IRENA
International Renewable Energy Agency

DECENTRALISED SOLAR PV

A GENDER PERSPECTIVE

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Abbreviations

DRE	decentralised renewable energy
FGD	focus group discussion
GOGLA	Global Association for the Off-Grid Solar Energy Industry
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
KOSAP	Kenya Off-Grid Solar Access Project
kW	kilowatt
MSME	micro-, small- and medium-sized enterprise
MW	megawatt
NEP	Nigerian Electrification Project
PV	photovoltaic
SDG	Sustainable Development Goal
SHS	solar home system
SME	small- and medium-sized enterprise
STEM	science, technology, engineering and mathematics
USD	United States dollar
W	watt

Highlights

- **The number of people without access to electricity rose by 10 million** in 2022, reaching 685 million, with the majority of the unelectrified population residing in sub-Saharan Africa. Decentralised renewable energy (DRE) is critical for providing clean, reliable, and affordable energy (Sustainable Development Goal 7 [SDG 7]) to remote and hard-to-electrify communities. Decentralised solar photovoltaic (PV) energy, in particular, presents a viable solution to this problem due to its scalability, adaptability to local conditions and ability to operate independently of a centralised grid infrastructure.

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- **Off-grid solar PV applications create many jobs**. It is estimated that in a select group of countries – Ethiopia, India, Kenya, Nigeria and Uganda – they employed 307 000 people in 2023. The share of women in the overall solar PV sector workforce is estimated at 40% globally,[1] with some regions faring better than others, according to International Renewable Energy Agency (IRENA) data. In Africa, women hold 38% of all employment positions in the sector. Women comprised 21% of the workforce in the distributed solar PV sector in India, 28% in Uganda, 35% in Nigeria, 37% in Ethiopia and 41% in Kenya.
- As is the case for the DRE industry overall, **decentralised solar PV requires many different roles**, including many that are not typically associated with the sector, such as factory assembly work, office-bound jobs, highly skilled engineers and site planners. The sector could employ women across a large variety of skills.
- Across **Africa**, 24% of science, technology, engineering and mathematics (STEM) roles in the PV sector, and 22% of other technical jobs, are held by women. The share is somewhat higher both in administrative positions and in other non-technical roles, where women account for 27% of roles. In the Asia-Pacific region, women's share is higher than in India, where the role of women in off-grid solar PV seems to be more prominent in jobs that require higher skills.

1 IRENA data did not show any significant difference between off-grid and on-grid employment of women; therefore, it can be assumed there are similar shares of women in both contexts.

- **Decentralised solar PV systems are transforming the entrepreneurial landscape**, particularly in underserved and remote areas. Entrepreneurship can thrive not only in sales and deployment of solar PV solutions but also through so-called "productive use" in various types of enterprises. By providing reliable and affordable energy access, solar PV systems enable entrepreneurs to establish and grow businesses that were previously constrained by limited or unstable electricity supply. The synergy between decentralised solar PV and entrepreneurship thus plays a critical role in advancing socio-economic development and energy equity. But to do so, countries that expand DRE need to make more jobs in the sector accessible to women, who face many barriers when aiming to tap into entrepreneurial initiatives.
- **Women face challenges that mirror those experienced in the on-grid space**. These include societal constraints, including social and cultural biases, dual burdens faced by women, and self-perception; skilling, educational and training-related barriers, including biases starting in early education that discourage women from pursuing STEM-based subjects ambitiously; and other gendered workplace barriers, such as biases from employers and customers, pay gaps, safety and mobility, and lack of workplace flexibility.
- To harness the vast, transformative potential women have in the decentralised energy sector, **policy makers and businesses need to make gender inclusion a pillar of the sector's further development**. This includes improving data collection and knowledge about women's inclusion in the sector; mainstreaming targeted policies and programmes that provide access to training, education, employment and entrepreneurship opportunities for women; and creating a positive enabling environment for women working in and outside the sector, such as through outreach programmes and media work, and by promoting job flexibility. Specifically with regard to entrepreneurship, women also require better access to resources, including collateral such as land or capital, as well as access to finance.
- Key to producing results is a long-term, economy-wide approach that makes societies aware of the role women can and should play in their economies, as well as in contributing to building more sustainable and resilient societies. **The role that women play in the DRE economy is critical to modern energy access** and to ensuring communities that have not yet achieved universal access do so in the coming years.


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Introduction

DRE[2] technologies, in particular solar PV, have emerged as a key solution to providing access to clean, reliable and affordable energy (SDG 7) for remote and hard-to-electrify communities (where eight in ten people without access live today) across the globe (IEA *et al.*, 2024). Some 685 million people globally were left without access to any form of electricity in 2022, 10 million more than in 2021, most of them in sub-Saharan Africa (*ibid*).

Women are usually characterised as potential beneficiaries of decentralised energy solutions, rather than as agents of change (ESMAP, 2022). This is in spite of the significant potential for women to contribute to the sector's development through their work. Decentralised solar PV technologies in particular can be an important employment engine and thus drive better, more sustainable livelihoods. In 2023, it was estimated that over 300 000 people were directly employed in the decentralised solar PV sector across Ethiopia, India, Kenya, Nigeria and Uganda, but women made up only a small portion of this workforce (see Chapter 1).

