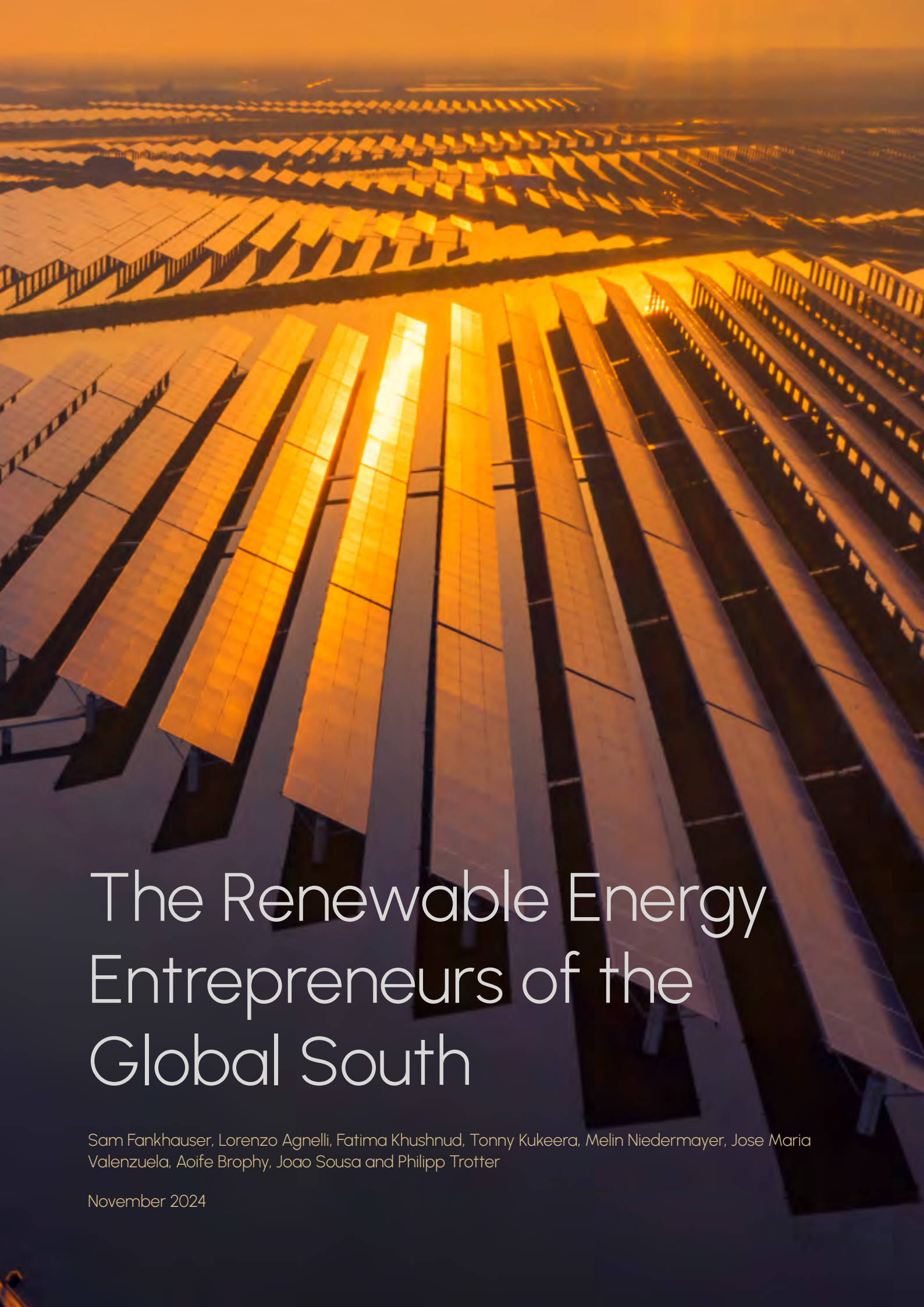

# The Renewable Energy Entrepreneurs of the Global South

Sam Fankhauser, Lorenzo Agnelli, Fatima Khushnud, Tonny Kukeera, Melin Niedermayer, Jose Maria Valenzuela, Aoife Brophy, Joao Sousa and Philipp Trotter

November 2024

## About the Oxford Smith School

The *Smith School of Enterprise and the Environment at the University of Oxford* (SSEE) was established with a benefaction by the Smith family in 2008 to tackle major environmental challenges by bringing public and private enterprise together with world-leading teaching and research. Research at the Smith School shapes business practices, government policy and strategies to achieve net zero emissions and sustainable development. We offer innovative evidence-based solutions to the environmental challenges facing humanity over the coming decades. We apply expertise in economics, finance, business and law to tackle environmental and social challenges in six areas: water, climate, energy, biodiversity, food and the circular economy.

## About this report

This report is Part Two of a three-year research project to consider the renewable energy transition in low and middle-income countries through the lens of renewable energy operators and project developers, complementing current thinking on green finance and the just transition. The first report in 2023 established a baseline of the issues and tested the attitudes of renewables firms to achieving scale. This second report deepens the focus on renewables companies by analysing in more detail the business strategies of, and challenges faced by, local and international renewable energy entrepreneurs.

The views expressed in the report represent those of the authors and do not necessarily represent those of the participating institutions or funders. The report is intended to promote discussion and to provide public access to the results emerging from our research. It has been peer reviewed internally before publication.

## About our partners and funders

Funding for this project was provided by SSE plc, a UK-listed company focussed on developing, building, operating and investing in the electricity infrastructure needed in the transition to net zero. SSE has a long-held vision to be a leading energy company in a net zero world. It understands that the achievement of a just energy transition in the developing world faces a set of challenges that are wholly different to those faced in its own developed world context. SSE hopes that this project will help aid understanding of those challenges and the associated solutions in order to accelerate the clean energy transition globally.

The project was also supported by Sustainable Energy for All (SEforALL), an international organisation that promotes faster action towards the achievement of Sustainable Development Goal 7. It was carried out in collaboration with the Climate-Compatible Growth (CCG) programme, which is sponsored by the UK Foreign, Commonwealth and Development Office.

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Shams Power Pakistan, On site installation at Shams Power's Rooftop.Photo credit: Shams Power Limited, Solar EmpowHer.

# Executive summary

**An agile, diverse cohort of renewable energy entrepreneurs is emerging.**

The transition to renewables is not just about new technology. The rise of renewables has engendered a new generation of local and international renewable energy entrepreneurs who are reshaping the energy sector. We have identified over 2,300 renewable energy startups in Africa and South Asia alone. Their arrival reflects a dynamic shift towards more agile entrepreneurship, which is reinvigorating the energy space and helping to address otherwise unmet demand through place-based solutions. Challenged by renewable energy startups, established operators are forced to adopt more fluid business models themselves.

**Renewable energy entrepreneurs are adaptable to multiple market contexts.**

Renewable energy entrepreneurs operate in highly diverse business environments and market contexts. They are adapting to these varied conditions. Generation levels are still low, but growing exponentially. Renewable energy generation depends on geographic, social and economic factors. However, leading renewable energy countries, such as Chile, Jordan and Namibia, do not merely exploit their favourable geographic and socio-economic fundamentals. They also have proactive renewable energy policies and a socio-cultural affinity towards renewables, enabling them to punch above their weight.

**Renewables provide more inclusive opportunities than traditional energy systems.**

The diversity of renewable energy entrepreneurship allows firms to respond nimbly to new business opportunities. Solar hotspots combine vibrant startup ecosystems with favourable business conditions. There are dormant opportunities in countries with favourable conditions but limited startup activity. Renewable energy also offers important social opportunities, particularly in terms of energy access and jobs. Modular renewables can reach dispersed communities and low-income consumers more readily than traditional energy systems. With suitable training, renewable energy can also bring attractive jobs to local communities, including for women.

**Disruptive new business models are reshaping the way energy is provided.**

The renewable energy entrepreneurs are introducing new business models and value propositions that are changing the way energy is provided. Renewable energy firms offer a much wider range of products and services than traditional utilities. Large operators provide power at utility scale. Mini-grid companies are experimenting with energy service (servitisation) models to generate additional value. The adoption of alternative payment models, such as pay-as-you-go (PAYG), is facilitating electricity access, often for the first time, to lower-income households. This process of "creative destruction" is good for innovation, growth and socio-economic development.

**Renewable energy entrepreneurship is held back by persistent barriers.**

Renewable energy entrepreneurs still face formidable obstacles, related to finance, planning, grid access, regulation and exchange rate risks. They have been remarkably resilient to these challenges, but their market position is still fragile. Barriers to renewable energy deployment have evolved from the early days, when renewable energy firms were mostly concerned about technology risks and costs. Today, renewable energy entrepreneurs, both local and international, are mostly pre-occupied with governance risks, market risks and macroeconomic risks.

**Ten actionable measures to accelerate the inclusive roll out of renewables.**

Given the dynamism and inventiveness of renewable energy companies and the continuing trend towards ever-lower costs, it is difficult to see how the transition to renewable energy could be stopped. However, the switch to renewables can be delayed or pursued in a way that reduces the benefits to local communities. Speed and justice both matter if we are to meet the objectives of the Paris Agreement and the Sustainable Development Goals. Drawing on last year's report, we set out 10 actionable measures that actors in the energy sector should take to accelerate the inclusive roll out of renewables (Table 1).

# Table 1: Ten actionable measures to accelerate renewable energy deployment

1. **Engaging with stakeholders:** Deep and meaningful engagement with local communities in the design of products and projects, with increasing models for shared value, can maximise renewable development and access to energy.

2. **Localising supply chains:** Shorter supply chains that use local or regional suppliers boost the benefits of renewables to the local economy and mitigate supply-chain risks.

3. **Holding renewable energy auctions:** Renewables auctions are a proven demand-pull measure, which provides revenue security for project operators.

4. **Improving planning regimes:** Project development is held back by cumbersome and non-transparent planning and licensing rules.

5. **Securing grid access:** Investment is needed into physical transmission and distribution capacity, but also into the regulatory arrangements for grid access.

6. **Offering new products and service models:** Solar retailers and mini-grid companies can reach new customers by adapting their business models to market contexts.

7. **Adopting alternative payment systems:** Payment models such as PAYG are facilitating energy access and opening up new markets.

8. **Providing affordable finance:** Access to finance, including working capital, startup support and blended finance are key to renewable energy development.

9. **Providing sovereign risk mitigation:** International firms, in particular, look to development institutions and export credit agencies to help de-risk projects.

10. **Providing currency risk mitigation:** International firms and companies with international supply chains are concerned about exchange rate fluctuations and currency convertibility.

Bangui Windmills. Photo credit: Paolo Dala from Marikina City, Philippines

# 1. Introduction

Renewable energy developers, operators and retailers – the renewable energy entrepreneurs – are the protagonists of the clean energy transition. Their ability to identify, structure, build and operate successful projects is key to scaling up renewable energy investment. Tripling renewable energy capacity by 2030, as called for in the first Global Stocktake under the Paris Agreement,[1] will require sustained annual growth rates of 17%.

Much of the capacity growth will occur in high-income markets, but the expertise of the renewable energy entrepreneurs is arguably even more critical in the low and middle-income countries of the Global South. Here, energy needs are most acute, but the business environment can be difficult.

A new generation of local and international renewable energy firms is emerging across low and middle-income countries. Most of them are still small in terms of business volume, but they are starting to reshape their industry and they actively help to advance global climate and sustainable development goals.

This report is the second in a series that analyses the clean energy transition in low and middle-income countries through the lens of renewable energy firms. In our first report we set out the context and highlighted the importance of project developers and operators in scaling up renewables.[2]

This second report sharpens the developer and operator focus by showcasing the renewable energy entrepreneurs of the Global South. We document the diversity and richness of renewable energy entrepreneurship. We highlight the impact renewable energy firms, particularly solar energy providers, are already having on their sector and their importance in bringing modern energy to currently underserved communities. We discuss the obstacles renewable energy firms face, but also the innovative solutions they are deploying to overcome them. Ten practical steps are put forward to support their success.

The analysis draws on multiple sources, including new evidence gathered for this report:

- We introduce a comprehensive new dataset of renewable energy entrepreneurship in Africa and South Asia, which covers over 2,300 startup companies.
- We carry out statistical analysis to better understand the socio-cultural and policy environment in which renewable energy firms operate.
- We report on 32 in-depth interviews with renewable energy companies that are active in Africa and internationally.
- A focus group with female solar engineers in Pakistan illustrates the potential for inclusive growth.

