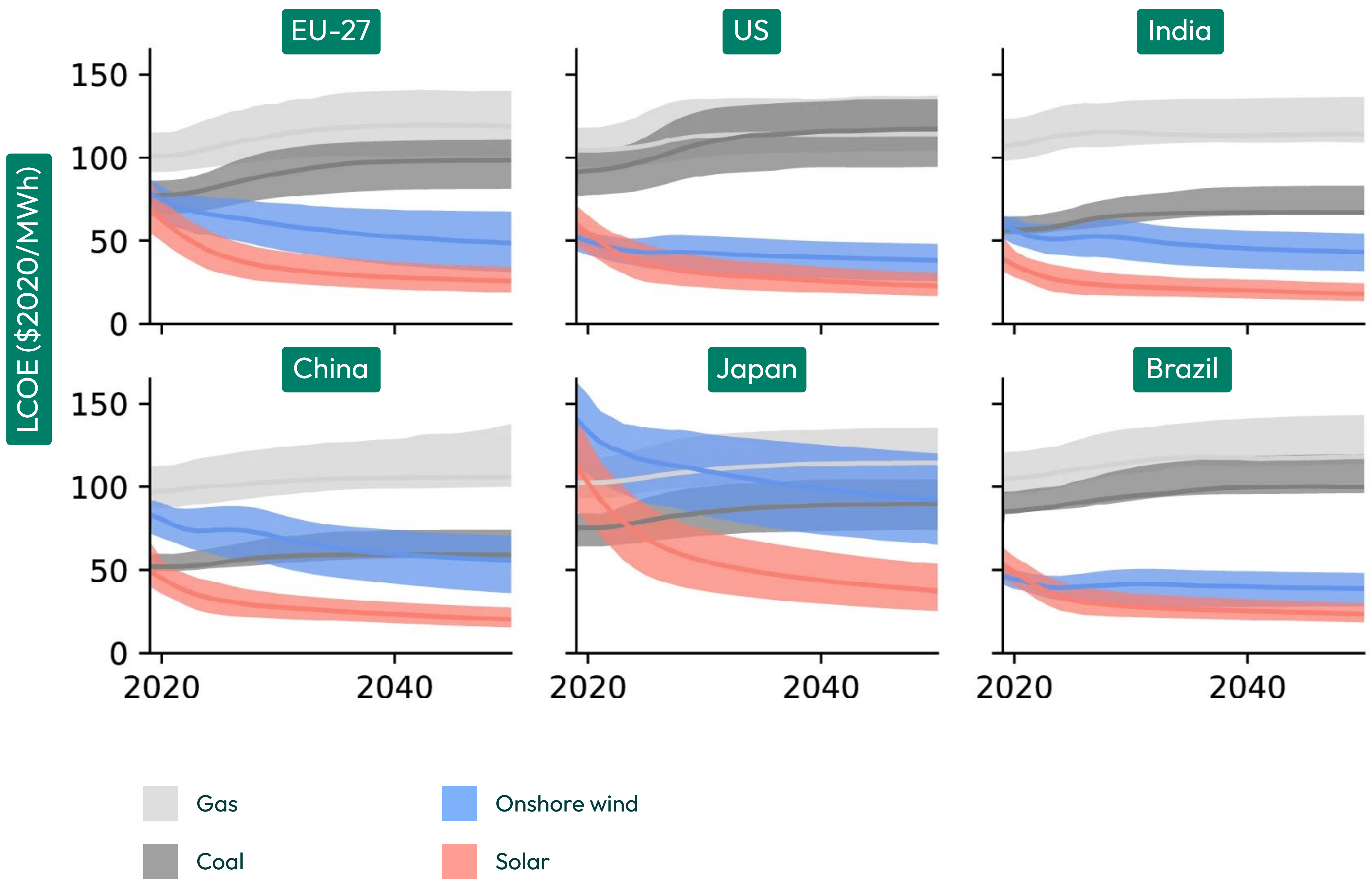
Source: BNEF (2023)*

*LCOE is Levelised Cost of Energy and measures the average net present cost of electricity generation for a generator over its lifetime.