Globally, the off-grid solar sector has the potential to employ up to half a million people by 2030, rivalling the employment numbers of the fossil fuel industry (Power for All, 2022). The sector has the ability to create local jobs, promote skill development and support sustainable development. This potential also contributes crucial arguments in favour of the sector's promotion among governments and financing bodies, including development agencies and philanthropies that aim to promote sustainable livelihoods (IEA *et al.*, 2024). The right policy frameworks can also help foster the creation of a social ecosystem that expands technology solutions tailored to the specific needs of communities, including women and children (IRENA, 2019a; IRENA and ILO, 2023).

The importance of women in the DRE workforce

Women have made tremendous gains in the small-scale and off-grid subsectors through employment as researchers, retailers, installers and maintenance workers; as entrepreneurs starting and/or growing their enterprises; and as household members with improved health and quality of life for themselves and their families (Nelson and Kuriakose, 2017). Despite this progress, especially in sub-Saharan Africa, the share of DRE jobs for women – including in decentralised solar PV – remains low.

Some of the reasons for this are country- and context-specific, but they can broadly be summarised under three distinct categories: i) societal constraints; ii) lack of access to educational and professional development;

2 *Notwithstanding some differences between them (see Vezzoli et al., 2018), for the purpose of this report, the terms "decentralised" and "distributed" are used interchangeably.*

and iii) other gendered workplace barriers. Female entrepreneurs face additional constraints, including access to finance. This deficit of women's access to jobs in the DRE sector exacerbates existing skills shortages, preventing a significant part of the population from contributing to the sector's development, as well as from benefiting from the enormous employment-generating potential of the sector.

Job creation in the DRE sector could become an important driver of socio-economic development in developing countries, but it will do so only with the inclusion of women, who make up roughly half of the population. Growing evidence demonstrates the benefits of a diverse workforce for the deployment of modern energy to last-mile users, such as a wider range of perspectives and experiences, and of increased female participation in sub-Saharan Africa in particular (IFC, 2022a). Women often shoulder most household responsibilities, and thus possess a unique understanding of energy needs, positioning them to drive creativity and innovation in the DRE field. Additionally, specifically in the decentralised energy space, women's strong relationships within their communities position them as effective last-mile distributors of clean energy products (UN Women and UNIDO, 2023).

Women are also critical to scaling up a skilled local workforce, especially at the community level, to deploy DRE solutions more broadly. Recent studies reveal a shortage of local skills needed to develop, install, operate and service DRE solutions for households and businesses, which could turn into a major hurdle to deployment, especially in developing countries (CEEW, 2023; Power for All, 2019, 2022). This means increasing the share of women in the DRE workforce is essential for unlocking the sector's untapped potential, bridging existing gaps, and promoting greater economic inclusion and well-being.


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About this report

This report explores the status of female employment in the DRE sector, with a focus on decentralised solar PV. It sheds light on the main barriers that women face in the sector's workforce and how to bypass them based on five country case studies: Ethiopia, India, Kenya, Nigeria and Uganda. With that aim, it presents data from an exhaustive literature review, focus group discussions (FGDs) and expert interviews conducted in the five countries. It also provides recommendations for how to make the sector more inclusive, so that gender no longer determines whether talent enters the off-grid sector, or not.

The report proceeds as follows: **Chapter 1** introduces employment in decentralised solar PV, providing figures for the focus countries, along with an overview of the various types of jobs in the sector. The chapter also describes female employment in the sector, and discusses female entrepreneurship in the focus countries. **Chapter 2** showcases the main barriers preventing women from joining the DRE workforce and presents examples of women who have succeeded in entrepreneurship. **Chapter 3** presents measures and policies that can help bring more opportunities for women in the sector and beyond, and **Chapter 4** offers the way forward and concludes.

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1 Jobs, skills and the role of women in the workforce

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Employment is a critical indicator of economic evolution and sectoral performance. It is also a major indicator of the indirect welfare benefits of industries, including in the DRE sector. As economies develop, shifts in employment patterns reflect broader changes in industrial composition, technological advancements and societal priorities.

IRENA analysis has over the years demonstrated that the renewable energy sector is a significant source of employment globally, spanning a wide range of activities and skill levels (IRENA, 2019b, 2020; IRENA and ILO, 2021, 2022, 2023, 2024). In 2023, employment in the renewable energy sector reached 16.2 million people worldwide, an increase of 18% relative to 2022, of which 7.1 million were from solar PV alone (IRENA *et al.*, 2024). The International Energy Agency (IEA) projects that more than half of the underserved population worldwide (55%) is expected to gain access through off-grid and decentralised energy technologies (IEA, 2022). Job creation in the sector will therefore continue growing over the coming years as efforts intensify to close the energy access gap.