More details on our analytical approach is provided in the Annex.

# 2. A new generation of energy entrepreneurs

The transition to renewables is not just about new technology. The rise of renewables has engendered a new generation of local and international renewable energy entrepreneurs who are reshaping the energy sector. We have identified over 2,300 renewable energy startups in Africa and South Asia alone. Their arrival reflects a dynamic shift towards more agile entrepreneurship, which is reinvigorating the energy space and helping to address otherwise unmet demand through place-based solutions. Challenged by renewable energy startups, established operators are forced to adopt more fluid business models themselves.

## Renewable energy startups in Africa and South Asia

The renewable energy landscape is much more varied than traditional energy sectors. The latter were organised around economies of scale, which favoured large operators and vertically integrated solutions. Renewable energy lends itself to smaller scales of operation, greater localisation and proximity to markets. Hence there is a natural alignment of many features of this new decentralised system with bottom-up entrepreneurship.

Utility-scale companies, both local and international, prevail in regions with strong electricity demand and well-developed power grids, such as Latin America. But in less developed markets, such as Africa, traditional energy utilities are also challenged by retail-oriented firms, local mini-grids companies and integrated energy service providers.

Most of these market entrants are still small, but they are growing in number. We have identified more than 2,300 renewable energy startups – companies that have entered the energy market after 2010 – across Africa and South Asia.

The highest number of renewables startups are found in the largest economies – India, South Africa and Nigeria. Together with Kenya, these countries have also attracted the highest amount of investment (Chart 1), but funding levels remain low. African startups have received less than 2% of cumulative global investment in renewable energy over the past 20 years.[3]

When analysed relative to GDP, Namibia, Lesotho, Rwanda and Kenya display the highest density of renewables startups relative to their economic size, suggesting that in the right business environment even smaller economies can become leaders in renewable energy. Uganda and Pakistan also have relatively vibrant renewable energy sectors, but in many other countries renewable energy entrepreneurship is still negligible.

The past decade has seen a steady increase in renewable energy startups (Chart 2), and many of the new market entrants remain active today. The average rate of closing a business is estimated at 15.5% over the past five years (2019-2023) and 13.7% over the past ten years (2014-2023).

However, the rates of market entry are levelling off. Macroeconomic and geopolitical trends, the lingering effects of the COVID-19 pandemic, and changes in funding dynamics have created a more challenging environment for new entrants.

The slowdown in market entry goes hand in hand with a steady decline in the average funding per startup. The aggregate funding trend remains positive, but decreased investor confidence and

concerns about startup quality have led to more conservative investment strategies. This means that an increasing number of startups are vying for the same amount of funding. Access to funding remains a binding constraint for many renewable energy firms (see section 6).

In terms of technology choices, solar energy solutions dominate the startup landscape. In Kenya, South Africa, Uganda and Pakistan, four leading startup ecosystems, solar accounts for 60-90% of renewable energy ventures (Chart 3). Wind is typically the second-most prominent technology, except in Uganda, where almost a third of startups focus on bioenergy.

**Chart 1: Renewable energy startups and their funding** (Africa and South Asia, as of September 2024)

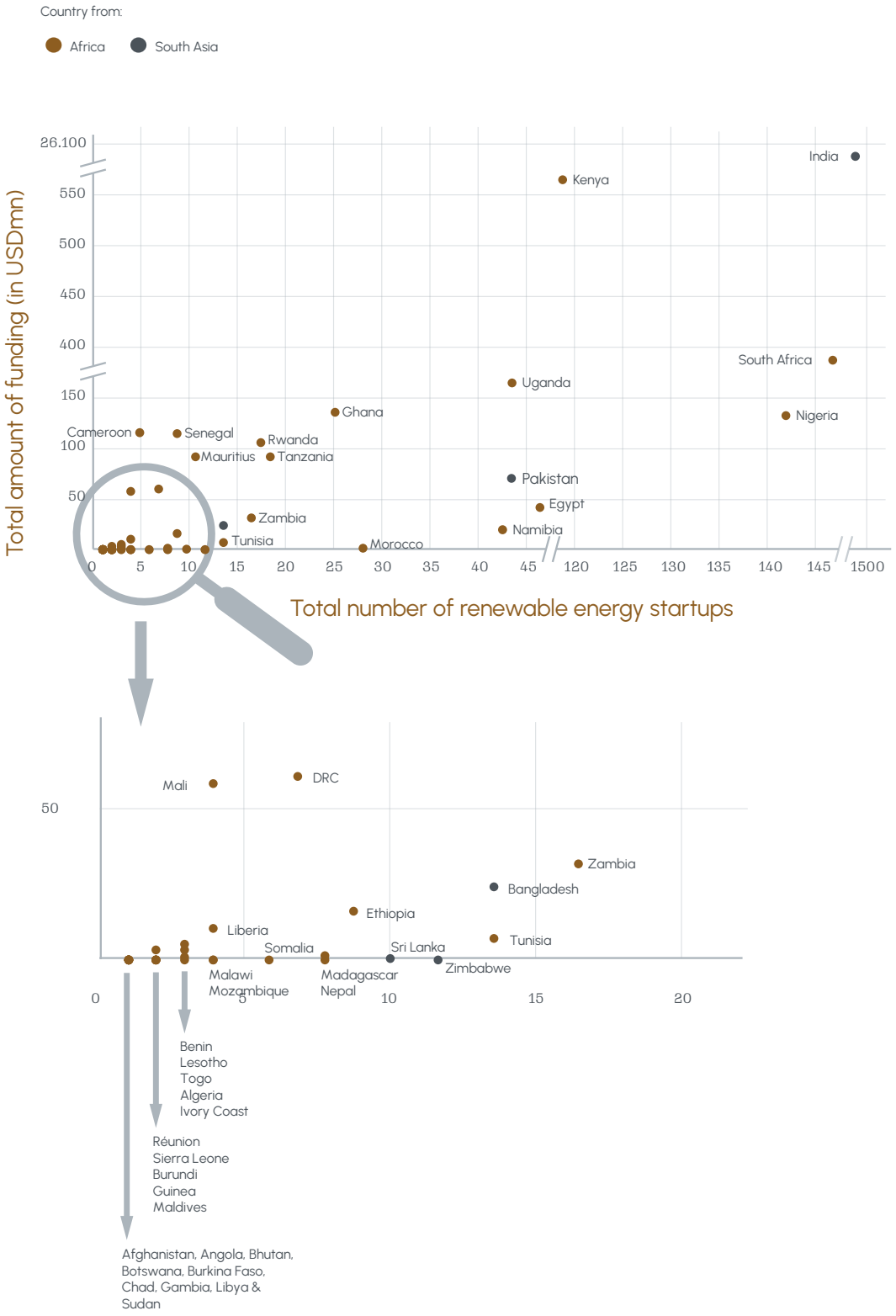
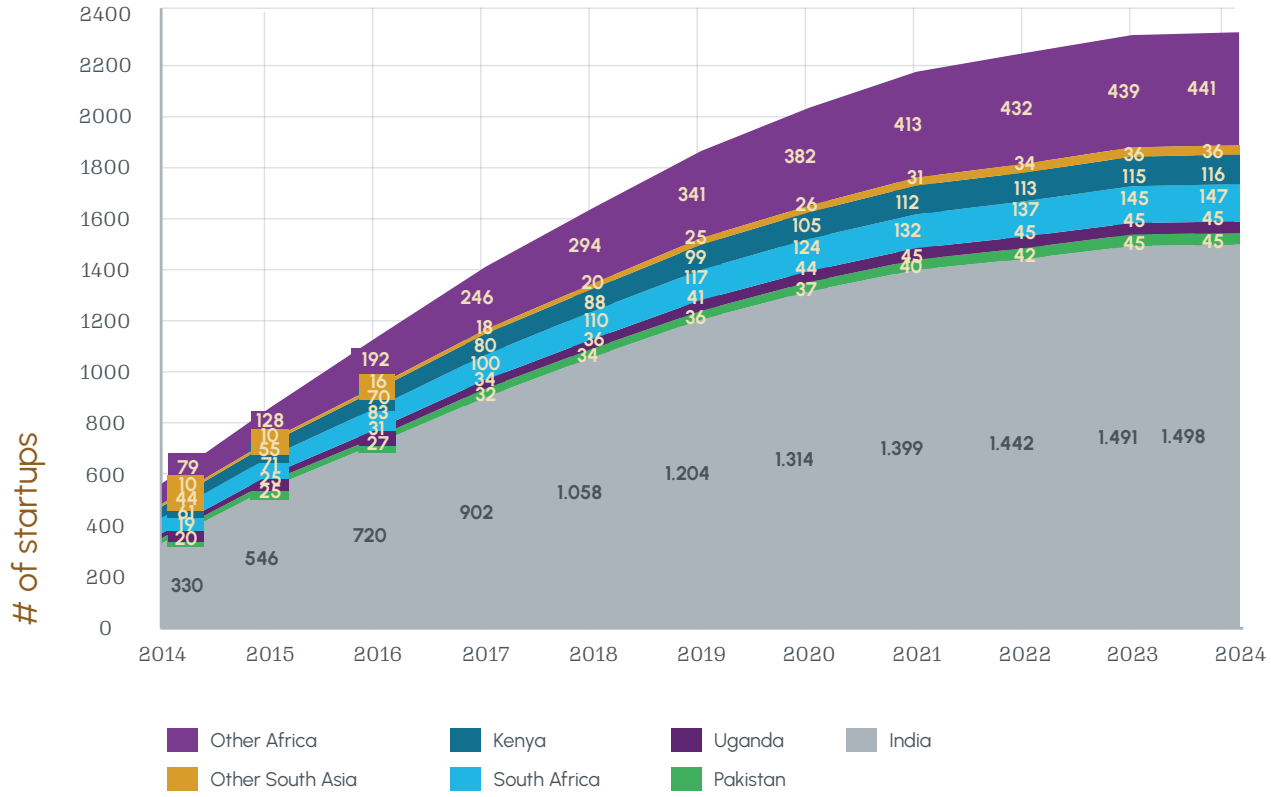