Sources: [1] BNEF (2023) [2] Nijsse at al. (2022) [3] Nijsse at al. (2022) [4] Way et al (2021); Kreps (2020)

New solar power plus battery storage will be half the cost of new coal power by 2030 in the largest markets

- **New solar plus storage is due to become cheaper than new coal in major economies this year (2023), except for Japan, when it should happen in 2025 [1].**
- **New solar plus storage is already cheaper than new gas power in the largest markets, where gas power tends to be more expensive than coal power [2].**
- **By 2030, in China, the US, the EU, Brazil and India, the cost of new solar PV & batteries will be at most half the cost of new coal power [3].**
- **Deployment in the largest markets will help drive down the cost of solar, wind, and batteries for all other countries.** Just five countries – China, the US, Japan, India and Germany – account for 63% of total global solar PV installed capacity [4]. Solar costs fall in proportion to cumulative global production, so these countries play an outsized role in making solar power cheap.

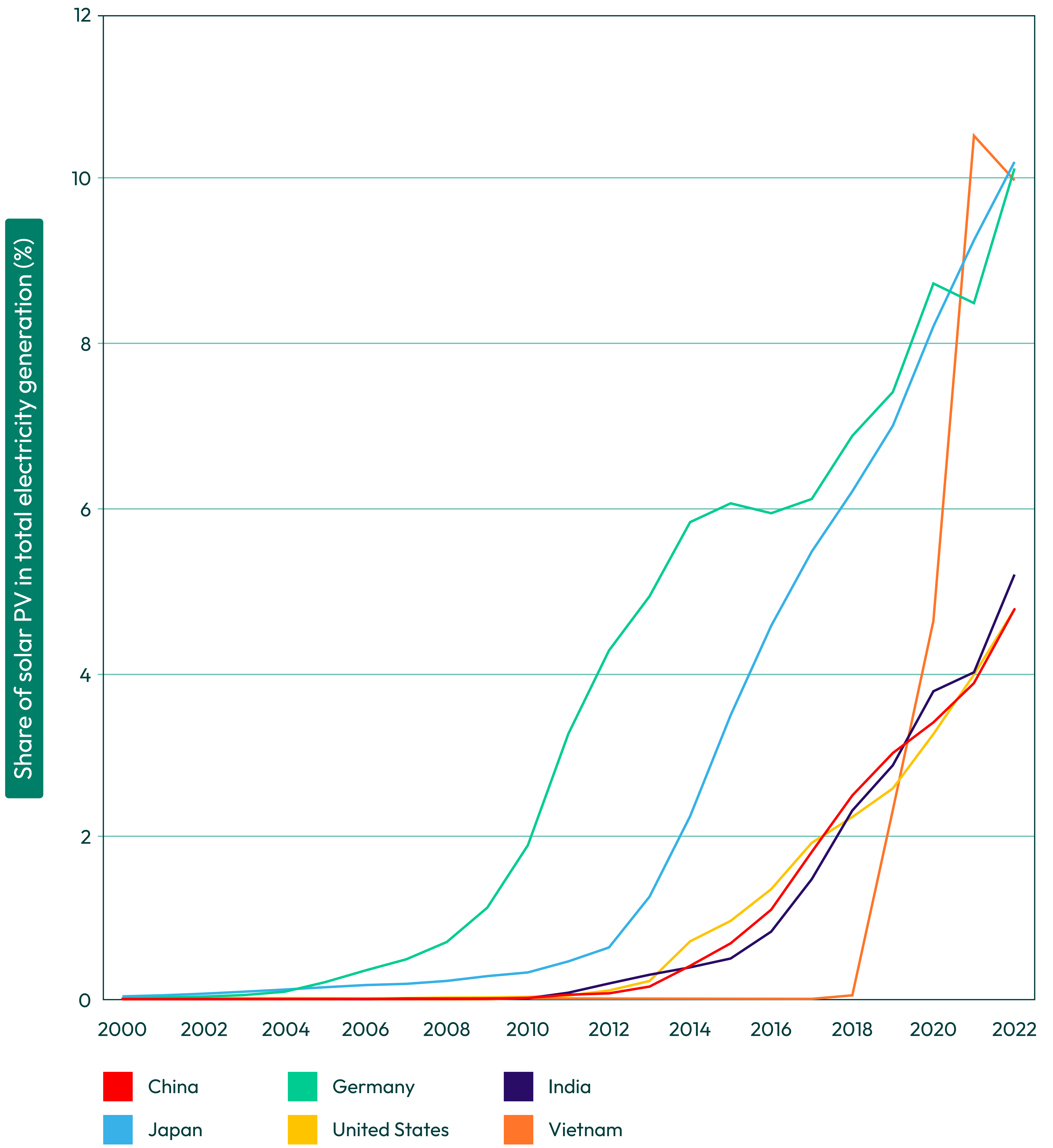


Sources: [1] Nissje et al (2023) [2] Nissje et al (2023) [3] Nissje et al (2023) [4] IRENA (2023)

Effective policies

Progress in the largest markets has been driven by feed-in tariffs; grid expansion is becoming ever more important

- **In Germany, solar PV feed-in tariffs induced large investment flows and cost reductions.** Together with China's investment in solar production and deployment, this brought the technology to mainstream markets [1].
- **In India, the National Solar Mission's** combined use of public procurement, waivers of inter-state transmission fees, grid expansion and specific subsidy schemes for rooftops and riverbanks resulted in the deployment of over 65GW of solar PV by 2022, compared to just 10MW in 2009 [2].
- **Japan implemented feed-in tariffs to diversify its energy mix** after the Fukushima nuclear accident in 2011. This led to solar's share of electricity generation increasing from 0.6% to 10.2% in ten years [3].
- **In Vietnam, a policy mix of targeted investment** including tax breaks and a bold feed-in tariff, and investments into transmission and distribution, drove exceptionally rapid deployment between 2018 and 2022 (though even more transmission lines and an updated pricing policy are now needed) [4].