Decentralised solar PV is the most widespread technology used for off-grid energy generation, and it has grown rapidly in recent years both in and beyond this study's focus countries (see Box 1). Its deployment has large socio-economic benefits for local economies, beyond providing access to modern energy to underserved communities. Unlike conventional electricity supply through a large-scale, centralised utility, DRE brings electricity generation and distribution close to the final consumer – often to their own backyard or rooftop – therefore also generating local jobs and business opportunities in remote and rural areas. Site planning and procurement, licensing, manufacturing/assembly, installation, operation and maintenance of the assets and sales are all labour-intensive activities that require a skilled, local workforce able to plan, sell, install and maintain the technology.[3]

Decentralised solar PV is the **most widespread technology** used for offgrid energy generation.

DRE generates **jobs and business opportunities** in remote and rural areas.

3 This study encompasses four primary technology categories within the DRE sector. Pico solar appliances represent small-scale solar devices typically generating less than 10 watts (W), commonly used to power a few lightbulbs or a phone-charging station. Solar home systems (SHSs) are capable of generating up to 100 W, enabling the operation of basic household appliances such as televisions and refrigerators. Commercial and industrial systems range from 100 W to multiple kilowatts (kW), serving stand-alone configurations for commercial or industrial applications. Mini-grid systems, larger-scale systems ranging from 1 kW to 10 megawatts (MW), are designed to provide electricity to entire communities or clusters of buildings, often in off-grid or remote areas. These categories collectively illustrate the diverse applications and scalability of solar off-grid technologies in meeting energy needs across various settings and scales.


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Box 1. The status of decentralised solar PV in this study's focus countries

This study focuses on five countries – Ethiopia, India, Kenya, Nigeria and Uganda – each for a particular reason. India is considered the biggest deployer of decentralised renewables globally, owing to its large population and electrification needs, as well as its successful private sector-led innovative business models and support from the national government through enabling policies for large-scale implementation.

In sub-Saharan Africa, Kenya has among the largest installed generation capacity of off-grid solar PV (IRENA, 2024), thanks to the relatively successful deployment of SHSs and pico solar in many peri-urban and rural areas (GOGLA, 2024) that is reflected in the fast growth of installed generation capacity (Figure 1). A new government initiative, the Kenya Off-Grid Solar Access Project (KOSAP), aims to achieve rural electrification targets by deploying hundreds of solar mini-grids.[4]

Nigeria, too, has been making significant progress in decentralised energy deployment since 2018, when the Rural Electrification Agency secured a USD 350 million (United States dollar) loan from the World Bank to deploy solar mini-grids in rural areas (Nana and Dioha, 2024). While solar PV has historically faced significant competition from the large and well-established oil and gas sector, subsidies for fossil fuel subsidies were ended in 2023. In the wake of this cessation, diesel and gasoline prices spiked, thereby enhancing the attractiveness of solar technologies.

The Ethiopian and Ugandan markets for DRE have grown over the past decade, but at a slow pace (Figure 1). In Ethiopia, the growth of the DRE sector has been held back by the foreign exchange shortage.[5] This shortage impeded firms' ability to access the necessary foreign currency to invest[6] or repatriate any profits. In addition, stringent regulatory barriers to entry (such as licenses "only for Ethiopian firms") deter foreign investors (Energise Africa and Power for All, 2021). However, with fast-growing demand for electricity as well as ambitious electrification targets, Ethiopia presents substantial opportunities for the development of the DRE sector.