**Chart 2: Trend in renewable energy startups** (2014-23)

(a) Trend in absolute numbers




(b) Trend in average funding per start up

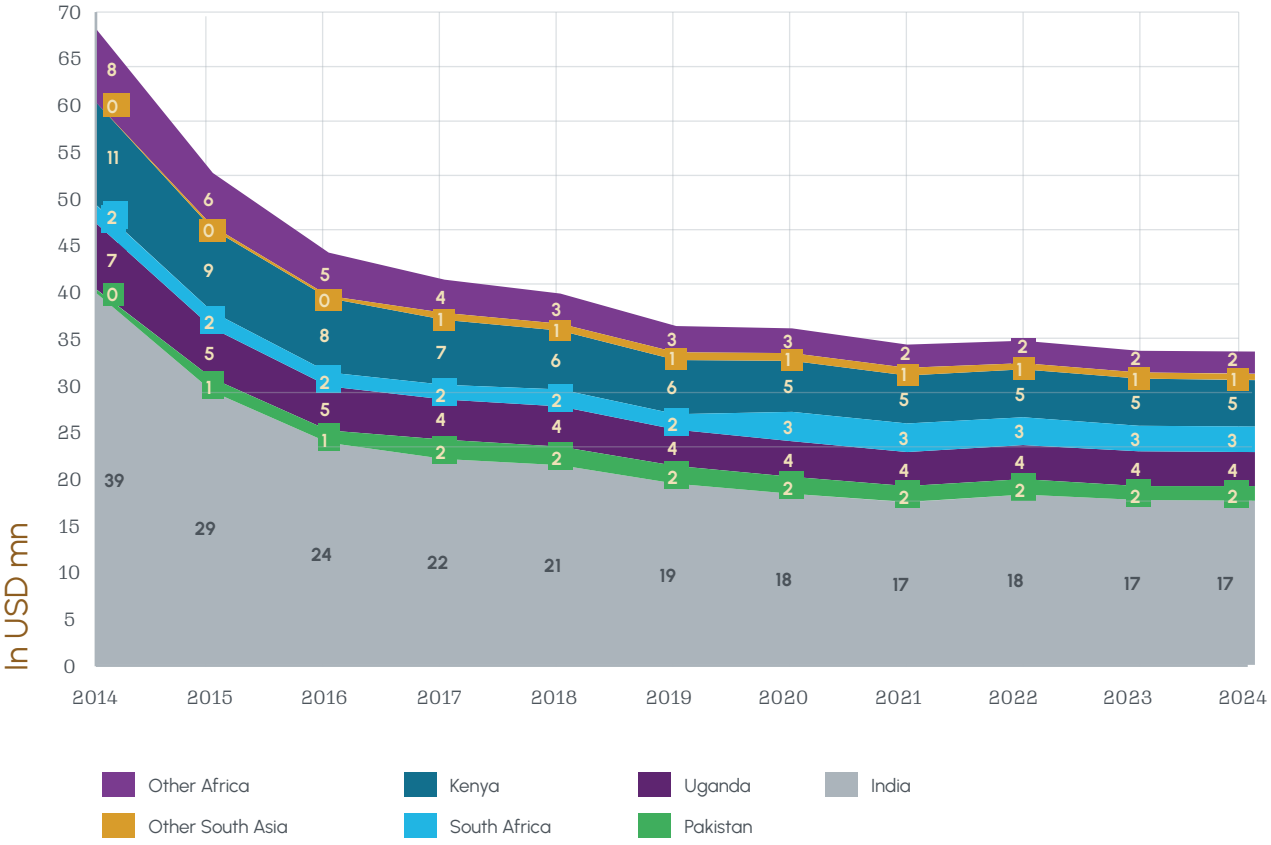
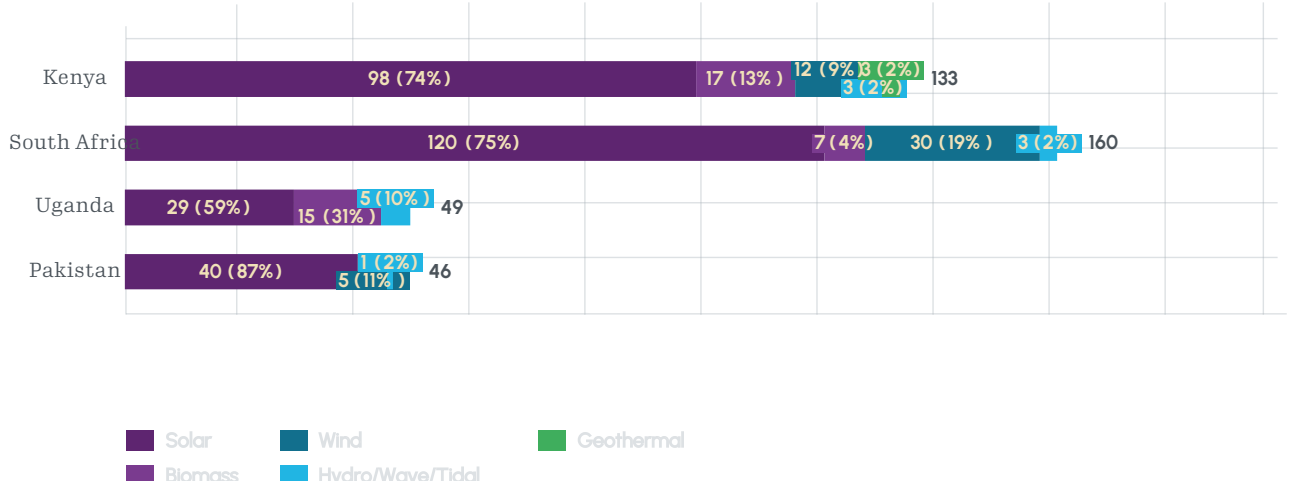
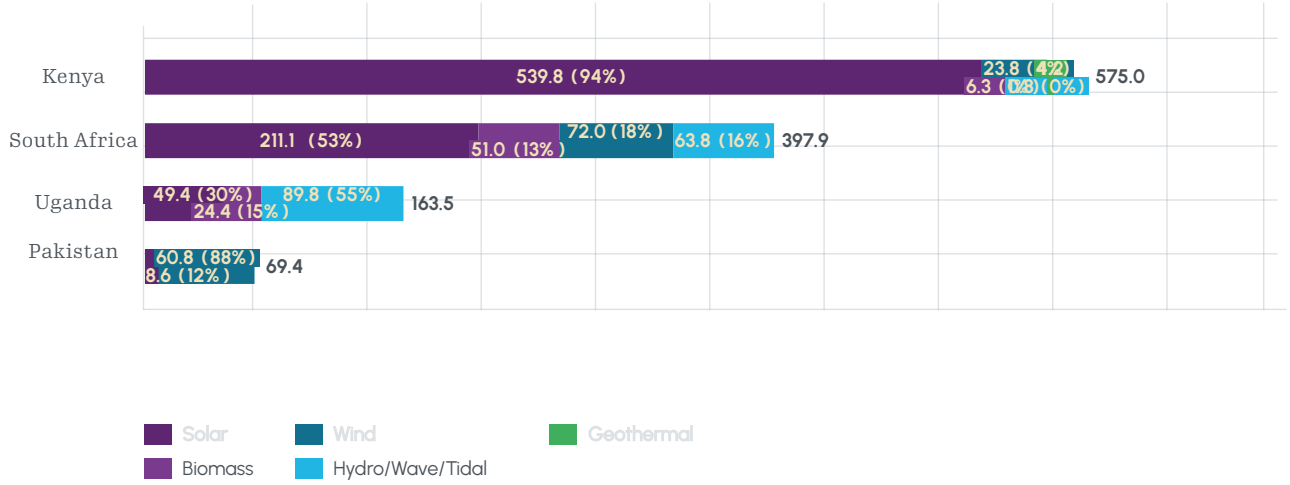


**Chart 3: Renewable energy startups by technology choices**

(a) by number of startups




(b) by investment (USD mn)




## An emerging economic force

Renewable energy firms have ambitious growth strategies, which should see their significance rise over time. As their market share grows, the structure of energy markets will be transformed. The clean energy markets of the future will feature an array of local, regional and international firms, and grid-connected and decentralised off-grid solutions in equal measure. International companies, with their superior balance sheets, will remain essential (Box 1), but a powerful cohort of local champions is emerging (Box 2).

The product portfolio of renewable energy companies is also becoming more diverse. It includes a range of solar retail products, hybrid inverters and standalone systems, alongside mini-grid systems. One mini-grid company CEO expressed their evolving mandate as follows, *"We are here to solve the problem. We want to solve all the [electricity access] problems. [...] Rural electrification is contextualised. It's not a Samsung phone that you just produce and sell. The problems you find in one place are completely different. So we always allow that flexibility so that we can solve the problem with minimal issues. We don't have a template."*

Product diversification is complemented by geographic expansion. Renewable energy firms are broadening their operations, sometimes through organic growth, sometimes through mergers and

acquisitions. Several of the retailers and mini-grid companies we interviewed have operations in more than one country.

The drive toward geographic expansion is even more pronounced among large-scale international operators. International companies are rapidly expanding their renewables portfolio. In doing so, they seek out the fastest growing markets, where projects at the hundreds of megawatt scale allow for a fast scale up. They find these opportunities in middle-income countries like Brazil, Chile and Mexico, while activities in smaller markets are pooled to ascertain economies of scale.

The choice to enter and remain in smaller markets is evaluated on the basis of the potential for future growth, which is related to the size of current demand and expectations for economic growth, but also the prospects for combining different business models. For instance, several companies are investing in grid assets (transmission or distribution) as a way to complement their generation business.

## Box 1: The international operators

### → COPENHAGEN INFRASTRUCTURE PARTNERS

**Headquarters:** Denmark

**Business strategy:** Copenhagen Infrastructure Partners (CIP) focuses on developing, financing and constructing greenfield renewable energy projects. Its value proposition is the ability to de-risk projects for long-term investors and operators. The company is active in both developed and developing market through dedicated funds with different risk profiles.

### → EDP

**Headquarters**: Portugal

**Business strategy**: EDP is investing globally in renewable energy generation in developed and middle-income economies, pursuing low-risk investment opportunities and taking advantage of long-term contract schemes, including centralized procurement. The company also makes investments in local companies in the field of energy access and energy services choosing not to operate directly in this field, and looking into the potential of a long-term business development.

### → ENEL Group

**Headquarters:** Italy

**Business strategy:** ENEL is a global power company operating internationally across generation, distribution and retail. The company is active in middle income countries at different scales on generation, grid and storage infrastructure. ENEL's preference for long-term ownership and operation means they can develop new value propositions for large-scale consumers where market structures allow, or participate in centralised purchasing mechanisms.

### → TAQA

**Headquarters:** United Arab Emirates

**Business strategy:** The Abu Dhabi National Energy Company, TAQA, is an energy and utilities company with a target to reach 100GW of global renewable energy capacity (through its majority stake in the UAE renewable energy company Masdar). The company ambition will be achieved, to a large extent, through mergers and acquisitions. The high ambition means prioritising the largest markets in the Global South.

## Box 2: The local renewable energy champions

### → Ayana

**Country:** India

**Value Proposition:** Ayana develops utility-scale wind and solar projects across India. Established in 2017 with support from British International Investment, Ayana has already commissioned projects in excess of 1.8 GW across ten locations. The long term ambition is to add this amount of capacity every year.

### → BBOXX

**Country:** Kenya-based, but operating in 34 countries

**Value proposition:** BBOXX provides clean, reliable, and affordable energy solutions to communities and businesses. A "next-generation utility", BBOXX's core offerings include solar home systems, such as the Solar Home-TV Package, which enables households to power essential appliances through renewable energy. BBOXX Kenya also uses a technology-driven approach through its platform, BBOXX Pulse, which helps monitor and manage energy distribution remotely, ensuring scalability and reliability.

### → Bui Power Authority

**Headquarters:** Ghana

**Business strategy:** Bui Power is a fully state-owned company that originated from a single hydro-power project. The company has evolved into a multi-technology renewable energy developer in Ghana, which has demonstrated the business opportunities of directly pairing hydropower with solar energy, and the feasibility of renewable energy state-owned enterprise as a model to scale up investment.

### → EcoEnergy

**Country:** Pakistan

**Value Proposition:** EcoEnergy provides customised solar solutions for a variety of uses, including homes, businesses, farms, schools, and health clinics. EcoEnergy focuses on providing an "on-grid" experience to off-grid communities by offering tailored solar solutions that include financing options and after-sales service. They integrate monitoring and data analytics to ensure peak system performance, providing a high level of customer satisfaction.

### → Solar Freeze

**Country:** Kenya

**Value proposition:** Solar Freeze uses solar-powered cold storage units to provide off-grid refrigeration. This technology is designed to help smallholder farmers in remote areas preserve their produce without relying on electricity from the grid. The company operates on a Pay-As-You-Store model, allowing smallholder farmers to pay only for the storage space they use. Solar Freeze emphasises inclusivity by targeting smallholder farmers who are excluded from conventional energy infrastructure.

Site visit at Metro Cash n Carry during the very first training in 2019. Photo credit: Women in Energy, Pakistan

# 3. Diverse market contexts

Renewable energy entrepreneurs operate in highly diverse business environments and market contexts. They are adapting to these varied conditions. Generation levels are still low, but demand is growing exponentially.

Renewable energy generation depends on geographic, social and economic factors. However, leading renewable energy countries, such as Chile, Jordan and Namibia, do not merely exploit their favourable geographic and socio-economic fundamentals. They also have proactive renewable energy policies and a cultural affinity towards renewables.

The market dynamics are particularly pronounced in solar energy, on which we focus in this section.

## The drivers of solar energy growth

Over the past decade, solar energy use has increased by a factor of three across the Global South, or about 11.6% per year on average. In absolute terms, solar generation levels are still very low at less than 100 kWh / person in most countries (Chart 4). This is less than 10% of average electricity consumption in most middle income countries, but for low-income households without prior access to electricity, solar energy can be transformative.[4]

Growth in solar generation reflects two factors: (i) the change in solar penetration, that is, the share of solar in total electricity consumption and (ii) the change in total energy demand. Chart 4 shows how these factors combine on a per capita basis.