- **More recently, the US's Inflation Reduction Act is now decreasing costs further** by providing production tax credits to battery cells and solar modules [5].
- **Non-price policies such as expanding grids, speeding up permitting, and incentivising deployment of energy storage are becoming ever more important** to maintain rapid growth in leading markets, while subsidies remain important in less developed markets.



Source: Our World In Data (2022)

Sources: [1] Nijsse at al. (2022) [2] Shrimali & Kekkalapudi (2014); IEA (2023); Government of India (2023) [3] IEA (2021) [4] Rapid Transition Alliance (2023) [5] Bricker & Eckler (n.d.)

Priority policies

Policies to accelerate progress across the solar & storage tipping point

- **Long-term contracts that guarantee demand or price for solar power can accelerate deployment.** These can be in the form of Contracts for Difference, or Feed-in Tariffs (often with Power Purchase Agreements). In the UK, Contracts for Difference provide price certainty for offshore wind, and played a central role in reducing its cost to below that of gas power [1].
- **Reforming power markets can help make best use of the new technologies** For example, China's implementation of time-of-use power prices helped reduce demand at peak times and made distributed rooftop solar economical in cities where it wasn't previously [2]. Policies rewarding energy storage for its role in balancing supply and demand will incentivise further deployment, and cost reductions [3].
- **Grid expansion is crucial, to incorporate higher levels of solar and wind power.** Investments in electricity networks and system flexibility needs to more than double by 2030 [4]. Leading countries are responding to this need. China is investing in ultra-high voltage transmission projects, and India's Green Energy Corridor Phase II is channelling over $1.4 billion into grid capacity additions [5].
- **Accelerated permitting for new solar and wind farms is needed to ensure investment is not held up.** In the US and EU, over 500 GW of solar plants are awaiting permits. The EU has set a target of 2 years to approve new wind and solar plants, but this is still being regularly exceeded [6].