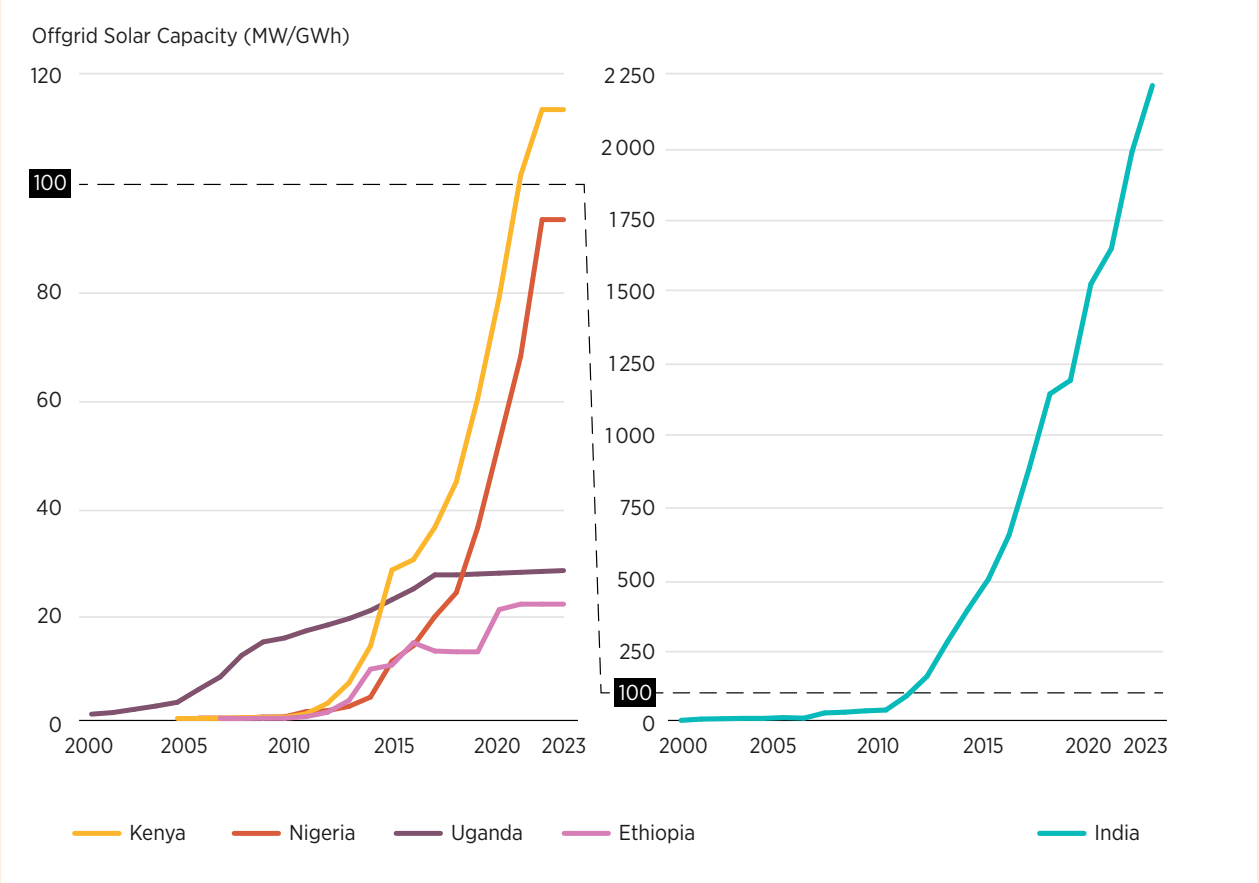
4 Targeting 14 counties in Kenya's northeastern and coastal regions, including Turkana, Garissa and Kwale, KOSAP aims to install a quarter-million stand-alone SHSs and 120 mini-grids by 2030 (Ministry of Energy and Petroleum Kenya, 2024).

5 Recent policy reforms in Ethiopia include the liberalisation of the foreign exchange market, which can result in an easing of restrictions on foreign investment. Consequently, a more favourable environment for the development of the sector could be expected.

6 E.g. by importing materials for assembly or final products for retail.

Finally, Uganda has abundant solar and hydro resources; in fact, the country has excess generation capacity. However, high upfront capital expenditures, a lack of financing options, lengthy and complex applications for licenses and permits, and a shortage of local expertise to operate DRE technologies are some of the main barriers to the growth of the sector.

Figure 1. Total installed off-grid solar PV electricity generation capacity by country, 2000-2023 (MW)



Source: (IRENA, 2024)

Decentralised solar PV jobs and skills

Employment in DRE, and in decentralised solar PV, has increased considerably over time. This is especially the case in countries with large existing energy access deficits, as the sector gains recognition from governments and donors for its indispensability in achieving ambitious electrification targets.

Globally, an estimated 116 million people lived in a household with improved access to energy through decentralised kits sold by GOGLA (global association for the off-grid solar energy industry) affiliates alone in 2023, 5.9 million people undertook more economic activity as a result of using off-grid solar energy kits and 3 million people used SHSs to support an enterprise (GOGLA, 2023a).

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Box 2. Labour requirements per MW in large- vs. small-scale decentralised solar PV

In PV technology, when it comes to direct job generation, there is a considerable difference between small- and large-scale facilities. For large-scale solar farms, which are designed to be connected to the grid, extensive work is necessary to prepare the land, transport and connect all the modules and inverters, carefully design, and study the production and efficiency of the farm. However, as automatisation is taking over, machinery accelerates and facilitates the work, resulting in a relatively low number of workers required per MW installed.

Table 1. Job-years generated per MW in small-, commercial- and large-scale deployment[7]

	Residential/small-scale	Commercial	Utility/large-scale
America	**26.5** jobs-years per MW	**19.1** jobs-years per MW	**2.1** jobs-years per MW
			462 person-days/MW
Asia	**24** jobs-years per MW		**3** jobs-years per MW
			669 person-days/MW
Africa	**28** jobs-years per MW	**18** jobs-years per MW	
	6 160 person-days/MW		
Global	**25** jobs-years per MW	**18.5** jobs-years per MW	**2.6** jobs-years per MW
	5 500 person-days/MW	**4 070** person-days/MW	**572** person-days/MW

7 Source: Analysis carried out by Deloitte, taking information from different sources and projects.

Labour requirements vary in terms of intensiveness between large- and small-scale solar PV, as their value chains differ slightly. Some are more labour intensive than others, with off-grid systems typically being significantly more labour-intensive than utility-scale plants (see Box 2). This labour intensity can benefit local populations in off-grid areas that deploy solar PV systems, provided skills match the required work.

Off-grid PV systems typically require significantly more labour than utility-scale plants.