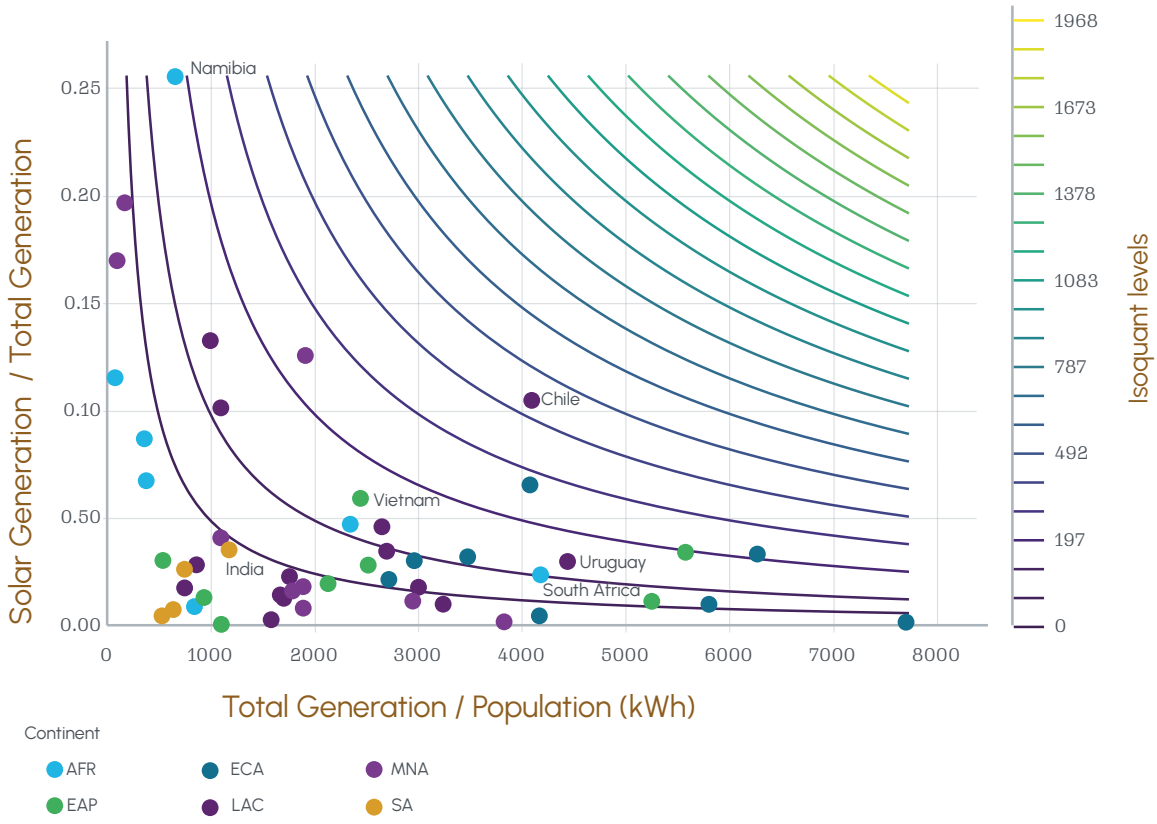
Some leading solar producers, most notably Namibia, combine low levels of energy consumption with high levels of solar penetration. Middle-income countries like South Africa and Uruguay have substantial electricity consumption per capita, but the share of solar in that consumption remains low. Chile, the leading solar country in the Global South, combines substantial energy consumption per capita with a high solar penetration (Chart 4, panel a).

Over the past decade, most countries have seen an increase in both energy demand and solar penetration. That is, additional energy needs are disproportionately met through solar and other renewables, pushing up their share in the overall energy mix (Chart 4, panel b).

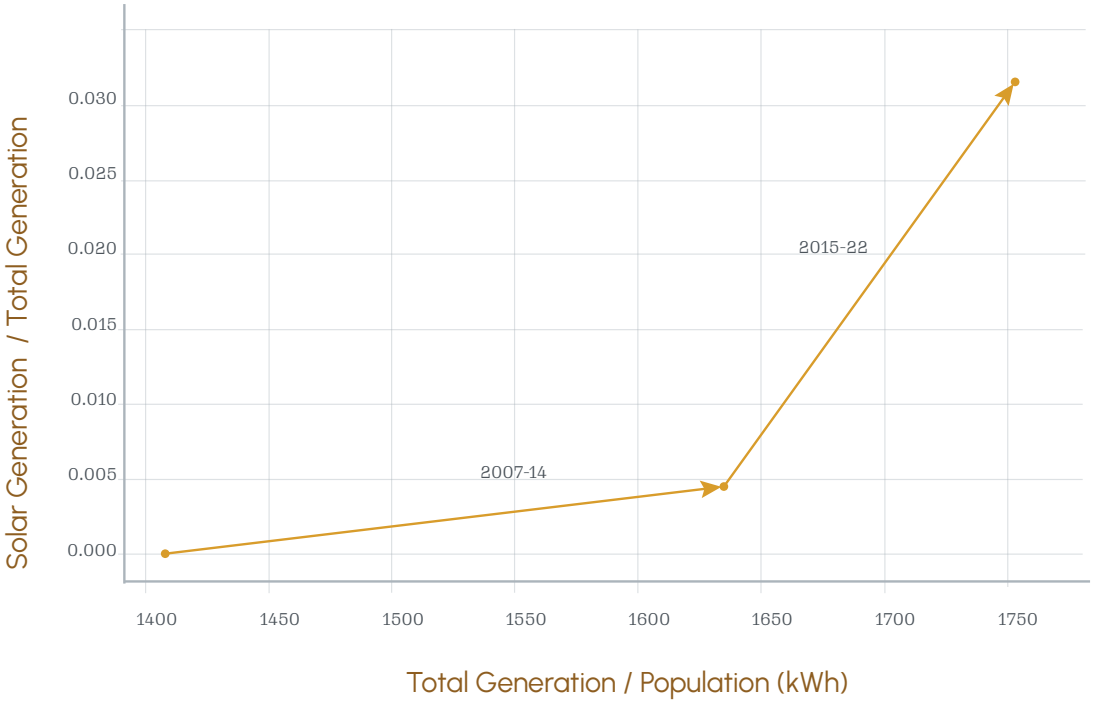
This pattern is fairly consistent across different regions, and provides the economic context in which the renewable energy entrepreneurs operate.[5] In both South and South-East Asia, solar expansion is fuelled by the rapid growth in energy demand, with renewable energy as an increasingly important solution for meeting it.[6] In Latin America, progress in renewable energy has been driven by energy auctions in countries like Brazil, Chile and Mexico, which have led to some of the lowest solar and wind energy prices globally.[7] In much of Sub-Saharan Africa, renewable energy providers have focused retail solutions, such as solar home systems and mini-grids, which suit Africa's still small and highly decentralised loads.[8]

**Chart 4: Solar penetration and electrricity use per capita**

(a) by country (2022)




(b) Over time, Global South average




*Note: Each curved line (isoquant) in panel (a) depicts a constant level of solar energy generation per capita (the product of solar penetration, on the y axis, and electricity use per person, on the x axis). Isoquants that are to the top and right reflect higher generation levels. The arrows in panel (b) show how solar penetration and electricity use per capita have changed from 2007 to 2014 (first arrow) and 2015 to 2022 (second arrow)*

## The policy and socio-cultural context for solar energy

The uptake of solar energy depends on multiple factors, some of which are external to renewable energy firms and some of which they or their stakeholders can influence.

A critical external factor is resource endowments, in particular solar irradiation, but also the potential in other energy sources, such as fossil fuels and other renewables. In countries like Brazil, for example, the clean energy transition is driven by abundant hydropower resources, leaving less room for solar. Elsewhere, an entrenched fossil fuel sector may tilt the energy playing field against solar energy contenders. Other environmental variables that may influence solar energy generation include land availability, water availability and climate conditions.

Social factors, which are external to solar entrepreneurs, but may be influenced by policy choices include population growth and income levels, which in turn determine current electricity consumption, as well as health and educational outcomes, all of which affect the demand for, and affordability of, solar energy.

Economic factors have to do with GDP and GDP growth, the structure of the economy (e.g., the importance of industry), macroeconomic stability and the strength of the financial sector. Many renewable energy providers see access to finance and macroeconomic risks as key barriers to their operations (see section 6).

Controlling for these variables when studying solar energy generation could change the relative performance of different countries. Some countries with relatively large solar energy sectors may simply take advantage of their environmental, social and economic situation. Others may have larger solar sectors than their fundamentals suggest.

The overperformers will be of particular interest to solar energy entrepreneurs. These countries have additional features that help boost solar energy generation. Many will have a proactive policy stance on solar energy, with favourable price incentives or regulatory provisions. In addition, people may simply have a social or cultural affinity towards solar energy.

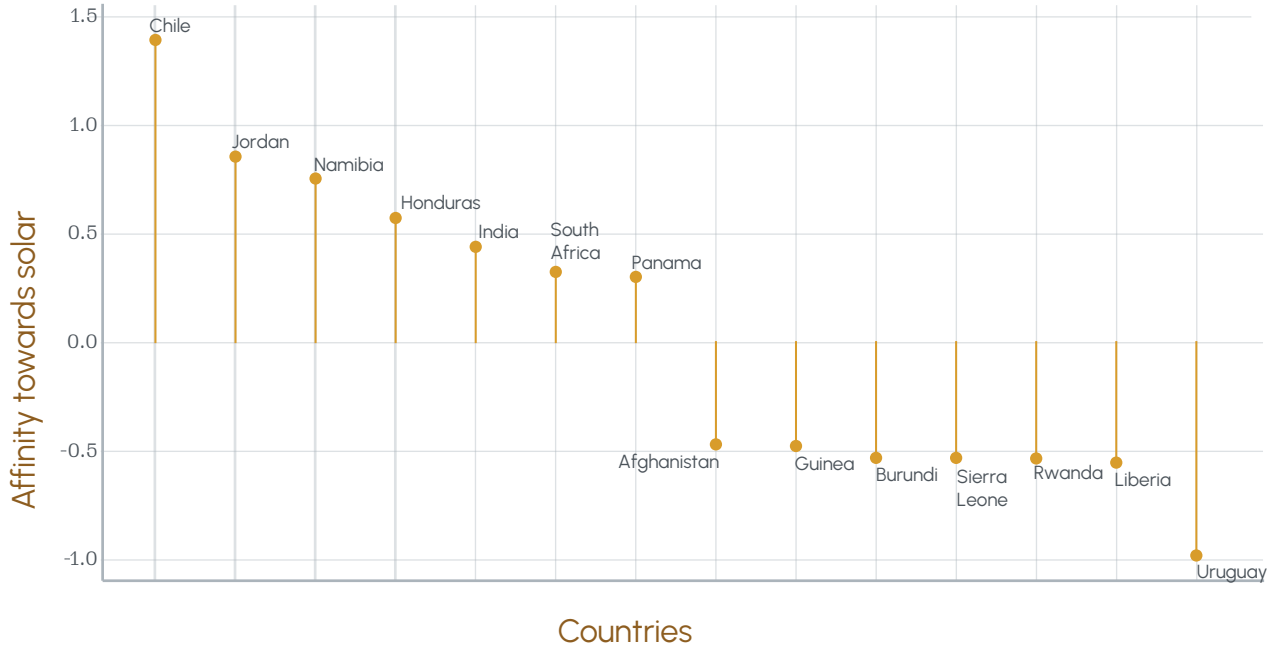
Chart 5 displays the countries with the highest and lowest policy predisposition and socio-cultural affinity towards solar.

The figure suggests that most of the leading solar energy countries in the Global South do not just take advantage of favourable fundamentals, although those clearly help. In Chile, Jordan (the two Global South countries with the highest solar output per capita), Namibia (the country with the highest solar penetration) but also Honduras, El Salvador, South Africa and Panama, solar energy receives an additional boost from a supportive policy stance and sympathetic socio-cultural attitudes.

In contrast, there are countries, such as Rwanda, Liberia and Uruguay, where solar energy underperforms relative to environmental, social and economic fundamentals. These are the countries that international development institutions may wish to target for policy dialogue and technical assistance.

A similar pattern emerges when we perform the same analysis for wind power (not reported here). The countries with the highest policy predisposition and cultural affinity towards solar also lead the field with respect to wind. There are no fundamental differences in attitudes towards these two types of renewables.

**Chart 5: Market contexts for solar energy**




*Note: The performance metric (y-axis) reflects the residual in a regression of solar generation against economic, social and environmental characteristics, which reflect the effect of policy predisposition and socio-cultural affinity to solar. See Annex for details.*

Shams Power Pakistan, On site installation at Shams Power's Rooftop.Photo credit: Shams Power Limited, Solar EmpowHer.

# 4. Inclusive opportunities

The diversity of renewable energy entrepreneurship allows firms to respond nimbly to new business opportunities. Renewable energy also offers important social opportunities in terms of energy access and jobs. Modular renewables can reach dispersed communities and low-income consumers more readily than traditional energy systems, bringing energy access targets within reach. With suitable training, renewable energy can also bring attractive jobs to local communities, including for women (Box 3).