Notes: US, United Kingciom and France show capacity in December 2023; Italy shows capacky in January 2023 and Spain in March 2023; wind inckdes onshore and offshore.

Source: IEA (2023)

Sources: [1] Anadon et al (2021) [2] China Dialogue (2022) [3] Victor, Geels and Sharpe (2019) [4] IEA (2023) [5] IEA (2023) [6] Energy Monitor (2023)

Opportunities for International Coordination

International cooperation can further accelerate the transition to low cost solar

- **The cost of capital is holding back investments in solar in developing countries. Financing costs can determine up to 50% of the cost of solar power in developing countries, deterring investment [1].** By one estimate, because renewables are capital intensive, their attractiveness decreases three times faster than that of gas-fired power plants for each percentage point increase in the cost of capital [2].
- By providing guarantees, advanced economies can reduce investment risks for developing economies, which in turn reduces the cost of their borrowing [3]. International risk guarantees could lower the LCOE by up to $31 per MWh in some regions [4].
- **Interconnectors can decrease the cost of electricity by helping to balance power supply and demand.** Interconnectors link the electricity systems of neighbouring countries and regions, allowing power to be transmitted from where it's abundant to where it's in demand. They make power systems more flexible and reduce the need for coal and gas plants to provide backup generation.
- By one estimate, interconnection could reduce the cost of electricity from 100% renewable-powered grids by around 31% in Europe, and 10% in North-East Asia and North America [5]. In West Africa, an interconnected regional power market could decrease the average cost of electricity generation by 25-33% [6].

Cost of capital across various countries

Country	S&P Rating	Climate Investment Risk Premium (CIRP)	Cost of Debt (Climate Project)	Required Rate of Equity Return (Climate Project)
Germany	AAA	1%	2.8%	8.3%
US	AA+	2%	5.3%	10.3%
Indonesia	BBB	9%	9.1%	14.7%
Brazil	BB-	14%	7.8%	22.2%
Nigeria	B+	17%	25.2%	30.8%
Tunisia	CCC+	23%	36.5%	42.1%

Source: CPI (2023)