On the other hand, in residential installations (usually located on the rooftop of buildings or houses), the number of new employees per MW is considerably larger. Each case requires an individualised study, depending on its characteristics, as well as some technicians/electricians to properly install all the equipment. The design, economic study and other phases of the process also need to be done for each specific case, requiring a number of employees/MW that can rise to as much as ten times more than those of large-scale facilities.

The employment, measured in job-years and person-days per MW, is shown in Table 1 for different regions of the world and divided into small, commercial and large-scale deployment.

As for the proportion of workers required in each stage of the process, the following tables indicate the distribution for solar PV technology in general and differentiating between small and large scale.

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Table 2. Jobs generated in each activity for large- and small-scale solar pv projects

Large-scale (ground-mounted)		Small-scale (rooftop)	
Operation and maintenance	14%	**Operation and maintenance**	2%
Construction and pre-commision	78%	**Construction and commisioning**	56%
Design and pre-construction	6%	**Design and construction**	36%
Business development	1%	**Business development**	6%

In 2021, it was estimated that around 220 000 people were directly employed in decentralised solar PV technologies in Ethiopia, India, Kenya, Nigeria and Uganda (Power for All, 2022). By 2023, this number was projected to have grown by nearly 40%, with over 307 000 people employed in these countries. The majority of these jobs were in Nigeria (36.1%), India (29.5%) and Kenya (19.4%), followed by Uganda (11.2%) and Ethiopia (4.1%). Globally, the sector has the potential to employ up to half a million people by 2030, rivalling the employment numbers of the fossil fuel industry (Power for All, 2022).

A notable characteristic of direct jobs in the off-grid sector, compared to those in large-scale or centralised energy settings, is the diverse and localised occupational profiles required. Employment in DRE involves mainly downstream activities and is primarily community-focused, necessitating skills in sales, installation, maintenance and repair, rather than large-scale manufacturing or construction. This localisation promotes sustainable employment within rural and remote areas, in contrast to centralised energy projects, which primarily generate jobs during the capital-intensive construction phase.

Employment in DRE is primarily community-focused, with skills in sales, installation, maintenance and repair, rather than large-scale manufacturing or construction.

Decentralised solar PV offers an array of different jobs along its value chain, offering both skilled and unskilled job areas from small-scale manufacturing. Operation and maintenance is the most important area for local training and job creation (IRENA, 2023), but it is important to realise that the direct job creation potential of DRE does extend across its entire value chain, from the fabrication of components to planning, siting, installation and management.

While manufacturing processes are not necessarily "local" and can happen anywhere in a country (or take place outside a country), many other jobs associated with decentralised energy are by nature localised, owing to the stand-alone nature of many off-grid systems. This includes commercial activities, such as sales, customer service and community engagement, alongside technical roles like installation and maintenance, which are most effectively carried out when localised. This diversity ensures that there are positions suited to various talents and professional backgrounds.


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This is in addition to many indirect jobs created by the availability of affordable electricity for households and businesses that can extend the time they are able to work under lighting, use electric equipment, and connect to the outside world through mobile phones and the internet (ESMAP, 2023). Table 1 below summarises some of the diverse, direct job profiles distributed solar PV systems can help create.

Table 3. Examples of jobs associated with decentralised solar PV technology deployment

Manufacturing	Engineering, procurement and commissioning	Operation and maintenance
• Solar Street Light Pole Fabricator • Solar PV-Pump Technician • Solar Street Lighting Technician • Solar Lantern and Solar Home Lighting Technician • Solar Off-Grid Production Manager (Solar Lantern & Solar Home Lighting) • Solar Off-Grid Production Supervisor (Solar Lantern & Solar Home Lighting)	• Solar Grid Entrepreneur • Solar Lighting Technician (Options: Home Lighting System/ Street Lights) • Solar Street Light Installer • Solar PV Pump Installation & Maintenance Manager/Solar Pump • Entrepreneur • Site Supervisor • Civil-Sub Contractor • Solar Off-Grid Street Lighting • Installation & Maintenance Engineer • Mechanical/Civil/Supervisor • Mason	• Solar PV Engineer (Option: Solar Water Pumping Engineer) • Solar PV Project Helper • Solar Pump Technician • Customer Care Executive • Solar Off-Grid Machine/CNC • Operator • Solar Off-Grid Manufacturing • Technician (Solar Lantern and Solar Home Lighting) • Solar Off-Grid Sales Manager • Solar Off-Grid Sales Executive

Based on: (IRENA, 2017; UNDP, 2021: 20)

Women in the decentralised solar PV workforce

Globally, women occupy a still unequal share of jobs in the renewable energy sector. IRENA estimates the average share of women in renewable energy workforce at 32% – relatively low, but ten percentage points higher than that of the broader energy sector. For solar PV, the female share climbs to 40% (IRENA, 2019a). According to GOGLA, currently, 27% of total full-time equivalent jobs in off-grid solar are held by women, and shares are expected to rise in the near future as the sector continues to grow (GOGLA, 2023b).