To better understand business prospects and energy access opportunities, we juxtapose startup activity in Africa and South Asia (per section 2) with the levelised cost of solar electricity and energy access rates. The two indicators reflect the differing economic and social contexts within which solar entrepreneurs operate (as seen in section 3).

Solar *hotspots* like India and Kenya combine vibrant startup ecosystems with low solar costs and/or significant electricity access. In other countries with significant startup activity, such as Nigeria, entrepreneurs may face *headwinds* in the form of high solar costs or low energy access rates. There are *dormant opportunities* in countries with favourable conditions but limited startup activity, such as Morocco and Namibia. There is a *bleak outlook* for countries, such as Chad and Malawi, which have difficult business conditions and limited startup activity.

## Business prospects

The solar startup landscape across Africa and South Asia remains uneven. At the same time, solar entrepreneurs can face vastly different socio-economic contexts. To understand the business opportunities arising from this pattern we study the relationship between startup penetration and the levelised cost of solar electricity (LCOE). LCOE is a key metric to assess the affordability and cost-effectiveness of electricity generation from various energy sources. LCOE is also related to innovation and entrepreneurship, as innovation can further drive costs down, thus enabling cheaper energy access.[9]

We identify four distinct market dynamics, or quadrants, that categorise regions based on their LCOE and startup activity, providing insight into both current market conditions and future opportunities for solar growth (Chart 6).

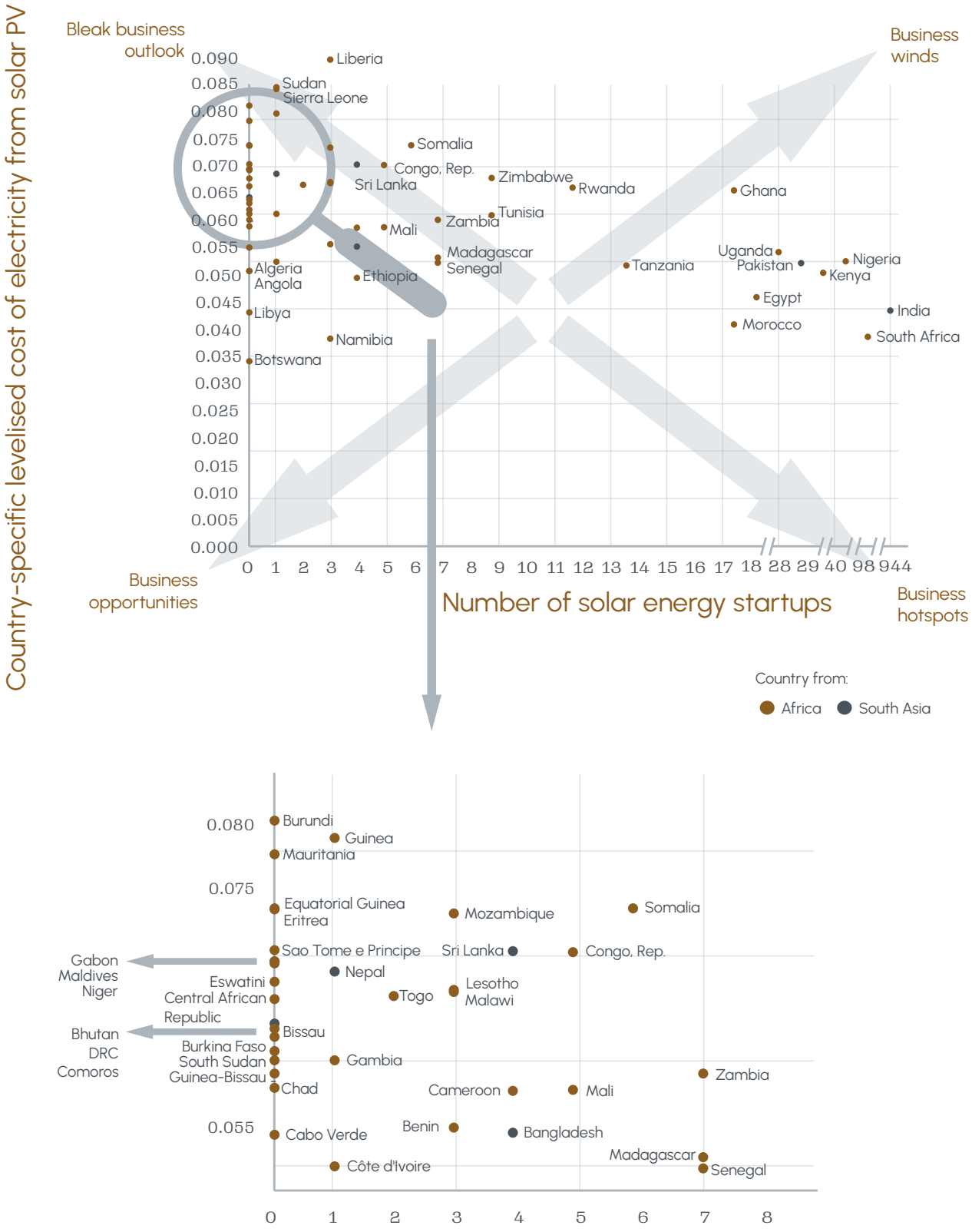
The first quadrant, *Business Hotspots (bottom right)*, represents the most promising market conditions, combining low LCOE and high startup activity. Here, startups have identified and leveraged opportunities in solar energy, contributing to strong market growth and increased innovation. Low solar costs seem to correlate with prospering solar startups, enabling these countries to scale their renewable energy solutions and meet growing demand. Countries like South Africa and Kenya exemplify how favourable market conditions—both in terms of startup ecosystems and cost efficiency—could foster growth in solar energy sectors. They represent the ideal conditions for solar startups, where both innovation and affordability align to foster strong market and sustainable development.

The second quadrant, *Business Headwinds (top right)*, is characterised by high startup activity and high LCOE (for example as a result of difficult market fundamentals). In these markets, continued high costs of electricity are a significant barrier to the widespread adoption of solar solutions, limiting the ability of startups to scale their operations. Despite a strong startup presence, high electricity costs make it difficult for these startups to offer affordable solar technologies to consumers. This dynamic creates a stalemate, where business innovation is present but cannot achieve its full potential.

The third quadrant, *Dormant Business Opportunities (bottom left)*, consists of countries with low LCOE but low startup penetration. These markets, which include Botswana, Namibia, and Morocco, exhibit significant untapped potential for solar energy development, but lack the robust startup ecosystems necessary to capitalise on it. With electricity costs already low, these countries are well-positioned for growth if startup activity can be nurtured and encouraged. However, the underdeveloped entrepreneurial landscape could be a barrier. In Namibia, for example, high solar penetration has largely been driven by the state. Strategic investments and government support could unlock private entrepreneurship and turn these countries into future solar hotspots.

The final quadrant, *Bleak Business Outlook (top left)*, represents the most challenging market conditions, where high LCOE and low startup penetration combine to create an unattractive environment for new ventures. Countries such as Sierra Leone, Sudan, and Mozambique fall into this category. In these countries, the high cost of electricity acts as a deterrent to both consumers and startups, making it difficult for renewable energy solutions to gain traction. Without significant changes in cost dynamics and business conditions, these markets will continue to struggle to attract startup activity. Countries in this quadrant may require external interventions, such as government subsidies, international investments, or technological breakthroughs, to make the solar energy market more viable.

**Chart 6: Solar startups and solar energy costs**



## Energy access

Looking at business opportunities only tells part of the story. Renewable energy entrepreneurs are also filling important underserved niches. Their business models are uniquely suited to meet small demands and boost electrification.

Retail-focused firms provide solar home systems, appliances, and pico solar products that can be scaled to address the basic energy needs of low-income households. For commercial and industrial operations, retailers install standalone solar systems, usually on the client's rooftop, tailored to the required system size. Service-focused firms, primarily mini-grid companies, provide electricity to communities, supporting a range of usage from basic lighting to high-power-consuming appliances and income-generating activities in rural and peri-urban areas.

To understand the electrification potential that arises from solar energy, we juxtapose solar startup activity with current levels of energy access. This again yields four quadrants with distinct energy access dynamics (Chart 7).

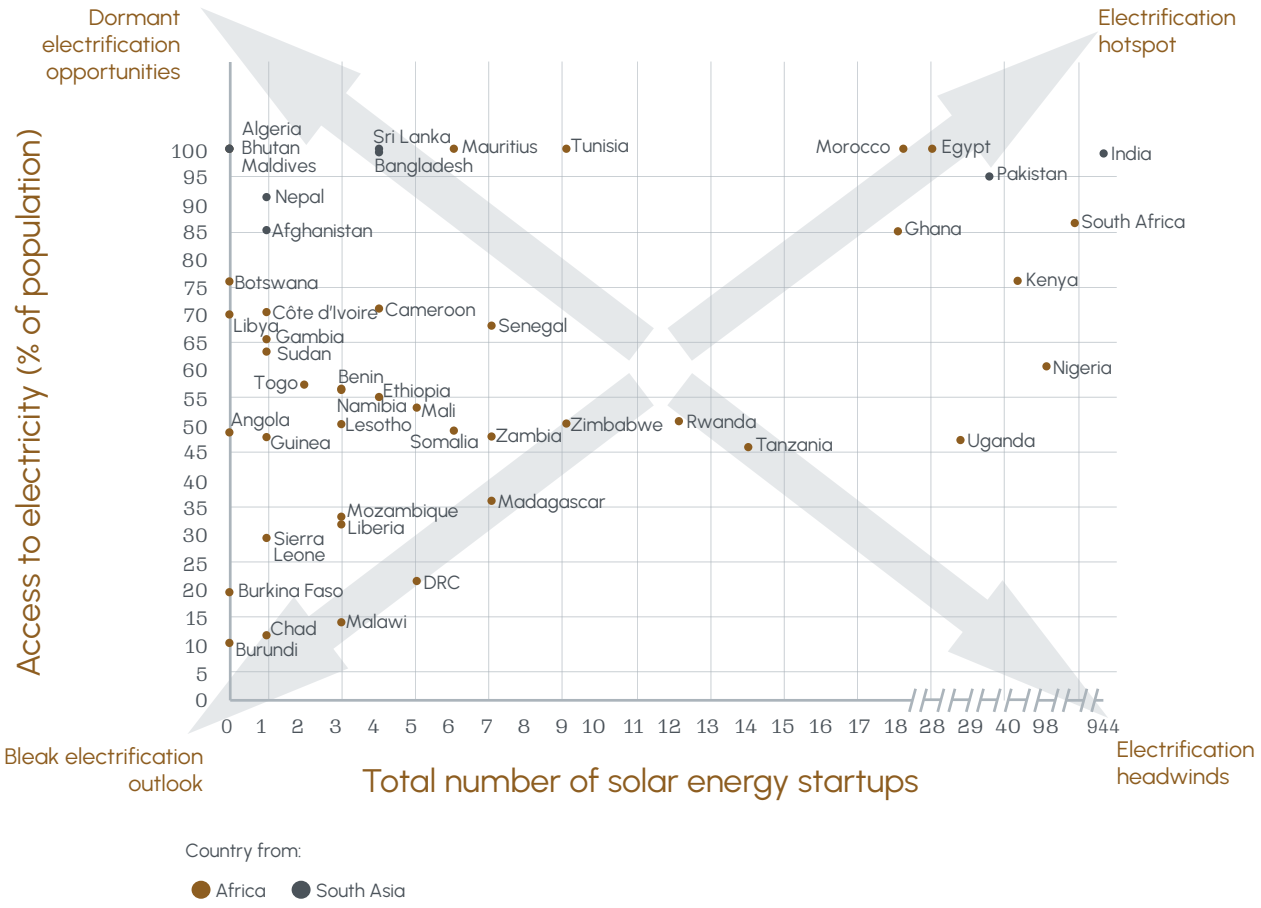
The first quadrant, *Electrification Hotspots (top right),* describes areas with relatively good access to electricity coupled with high solar startup penetration. In these countries, the focus shifts from addressing basic energy needs to deepening access and enhancing energy delivery. India exemplifies this quadrant. Many communities have notional access to electricity, but comprehensive, scalable electricity supply may still be lacking. Solar startups can thrive by offering large-scale solutions and by seeking ways to address remaining gaps in energy services. They are involved in optimising energy use, integrating advanced technologies, and exploring new applications for solar energy, thus contributing to ongoing improvements in energy delivery and sustainability.