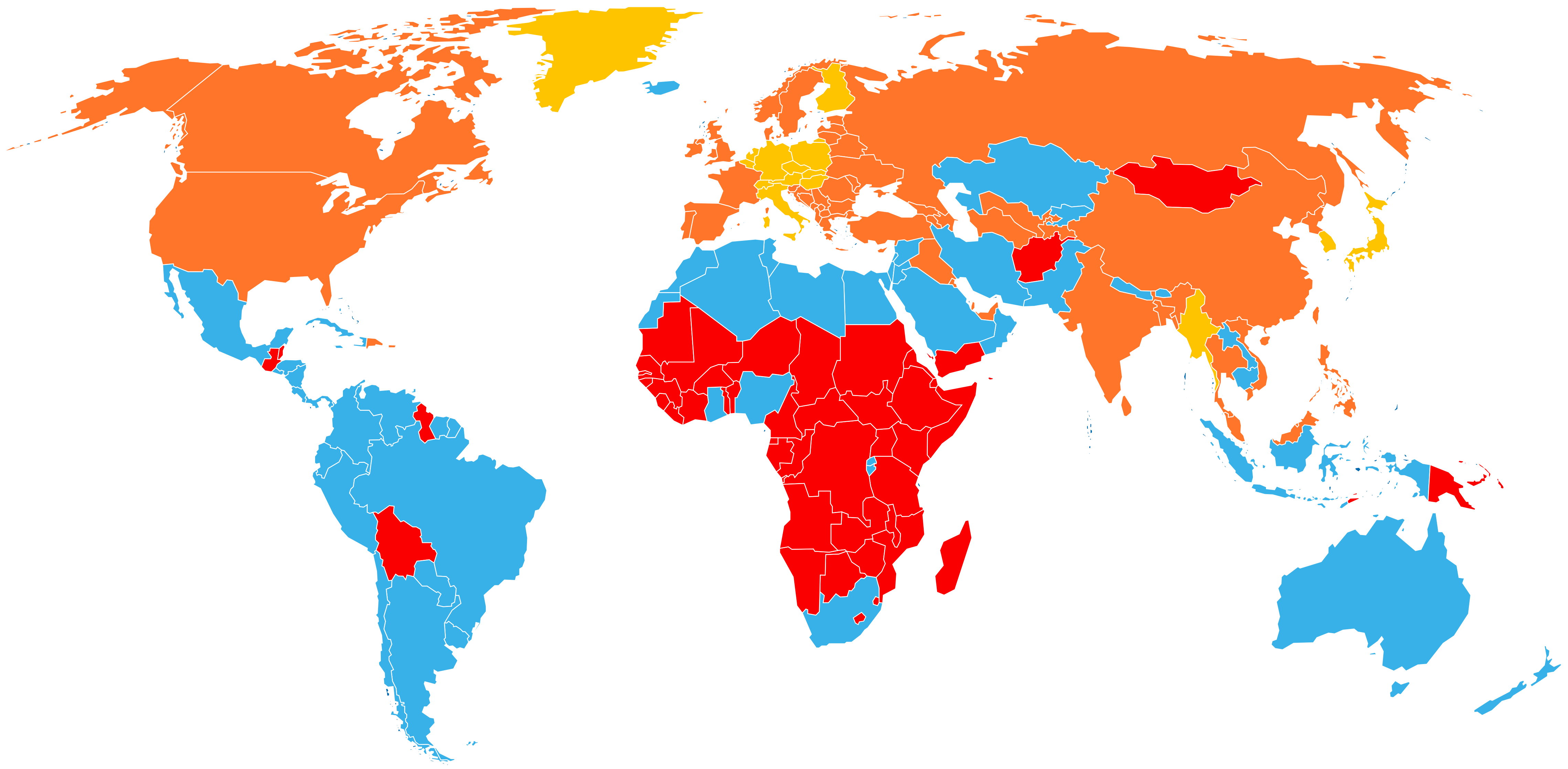
Sources: [1] UNCTAD (2023) [2] UNCTAD (2023) [3] Hourcade et al. (2020) [4] Matthaus & Mehling (2020) [5] Wu et al (2021) [6] World Bank (2021)

More jobs and cleaner air

Accelerating solar PV & storage deployment boosts access to affordable electricity and reduces local air pollution

- **The transition to renewables can cut expensive oil imports, allowing more money to be invested domestically instead.** 60% of people in Africa live in net fossil fuel importing countries, and most of sub-Saharan Africa has more than 1,000 times as much renewable energy potential as energy demand [1].
- **The transition to renewable power is enabling first-time energy access.** Solar-powered mini-grids and standalone systems are now the cheapest way of electrifying remote areas in Sub-Saharan Africa, where 600 million people lack access to electricity [2]. In Bangladesh, 6 million solar home systems have brought access to electricity to 20 million people in rural off-grid remote communities between 2020 and 2018 [3].
- **Being a leader in the transition can be good for jobs and industrial competitiveness.** Solar energy is currently the fastest growing source of new jobs among electricity generation sources, with the number of people in related jobs having increased 45% between 2017 and 2022 to a total of 4.9 million [4].
- **A rapid transition can save lives. Coal-burning is a major contributor to air pollution that is harmful to public health.** An estimated one in five deaths globally every year are attributed to fossil fuel pollution (coal, petrol and diesel), which contributes to asthma, lung cancer, coronary heart disease and strokes [5].

Solar and wind energy potential as a multiple of energy demand



Superabundant: >1,000 times as much technical potential as current energy demand
Replete: >10 times
Abundant: >100 times
Stretched: <10 times

Source: Carbon Tracker (2021)

Sources: [1] RMI (2022) [2] Egli et al (2023) [3] BSS (2018) [4] IRENA and ILO (2023) [5] Vohra et al (2021)

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