According to IRENA's solar PV gender survey, women comprise 38% of the workforce across all positions in Africa's solar PV sector. This regional average aligns closely with national estimates in this report's focus countries, where the decentralised solar PV sector employs 41% of women in Kenya, 37% in Ethiopia, 35% in Nigeria and 28% in Uganda (Power For All, 2022). IRENA's survey data reveal that in Africa, women's representation in STEM fields is notably lower, with only 24% of these roles occupied by women. The situation is similar in other technical areas, where female employment stands at 22%. In contrast, women are slightly better represented in administrative and other non-technical roles, each with 27% participation. Leadership positions show greater disparities, with women holding only 18% of management roles and 15% of senior management positions, highlighting the ongoing challenges in achieving gender parity at higher levels of responsibility (IRENA, 2019a).

Women comprise 38% of the workforce in Africa's solar PV sector.

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Women hold only 18% of management roles and 15% of senior management positions.

The DRE sector in Nigeria experienced the fastest recovery immediately after 2020, adding approximately 30 000 jobs for women between 2020 and 2023 alone, nearly quadrupling the 2020 figures. Rising demand for SHSs in the populous country, which was already on an upward trajectory pre-pandemic, played a pivotal role in driving this rapid recovery. Policies encouraging off-grid renewable energy systems clearly helped, including significant financial support from the World Bank and the Africa Development Bank via the Nigerian Electrification Project (NEP) (Rural Electrification Agency, 2024a).

While IRENA's solar PV data on gender indicate that women are participating in the solar PV sector in the Asia-Pacific region, these results are heavily influenced by the large-scale manufacturing sector in China, which employs a significant number of women (IRENA, 2022). Overall, estimates suggest that women make up about 21% of the workforce in India's decentralised solar PV sector (Power for all, 2022).

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Box 3. The Nigerian Electrification Project (NEP)

The NEP is an initiative from the Nigerian federal government driven by the private sector to address the energy access gap in unserved and underserved rural communities. It aims to provide electricity to households, micro, small and medium-sized enterprises (MSMEs), as well as educational and healthcare facilities. This is achieved through the deployment of mini-grids, SHSs, captive power plants and productive use appliances to ensure the sustainability of these off-grid solutions.

The NEP is fully aligned with the Rural Electrification Strategy and Implementation Plan and supports the Power Sector Recovery Plan (2017-2021) objectives. These objectives focus on increasing private investment in the energy sector and implementing rural energy access and off-grid/mini-grid energy services. To facilitate the NEP's implementation, the federal government of Nigeria, through the Rural Electrification Agency, has secured financing from the World Bank (USD 350 million) and the African Development Bank (USD 200 million).

The project has made significant progress in enhancing energy access across rural communities. It has brought electricity to 3.8 million people. Through mini-grids, 58 694 electricity connections have been established, while SHSs have facilitated 1 086 235 connections, including 6 543 MSMEs. Additionally, 14 treatment/isolation centres have been completed, and the procurement process is underway for 3 teaching hospitals, 15 federal universities and 400 primary health centres (Rural Electrification Agency, 2024b). In addition, the NEP is also estimated to have created over 5 000 private sector, local green jobs in Nigeria (World Bank, 2023).

In all focus countries except for Uganda, the sector mirrors the share of women in the overall labour force – suggesting that the same barriers to women's participation apply as elsewhere in the economy. Uganda, by contrast, has almost achieved gender parity in its national economy, with women accounting for 49% of the workforce. However, women's representation in the decentralised solar PV sector remains notably lower at an estimated 28% of the workforce. It is unclear what precisely is causing this difference, which highlights the need for much better data.

Across the focus countries in the decentralised solar PV sector, the level of women's participation varies significantly depending on the skill level of the workforce.[8] India stands out as a case where women's participation increases notably with higher skill levels. In Kenya and Nigeria, on the other hand, the lowest levels of female participation are observed at the semi-skilled level. Uganda presents a different scenario, with relatively low variation across skill levels. Finally, in Ethiopia, women's participation rates at the skilled level reach the lowest levels. These findings underscore the importance of considering skill-level dynamics when designing policies to enhance gender diversity within the DRE sector (Power for all, 2022).

While initiatives aimed at increasing women's participation in India should focus on harnessing higher skill sets, strategies for Kenya and Nigeria must address the challenges faced by semi-skilled workers. Uganda's relatively consistent participation rates across skill levels suggest the need for holistic approaches to foster gender inclusivity. In Ethiopia, targeted interventions are necessary to address the barriers hindering women's participation at the skilled level. As the sector progresses, the evolution of skill requirements will shape the nature of employment opportunities, necessitating adaptable policies that cater to the changing needs of the workforce.

However, training and skills development are not the only barriers women face in participating in the sector. The reality is far more complex, as social norms and cultural expectations also play a significant role, influencing every decision women make, and shaping their expectations in the labour market. As with other technologies, sectors and areas of the economy, these factors create additional layers of challenge. Chapter 2 delves into the specific barriers women encounter as entrepreneurs and explores the various dimensions they must navigate to fully engage in the sector.

The barriers women face in participating in solar PV range from unequal access to training and skills development to social norms and cultural expectations.