The second quadrant, *Electrification Headwinds (bottom right)*, represents countries with high solar startup activity but low access to electricity. Solar startups can play a crucial role in bridging the energy access gap, but difficulties in reaching consumers and low levels of demand can also be a constraint. The challenge for entrepreneurs is to turn a difficult business context into an opportunity. Nigeria, where only half of the population has access to electricity, is a prime example. The country's high level of solar startup activity reflects a concerted effort to expand energy access through solar technologies. Nigeria's solar startups are not only filling a vital gap but also demonstrating the potential for solar energy to have social impact in regions with limited energy infrastructure.

The third quadrant, *Dormant Electrification Opportunities (top left),* includes countries with high access to electricity but low solar startup activity. There is a significant, untapped potential for solar entrepreneurship. Egypt and Morocco are examples of countries in this quadrant. While they have achieved high levels of electrification, their solar startup ecosystems have yet to fully capitalised on this opportunity. By fostering a more dynamic solar sector, these countries can drive both social and environmental development, leveraging their existing infrastructure to support further growth in renewable energy technologies.

The final quadrant, *Bleak Electrification Outlook (bottom left),* represents the most challenging scenario, characterised by both low access to electricity and low solar startup activity. In countries like Burundi, Chad and Malawi, extreme poverty, fragile institutions and often political instability create significant barriers to energy access and deter entrepreneurial activity. Addressing energy access will require substantial interventions to create an environment conducive to solar startup activity. Until the underlying challenges are addressed, progress in expanding energy access through solar technology may remain limited.

**Chart 7: Solar startups and energy access**




## Box 3: Empowering Women through Solar Energy

The growing field of renewable energy presents accessible opportunities not just for entrepreneurs, but also individuals seeking careers in clean technology. This trend is exemplified by initiatives such as Women in Energy (WIE), a professional network in Pakistan dedicated to training women as solar power engineers

Collaborating with Shams Power, a leading solar energy provider, WiE has so far completed five training cohorts, encompassing a total of 70 women predominantly from lower-middle-class backgrounds in Lahore and neighbouring vicinities. The majority of participants are recent graduates, while a few possess limited experience in other industries.

All participants saw working in the solar industry as a career opportunity. One participant described her journey as follows, "*I didn't know much about solar panel installation or the different types of solar panels. … When I heard about this female-only training opportunity, I knew I couldn't miss it.*"

**Skills development**

Structured as a compact three-day programme, the training included comprehensive theoretical sessions alongside practical hands-on experience. The curriculum was tailored to meet the specific needs of Shams Power's technical workforce but is aligned with industry standards and expectations more broadly.

A participant who was already working in renewable energy, admitted to initial scepticism; *"Solar felt unfamiliar despite my experience. I admit, after 1.5 years in energy, practical installation was new. This training bridged that gap for me."*

Another recent trainee underscored the discrepancy between university education and industry demands: *"In an interview, I stumbled on transformer-related questions. My education, despite being in the 6th semester, lacked practical relevance. Employers stressed the need for current knowledge and skills."*

**Overcoming barriers**

Solar installation remains an unconventional career path for women in Pakistan, and participants often confronted entrenched cultural prejudices. A trainee from Peshawar highlighted the pervasive gender stereotypes that hinder women's advancement in the sector, noting that "*Women encounter significant stigma in the sector. Many companies prefer women for presentations rather than fieldwork, which limits career opportunities*."

Despite initiatives aimed at fostering gender diversity and empowerment within the industry, systematic barriers persist, and not all participants were able to overcome them. One trainee who completed the programme ultimately chose not to pursue a career in solar due to familial disapproval. Another trainee had to drop out due to childcare responsibilities in a joint family setup, opting for a teaching position instead. These cases highlight the complex intersection of cultural expectations, family dynamics, and professional aspirations that shape women's career choices in the renewable energy sector.

**Empowerment**

Despite prevalent barriers, solar power is seen as an easier entry point for a career in energy. Participants felt that the training had enhanced their employability, skills, and confidence. A participant from **t**he second training batch shared her journey**; "***Being added to a network of women was a revelation. Through a job posted [via] Women in Energy, I secured a pivotal role. Two years later, I joined [an] international Women Mentorship Program, gaining not just a job but mentorship and recognition for women empowerment."*

Another participant shared her journey from employee to Operations Manager, mentor and trainer. She is now managing 36 sites and overseeing 35 staff members. In doing so, she has broken significant barriers in a male-dominated field and has become a mentor and role model to numerous young female engineers. A participant from a later cohort described her as "*her greatest inspiration, ... exemplifying leadership for women in the energy sector*".

**Conclusion**

Efforts to upskill workers to the demands of the solar industry are crucial to its success. Challenges persist, including entrenched gender stereotypes and limited industry acceptance of female workers, but the WiE programme demonstrates that with strong industry engagement, leadership and adequate training renewable energy can offer rewarding career prospects for all.

*Source: Khushnud and Salman (2024).*[10]

*Both images: Shams Power Pakistan, On site installation at Shams Power's Rooftop. Photo credit: Shams Power Limited, Solar EmpowHer*

Shams Power Pakistan, On site installation at Shams Power's Rooftop.Photo credit: Shams Power Limited, Solar EmpowHer.

# 5. Disruptive business models

The renewable energy entrepreneurs are introducing new business models and value propositions that are changing the way energy is provided. As a group, they offer a much wider range of products and services than traditional utilities.

Large operators provide power at utility scale. Mini-grid companies are experimenting with energy service (servitisation) models to generate additional value. The adoption of alternative payment models, such as pay-as-you-go (PAYG), is facilitating electricity access, often for the first time, to lower-income households.

This process of "creative destruction" is good for innovation, growth and socio-economic development. To illustrate the diversity of emerging business models, we focus on developments in Kenya, South Africa, Pakistan and Uganda, four countries with particularly innovative startup ecosystems that may serve as a blueprint for other renewables markets.

## Products and value propositions

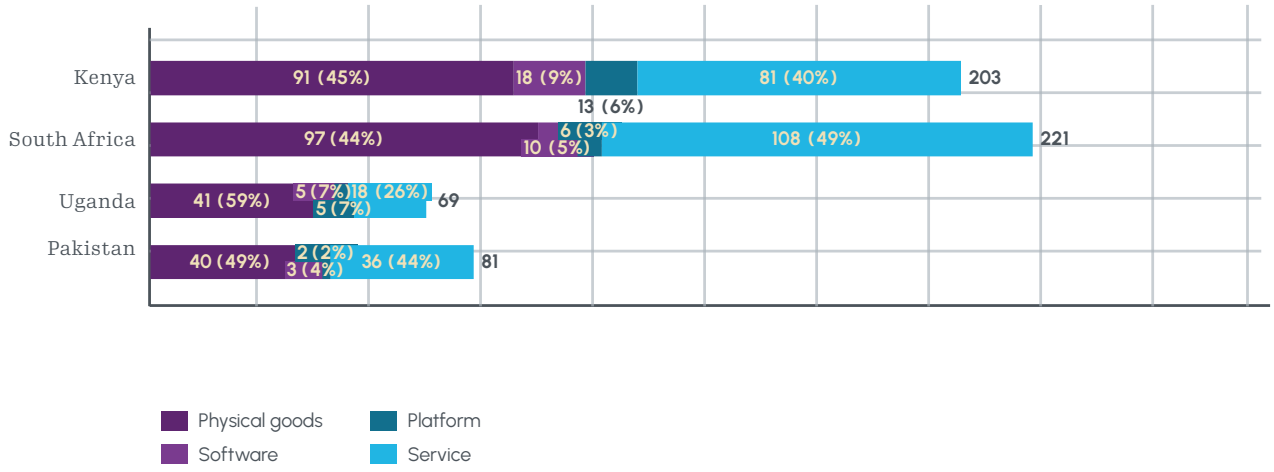
The traditional solutions of offering physical goods and services remain central to renewable energy entrepreneurship, particularly among international firms. The large private companies we interviewed see themselves primarily as electricity providers. They create value primarily through two core functions: (i) executing the development of utility-scale renewables projects, and (ii) managing the operation of high-capacity generation assets, typically selling the produced electricity in wholesale national or regional energy markets. They are also experimenting with different value propositions, for example by offering customised energy service products for corporate consumers.

The local entrepreneurs and renewable energy startups we studied also prioritise physical goods and services (Chart 8). Platform-based solutions and software offerings are much less common, underscoring a continued reliance on tangible, physical products and direct services. However, product innovation is starting to diversify the landscape. Most renewable energy startups in Kenya, Pakistan, South Africa and Uganda offer a combination of multiple solutions. Solar retailers are introducing new products, which essentially change their business model from retail to services.

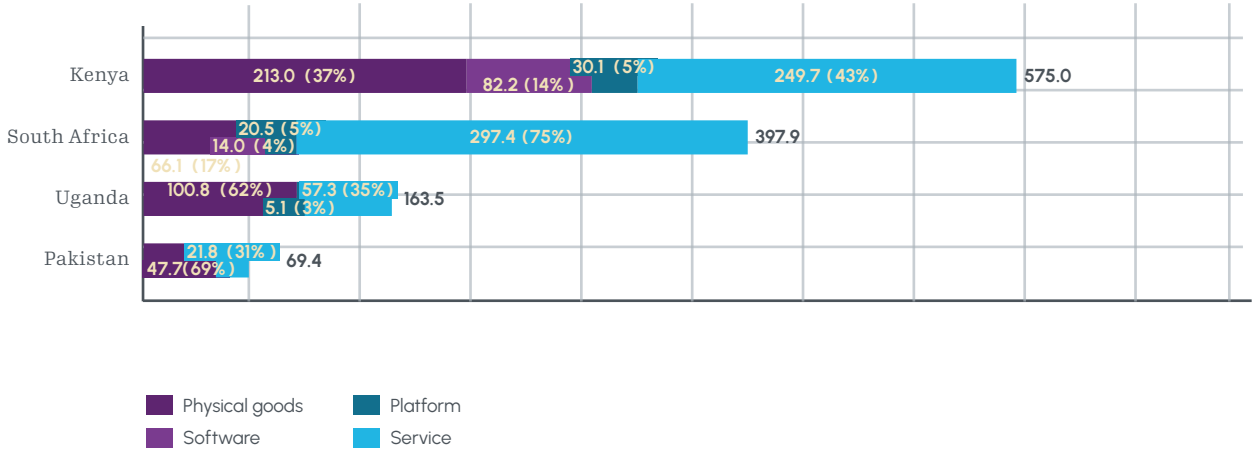
Some established energy providers have followed suit. BUI power in Ghana, for example, started as a single hydropower project operator under a long-term power purchase agreement. Insufficient power generation to meet its contractual obligations led the company to diversify into solar energy, which required a change on the company statutory mandate. The company is now considering a portfolio of potential projects across the country and potentially neighbouring countries in the future.

**Chart 8: Product solutions**

(a) in numbers




(b) by investment (USD mn)




## Revenue models

There is more innovation with respect to revenue models. Mini-grid operators in particular are expanding their focus beyond basic electricity provision to explore productive uses of energy that can generate additional revenues.

These servitisation models – where products are offered as a service rather than sold outright – are challenging the traditional sale/resale approach. Pertinent examples include agro-processing services, such as cold storage for perishable goods and ice flakes for fish preservation. Other offerings include solar powered water pumping and irrigation, small business support such as milling, carpentry and metalworks, and electric mobility services such as charging stations for e-bikes and motorcycles.

In Kenya and South Africa servitisation models are offered by 35-40% of renewables firms, but 50-75% of renewables investment is directed towards these solutions (Chart 9). In Pakistan, over 90% of startup funding is dedicated to service-based strategies. These statistics underscore the shift towards innovative, service-based business model. Renewable energy entrepreneurs value the scalability and flexibility that these models offer in a rapidly evolving market.