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8 Skilled work involves leadership, management and professional roles (such as chief executive officers, C-level executives, and technical roles such as installation technicians or engineers). Semi-skilled work requires attention to detail and risk management but does not involve complex tasks or advanced training (office assistants and sales agents). Unskilled work consists of simple tasks that require little judgment and can be learned on the job, such as cleaners, cashiers and security guards.

9 The analysis relies on data from focus group discussions (FGDs) and expert interviews, conducted in all focus countries, as well as secondary sources to shed light on the current status of female employment in the DRE workforce. Technology-wise, the present study mostly covers the solar off-grid spectrum, from employment in pico solar appliances of less than 10 W to large solar mini-grids of over 1 kW.

Women and entrepreneurship in the decentralised solar PV sector

Decentralised solar PV systems are also revolutionising the entrepreneurial landscape in many countries deploying the technology, particularly in underserved and remote areas. The sale and deployment of solar PV solutions offers many localised business opportunities beyond those created by access to electricity, including for women. Recent evidence demonstrates that DRE solutions have enabled unprecedented opportunities in rural communities, especially for women, who can be strong agents of change (Alliance for Rural Electrification, 2020). This not only holds large potential to drive economic growth and job creation, but also to promote sustainable development by reducing dependency on fossil fuels and mitigating environmental impacts.

This is in addition to the potential for entrepreneurs to leverage solar energy to power a variety of ventures, from small-scale manufacturing and agricultural processing to retail and services. Globally, small and medium-sized enterprises (SMEs) play a crucial role in driving economic activity, constituting around 90% of business operations and generating over 50% of employment and GDP (World Bank, 2019a). Research shows that women make up 58% of Africa's self-employed population (World Bank, 2019b). Empowering more women to become entrepreneurs in the off-grid solar PV sector could further add to the socio-economic benefits of the DRE sector, including supporting the dual goals of impactful and inclusive economic growth and women's empowerment.

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Decentralised solar PV systems are revolutionising the entrepreneurial landscape in underserved and remote areas.

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By owning and operating clean energy enterprises, women not only generate income for themselves, but also create employment opportunities and contribute to community resilience. Across sub-Saharan Africa and India, numerous examples of successful female-led initiatives in the DRE sector demonstrate the transformative power of women's entrepreneurship in driving sustainable energy access and fostering inclusive development.

This has also been recognised by larger projects and initiatives that promote off-grid access to clean energy. India's Lighting a Billion Lives initiative provides opportunities for women's employment in sales, rentals and repairs of solar lanterns, cookstoves, solar home lighting systems and solar micro grids (Baruah, 2015; Nelson *et al.*, 2017). In sub-Saharan Africa, the Lighting Ethiopia programme actively encourages women's participation across the off-grid sector's value chain and works with women's groups to access financing for energy products (Nelson *et al.*, 2017).

Transitioning from a male-dominated fossil fuel sector to an inclusive, decentralised renewable sector presents a significant opportunity for sub-Saharan Africa and India. This transition addresses energy poverty, enhances climate resilience and promotes gender parity. By empowering women as entrepreneurs in the decentralised solar PV energy space, communities can benefit from sustainable energy solutions that are accessible, affordable and environmentally friendly. Moreover, women's participation in the sector fosters economic growth and social development, contributing to more equitable societies.

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Women entrepreneurs in the decentralised solar PV energy space foster local economic growth and social development.

2 Barriers to women's employment in the decentralised solar PV sector

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Barriers to female employment in the decentralised solar PV and the wider DRE sector are manifold. They reflect a combination of local socio-economic factors as well as more general challenges women face in any workforce across the world. The cases of India and the four sub-Saharan African countries highlight the fact that reforms to strengthen women's participation across economic sectors hold large benefits for the economy, and the DRE sector is part of that. For policy makers and the business community, understanding these main challenges and barriers preventing women from joining the workforce is essential for devising effective strategies and policies to promote gender inclusivity.

For this reason, this chapter explores four sets of barriers to women's employment in the DRE sector: i) societal constraints, such as cultural expectations, stereotyped gender roles and other practical challenges for girls and women to set foot into the sector; ii) skilling, education and professional development-related barriers, including lack of access to (STEM-related) education and limited training opportunities; iii) gendered workplace barriers, including gender bias in recruitment, lack of family-friendly employment terms and mobility issues; and iv) specific challenges for women entrepreneurs.

Barriers to female employment in the decentralised solar PV and the wider DRE sector are manifold.

Societal constraints

Just as women in many emerging markets are constrained by socio-cultural norms and traditional male-dominated structures to electricity access – through a lack of skills, knowledge, decision-making power and/or financial means – societal constraints are important barriers to women's full participation in job markets created around energy access (Alliance for Rural Electrification, 2020; Huyer and Hafkin, 2013; MacKenzie and Wajcman, 1999; Rosser, 2005). In the countries studied for this report, this factor presents a significant challenge further linked to other barriers, including access to education and training, and other gendered workplace barriers. While societal constraints can take many forms, below we focus on three key challenges: societal and cultural bias, perception of gender roles, and self-perception of women.