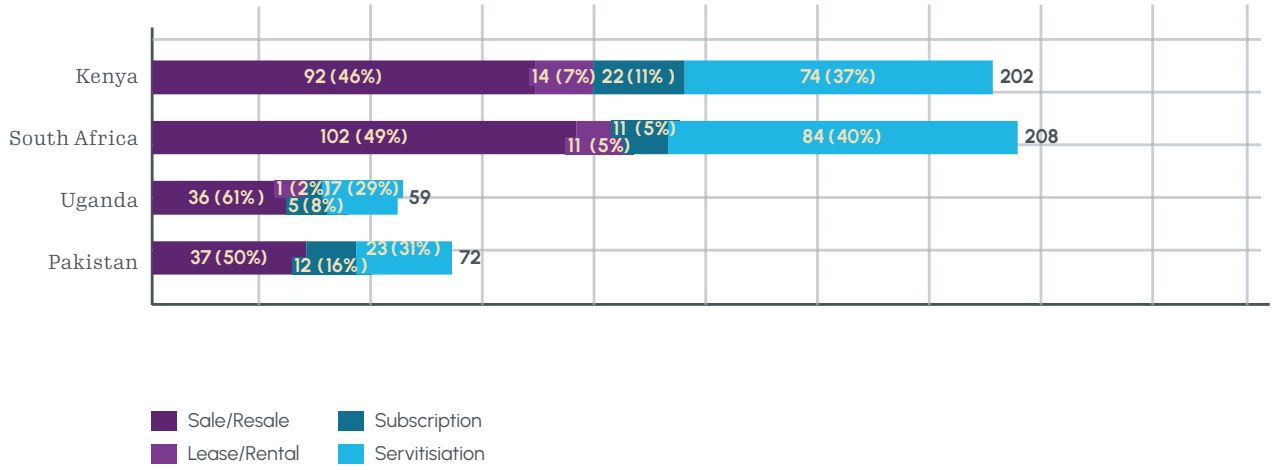
By adopting new revenue models, renewable energy entrepreneurs are beginning to move beyond the traditional frameworks of sale and resale, positioning themselves to better meet the diverse

needs of both businesses and consumers. As one interviewed CEO reported. *"We deploy technology enabled solar home systems for both businesses and households. And one of the primary goals for us is to be able to use those systems to catalyse productive use."*

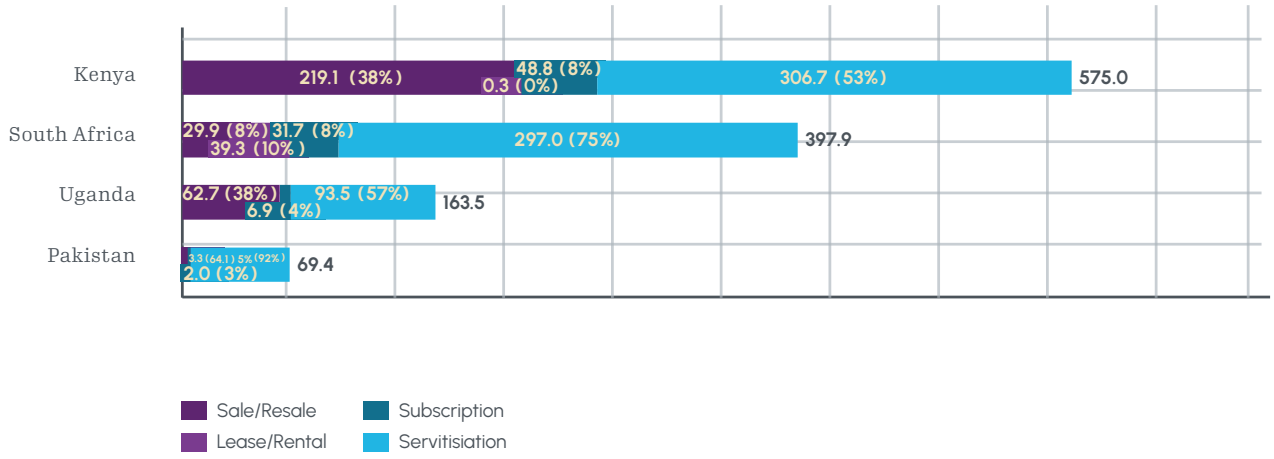
Further deepening the impact of these initiatives, mini-grid companies are also adopting new collaborative approaches. In rural areas, they are partnering with organisations that offer capacity building and training to farmers, as well as companies involved in agricultural marketing. This evolution in mini-grid business approaches reflects a growing desire to align energy provision with broader economic development goals in underserved areas.

**Chart 9: Revenue models**

(a) in numbers




(b) by investment (USD mn)




## Routes to market

When examining routes to market, regional disparities emerge between the leading ecosystems of Kenya and South Africa, and those of Uganda and Pakistan (Chart 10). Kenya and South Africa tend to prioritise business segments (B2B), reflecting a stronger focus on serving corporate clients and enterprises. Meanwhile, Uganda and Pakistan lean slightly more towards consumer markets (B2C).

The B2C market holds significant potential for fostering inclusive opportunities. By prioritising consumer markets, renewable energy firms can extend renewable energy access to underserved

populations, targeting both urban and semi-urban areas with unreliable supply and remote areas, where traditional energy infrastructure is lacking or insufficient. As one interviewee explained: *"We're trying to integrate ... things [so] we can deploy the solutions for either off-grid or on-grid where the grid is not reliable."*

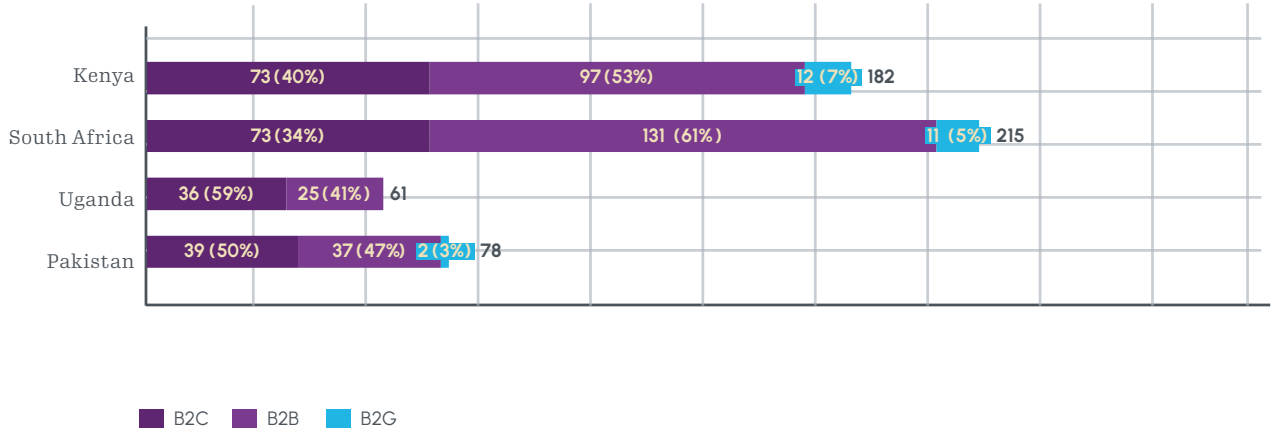
Retailers are innovating with new energy products and payment models to reach higher-risk, lower-income consumers while maintaining financial sustainability. A key development has been the widespread adoption of PAYG models, which allows for flexible payments.

Simultaneously, companies are adjusting their approaches to initial deposits, payback periods, and instalment sizes to balance impact with financial sustainability. The delicate balance between financial and social objectives is exemplified by one CEO's statement: "*The model is pay as you go, but we're very conservative on credit. ... We typically don't offer more than three to six months of credit. [The model] needs to be profitable because as we always say to our staff, in order to have impact, we need to be alive.*"

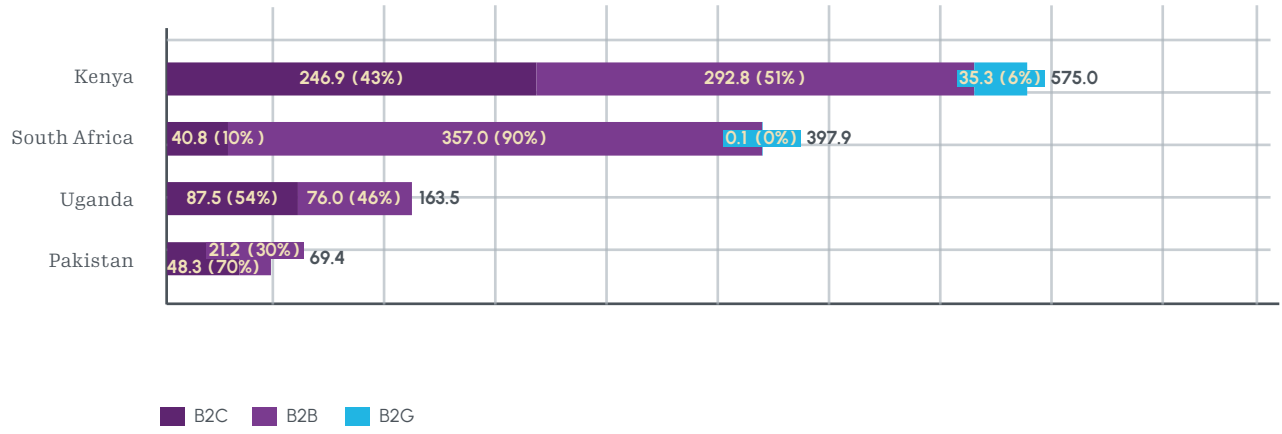
The ability to offer these options is also constrained by insufficient or expensive working capital. PAYG systems require capital. As one interviewee observed: *"[Investors] are all willing to fund project CAPEX, but there are almost no investors that are willing to fund working capital, and that's a huge problem."*

**Chart 10: Routes to market**

(a) in numbers




(b) by investment (USD mn)



# 6. Persistent challenges

Renewable energy entrepreneurs still face formidable obstacles, related to finance, planning, grid access, regulation and exchange rate risks. They have displayed a remarkable ability to adapt to these challenges, but their market position is still fragile.

Barriers to renewable energy deployment have evolved from the early days, when renewable energy firms were mostly concerned about technology risks and costs. Today, renewable energy entrepreneurs, both local and international, are mostly pre-occupied with governance risks, market risks and macroeconomic risks.

Technology risks still feature, but they have more to do with reliable supply chains than technical performance *per se*. Renewable energy entrepreneurs also worry about public acceptability, consumer satisfaction and their relationships with governments. However, in general, reputational risks and social / environmental risks are less of a concern.[11]

> *"One of the major goals of the company is having a low risk profile in the market and that can be supported with the longer term PPAs."*

## Market risks

Market risks are the primary preoccupation of renewable energy firms. They are focused on ensuring tariffs are set at sustainable levels, balancing affordability for consumers with the need for cost recovery, while also navigating competition in the market.

Utility-scale projects often mitigate these risks through power-purchase agreements (PPAs), which contractually guarantee an agreed tariff and reduce off-taker risks. PPAs are also the mainstay of conventional power sector projects with private sector participation. As one interviewee stated: *"One of the major goals of the company is having a low risk profile in the market, and that can be supported with the long term PPAs."*

An alternative risk mitigation strategy, pursued both by large international firms and mini-grid companies, is to have diversified revenue portfolios. This allows companies to spread risks and potentially access larger funding pools by presenting a more comprehensive business case to investors. However, the strategy requires markets that are of sufficient scale, with multiple business areas that are open for investment.

As one industry expert explained: *"[Mini-grid developers] will probably be building multiple mini-grids. [...] Under that portfolio, they can aggregate all of the business so that the business itself can attract funding."*

Portfolio financing is also preferred by large international developers. Interviewees stated their preference to manage risk profiles at portfolio level, or even multiple portfolios. For example, Copenhagen Investment Partners, a global project developer, operates with multiple funds with complementary strategies and different risk profiles, using funding round with different return targets (Box 1).

Companies that serve low-income consumers need to address affordability constraints more directly. They seek to reduce their financing costs by accessing concessional funding. *"When it comes to financing [...] you definitely combine different sources of financing. So apart from investors, you go to philanthropic organisations where they can offer you grants. ...You might get some concessional loan to help reduce the interest rates for paying back. [...] Most developers do that."*

What repayment risks remain are then mitigated through the pay-as-you-go (PAYG) model introduced in section 4. PAYG is both a way to expand markets and manage associated credit risks. As one interviewee put it: *"We mitigate our demand risk with the credit risk"*.

> *"You definitely [want to] combine different sources of financing"*

## Governance risks

The main governance (or sovereign) risks include administrative barriers, for example related to planning and licensing, political stability and the rule of law. Utility-scale operators also worry about grid access and grid integration.

For international companies, an unsatisfactory sovereign risk profile can deter market entry. One interviewee related how they were deprioritising a promising market because *"the regulatory framework [had] not followed at the speed we were expecting"*. The problem was compounded by lack of infrastructure development. *"The grid company, ... their credit risk or their ability to raise capital to fund transmission reinforcement was not there"*.

However, for the most part, renewable energy entrepreneurs try to mitigate excessive risks and bring them within risk appetite. For large-scale operators, power-purchase agreements, typically secured in a renewable energy auction, are again the most evident mitigation strategy. The assumption is that a legal agreement, protected by contract law and enforceable in the courts, offers more security against policy risks than tariff regulation.

The risk of slow and non-transparent administrative processes is more difficult to mitigate. Some countries are experimenting with a streamlined approach to awarding operating licenses. They are granting licensing for multiple projects at the same time, including the combination of environmental and impact assessments for all projects into a single, efficient process. Such measures can cut through layers of bureaucracy and accelerate project roll-outs. However, this progress is far from universal across different African countries.[12]

## Macroeconomic risks

Exchange rate fluctuations and currency convertibility are a worry both for international companies and local firms with international supply chains. Nearly, all the companies we interviewed highlighted currency fluctuations as a constraint to their scaling abilities.

A particular issue, expressed by Nigerian retailers, are supply chain bottlenecks, which can delay delivery by between four to six months. During this period currency values may shift dramatically. As a result, a product sold at what seemed a reasonable price can become significantly more expensive by the time it arrives. *"There are instances whereby you try to include some escalation factor into*

*your pricing and then of course you get a lot of pushbacks from customers*", one CEO explained.

International companies have access to risk mitigation tools offered by multi-lateral development banks and export credit agencies. However, currency risk mitigation is seen as costly, and many international firms see the main role of development banks in supporting the institutional development for renewable energy markets. As one international operator expressed: "*For many countries it is very difficult to manage that currency exposure. [...] The likelihood that a country will default on that contract because of a currency event is greater if [the project] is in dollars. ... If we didn't have to do currency hedging, we could offer a lower power price on our projects*".

> *"If we didn't have to do currency hedging, we could offer a lower power price on our projects"*

Climbing the Ngong Hills in the Rift Valley. Kenya. Photo credit Lebrazzah

# 7. A call to action

Given the dynamism and inventiveness of renewable energy companies, which we document in this report, and the continuing trend towards ever-lower costs,[13] it is difficult to see how the transition to renewable energy could be stopped. However, the switch to renewables can be delayed or pursued in a way that reduces the benefits to local communities. Speed and justice both matter if we are to meet the objectives of the Paris Agreement and the Sustainable Development Goals.

Scaling up renewable energy equitably and at pace involves a concerted effort from all stakeholders, including national governments, regulatory agencies, development banks as well as the renewable energy entrepreneurs themselves. In last year's report we set out 10 actionable measures that these actors can take to accelerate the inclusive roll out of renewables.[14] The insights gathered in this report corroborate and reinforce the importance of these ten steps (See Table 1 above).

1. **Engaging with stakeholders.** We have seen how renewable energy firms engage proactively with prospective clients and local communities to tailor products to their needs. Together with inclusive planning processes this ensures the effective and more widespread use of renewable energy.

2. **Localising supply chains.** Some renewables firms create additional benefits and jobs for local communities by shortening supply chains and procuring inputs locally. The measure can also help to reduce supply chain risks.

3. **Holding renewable energy auctions.**.Utility-scale operators have fairly traditional business models, with a focus on de-risking projects and selling electricity to large clients or into the grid. They rely heavily on renewable energy auctions, which remain an effective demand-pull measure and a way to guarantee a stable revenue stream.

4. **Improving planning regimes.** Utility-scale projects (but also mini-grid developments) are held back by lengthy, non-transparent planning processes, which can materially delay project development.

5. **Securing grid access.** Large companies are also concerned about physical and institutional constraints in accessing the electricity grid, with some companies opting to enter into direct offtake agreements with industrial clients instead. Other firms see transition and distribution investments as a complement to their power generation business.

6. **Offering new products and service models.** Mini-grid companies and retailers have a more diverse set of B2B and B2C business models, which provide viable alternatives to simply selling electricity. Many have adopted servitisation or energy-as-a-service models, which allow them to capture value and generate new value propositions.

7. **Adopt alternative payment systems.** An important feature of renewable energy is the ability and willingness of renewables firms to reach as yet underserved consumer groups. The more widespread use of PAYG payment models has proven effective in managing associated payment risks.

8. **Providing affordable finance.** The alternative business models of renewable energy firms generate specific new capital needs. Servitisation is associated with additional capital investment, while PAYG increases working capital needs. Blended finance may be required to make renewables affordable to low-income households, and the growth of startup firms has been constrained by insufficient venture capital. Access to finance remains a key concern for

most renewable energy entrepreneurs.

9. **Providing sovereign risk mitigation.**International firms have an edge over local companies in that they can rely on the balance sheet of their parents. However, they are more susceptible to other risks. In particular, they may be more averse to sovereign risks and often look to development finance institutions and export credit agencies to help de-risk projects.

10. **Providing currency risk mitigation.** International firms are more discerning with respect for foreign exchange risks, including currency availability and exchange rate fluctuations. Currency hedges are sometimes seen as expensive, and internal firms prefer development agencies to address the underlying macroeconomic issues.

Renewable energy companies have proven to be remarkably innovative and adaptable to different business risks. However, their market position is still tenuous. Applying the above recommendations at scale would go a long way to ensure that the renewable energy entrepreneurs of the Global South continue to thrive.

Darling wind farm. Photo credit: Warren Rohner Cape Town, South Africa

# Annex: Methodological notes

**Macro analysis**

The country-level analysis of the report applies advanced machine learning techniques using publicly available datasets. The approach begins with a simple reasoning: If we assume that all countries have identical renewable energy dynamics, differences in renewable energy generation would arise purely from the differing conditions they face, such as environmental, social and economic factors. In reality, countries deviate significantly—both positively and negatively—from their expected level of generation even when accounting for their circumstances. This suggests that other factors, possibly related to cultural attitudes, also influence renewable energy outcomes. We are interested in these additional factors, which we call a country's socio-cultural affinity to renewable energy.

Our method involves using as many characteristics as possible to ensure that the comparison is as precise as possible, accounting for all available information. This initial description is high-dimensional, involving many variables, not all of which are equally informative. Some may fluctuate due to random noise, there may be missing values, and there is often strong co-movement both within and across subsets of data.

To filter out noise and impute missing data, we apply a low-rank model. To avoid multicollinearity and select the most informative variables, we condense the information into a few indices. This results in a lower-dimensional representation of the data: a set of synthetic variables that condense the initial information into three factors: economic, social and environmental. They are complemented by a variable measuring renewable energy policy.

We are left with a few, highly informative, and uncorrelated synthetic variables that explain a significant portion of the variation in solar energy generation within a linear model. The linear model is estimated using the Generalized Method of Moments (GMM), and socio-cultural affinity is determined by computing the average deviation from the model's predictions, similar to methods used in the finance literature.

Our data sources are as follows. We use data from the World Bank's *World Development Indicators* database to populate the economy (e.g. GDP, external debt, foreign direct investment), social (e.g., population, education levels, life expectancy), and environment (e.g. forest area, energy use) variables. We use data from the *Global Solar Atlas* and Global Wind Atlas to measure renewable energy potential. To account for other energy sources, we use production data on biofuels, coal, gas, oil, hydropower and nuclear energy from *Our World in Data*. Data on renewable energy policy is taken from *Climate Change Laws of the World*. The dependent variables are solar and wind energy generation from the same dataset. The horizon considered is between 2000 and 2022.

**Meso analysis**

The report makes unique use of a newly collected dataset of clean technology startups in Africa and South Asia. We define a "startup" as a business founded after 2010 with the aspiration to scale and be headquartered in Africa or South Asia. We specifically focus on startups, excluding other types of entities such as non-profit organizations or investors.

To build our dataset, we utilise the SIIA Agritech database, which consolidates information from several sources, including Disrupt Africa, Big Deal Africa, and many others. We apply a sectoral filter to narrow the scope of our research to climate-tech and energy startups. Next, we expand the climate-tech dataset by merging additional information from Crunchbase and Dealroom. To identify relevant startups in these databases, we apply filters based on founding year, geographic location, and

relevant keywords to focus on climate-tech.

After merging the data from multiple sources, we conduct a top-down identification process for renewable energy startups. This is achieved by performing a keyword analysis to identify startups that were "solar," "biomass," "wind," "hydro," "wave," "tidal," "geothermal," and "renewable".

We automatically retrieve standard categories from databases, such as startup name, description, founding year, funding information, and contact details. However, for more detailed aspects such as climate solution type, specific types of solutions offered, revenue models, and business relationships, we apply qualitative coding. Given the vibrancy of their renewables markets, we prioritise Kenya, South Africa, Uganda and Pakistan to study in depth. To ensure accurate and comprehensive coding, we utilise multiple sources, including startup websites, news articles, and social media platforms, allowing for a deeper understanding of each startup's operations and business models.

To ensure data accuracy, we thoroughly clean the dataset, correcting for duplicates and removing false positives. This process helps ensure that only unique renewable energy startups remained in the final sample. To further prepare and clean the dataset for analyses, we manually double-checked for false-positives, filled missing values and corrected incorrect information for data on startups from Kenya, South Africa, Uganda, and Pakistan. For startups in other countries, we apply an estimated false-positive rate to adjust the total count and ensure the figures were as accurate as possible. This includes accounting for startups that are either non-operational or do not have a clear founding date.

The cutoff date for the analysis is 1 September 2024. Due to delays in data collection and reporting, the figures for startups founded in 2023 and 2024 may not be complete. Furthermore, data may change—particularly regarding funding figures, which are primarily based on the reporting of Crunchbase and Dealroom.

**Micro analysis**

We collected primary micro-level data through semi-structured interviews with 32 renewable energy firms of different sizes, with different business strategies and operating in different geographies. Box 2 is based on a qualitative case study, which features a focus group with 12 project participants and three key informant interviews.

The pool of interviewed companies includes twelve local equipment suppliers and retailers (e.g. vendors of solar lanterns and home systems) active in West Africa (Nigeria, Ghana, Senegal, Sierra Leone, Niger), 14 mini-grid developers and experts in East Africa (Kenya, Rwanda, Uganda, Tanzania) and 8 large-scale international firms, which are active across the Global South.

The interviews were conducted with senior company representatives, conducted after obtaining ethics approval from the University of Oxford. They lasted between 45 to 60 minutes and were designed to delve deep into the practical realities of day-to-day operations in the renewables industry. In particular, they covered the following key areas:

- Companies' experiences in the renewable energy sector;
- Their approaches to business models;
- Industry challenges they face;
- Mitigation strategies employed to lower various risks.

The semi-structured format provided flexibility to explore emerging themes while ensuring consistency across interviews. The interview recordings were transcribed and coded using NVivo

software. To ensure the accuracy and completeness of our data, we maintained an open line of communication with the interviewed companies. When our analysis revealed areas requiring clarification, we reached out to the respective companies for additional information or context. Going through this process enabled us to construct a comprehensive picture of the current state of the renewable energy sector from the perspective of its key players.

# Endnotes


1 UNFCCC. 2023. Outcome of the first global stock take. Decision 1/CMA.5, UN Framework Convention on Climate Change.

2 Fankhauser, S., C. Hepburn, S. Hirmer, T. Kukeera, D. Singh, I. Sundvor, P. Trotter and P. Yang 2023. Rolling out renewables in the global south: A developers' perspective. Smith School of Enterprise and the Environment, University of Oxford, December.

3 IRENA. 2022. Renewable Energy Market Analysis: Africa and its Regions. International Renewable Energy Agency, Abu Dhabi.

4 World Bank. 2024. World Development Indicators, https://databank.worldbank.org/source/world-development-indicators

5 IRENA. 2024. Renewable Energy Highlights. International Renewable Energy Agency, Abu Dhabi.

6 Khushund, F. and A. Salman. 2024. Empowering Women through Solar Energy: A Case Study from Pakistan. Smith School of Enterprise and the Environment, University of Oxford, December

7 IRENA. 2016. Renewable Energy Market Analysis: Latin America. International Renewable Energy Agency, Abu Dhabi.

8 Op cit. ref 3.

9 Way, R., Ives, M.C., Mealy, P. and Farmer, J.D., 2022. Empirically grounded technology forecasts and the energy transition. Joule, 6(9), pp.2057-2082.

10 Op cit. ref 6.

11 Op cit. ref 2.

12 Africa Mini-grid Developers Association. 2022. Benchmarking Africa's Mini-grids Report, AMDA, Nairobi.

13 Op cit. ref 9.

14 Op cit. ref 2.

Wind farm near Nha Trang, Vietnam. Photo credit: Martha Zumack