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Societal and cultural bias

As in many other economic sectors, societal biases and cultural practices are critical factors influencing the degree to which women in emerging economies seek employment in the off-grid sector. Cultural and social norms dictating rigid gender roles and expectations constrain women's opportunities within the sector. Technical jobs in the energy sector are prone to such societal barriers, being typically associated with male labour, given the frequent association of such jobs with hard, physical work. This is in addition to the widespread assumption (not only in Africa and India) that men are generally better in STEM subjects than women (see also IRENA, 2019a). Societal expectations may drive many girls and women to choose more gender-typical jobs, such as those in education and healthcare. This trend was also found in focus group interviews for this report.

Societal and cultural norms may also affect other factors that prevent women from choosing energy- and DRE-related jobs. Paternal or spousal disapproval and cultural expectations about women's childcare duties, with cultural preferences for jobs that women can do from home, also play a role (FGD Ethiopia, 2024). In Kenya, women interviewed for this study reported that some companies resorted to discussing job safety and suitability for women with their husbands and fathers (FGD Kenya, 2024). Focus group interviews in Nigeria also highlighted factors such as dress codes in the DRE sector, like the need to wear trousers, which some women would not choose for cultural-religious reasons (FGD Nigeria, 2024).

Cultural and social norms may dictate rigid gender roles and expectations, constraining women's opportunities within the DRE sector.

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Perception of gender roles

The distribution of time between work and other activities is also highlighted as a critical barrier for women. This is compounded by women's traditional responsibility for household tasks, which are perceived as obligations. The problem is not only one of self-perception by women (discussed below), but also views held by men, whose attitudes toward what their daughters, wives and colleagues can do are often critical to determining women's access to education and jobs (IRENA, 2019a). In homes with limited financial resources, boys often take priority in education. Women, traditionally tasked with the majority of family obligations, also find their opportunities constrained in practice due to the substantial time and energy invested in these duties, and lacking options for childcare – a universal problem across all continents.

Research underscores this disparity, revealing that housework ranks as the most time-consuming activity for women in countries such as Kenya, Nigeria and Uganda. Across these countries, women dedicate over seven hours daily to unpaid care work, further limiting their capacity to pursue careers in sectors like DRE (ActionAid International, 2013). Unpaid care work includes all those activities that go towards caring for a household – such as cooking, cleaning, collecting water and firewood, and caring for the ill, elderly and children – when these activities are done by family members for no pay.

Women interviewed for this study in Ethiopia also pointed out that the lack of recognition of social barriers translates into inadequate representation of women in policy making, who could address invisible barriers. This, in turn, perpetuates the invisibility of these barriers, reinforcing their continued neglect. In addition, gender stereotypes also meant many men would not tolerate having a woman as boss, thereby restricting women's ability and prospects to achieve career development in this and other technical sectors (FGD Ethiopia, 2024).


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Self-perception

According to almost all the women interviewed for this study, another relevant barrier women face is their own perception of their capabilities and skills. This barrier affects their ability to access jobs, obtain equitable pay, get promoted and grow their careers. Societal and cultural biases shape women's expectations of their lives and ability to work in non-traditional fields such as DRE significantly. Women also tend to undervalue their own skills and suitability for certain jobs, including technical ones. This is something rooted in deep cultural aspects and stereotypical assumptions, as women are reminded from their childhood days what they can or cannot do in relation to what boys can or cannot do (GEAPP, 2023). During a focus group interview in Kenya, a participant said, "It's very hard because growing up, women are given the kitchen things like utensils – you wash, you clean. That's what is imprinted in your mind, and your work is just seen as in a kitchen."

Shaped by societal and cultural biases, another relevant barrier women face is their own perceptions of their capabilities and skills.

In addition, women tend to be more risk-averse than men, and they usually hesitate to apply for positions for which they do not perfectly match all the requirements. This may limit their advancement in and opportunities to join the DRE workforce (FGD Kenya, 2024; FGD Uganda, 2024).

The absence of mentors and role models was also highlighted as a significant barrier hindering women from entering the DRE workforce in all focus countries. Without visible female leaders and mentors within the industry, aspiring women professionals encounter limited opportunities to emulate and aspire to successful career paths in the DRE sector. Taking on such jobs therefore may involve the need to be willing to actively break gender norms. This absence of role models perpetuates a cycle of under-representation, as women may struggle to envision themselves thriving in technical or leadership roles within the sector.

Moreover, a lack of women already working in the sector often means teaching, training and recruiting is done overwhelmingly by men, with training often given to groups dominated by men, further dissuading many women from pursuing careers in DRE. Kenyan women interviewed for this study also highlighted that almost always, interview panels for jobs in the DRE sector are staffed primarily or exclusively by men, which leads the female candidates to underperform or feel uncomfortable.

Skilling, educational and professional development-related barriers

The differences between men's and women's access to education begin early in life and present a formidable challenge to women's participation in the DRE workforce. Globally, many girls and women are held back by biases, social norms and expectations influencing the quality of the education they receive and the subjects they study, in particular in the case of STEM education (UNESCO, 2020, 2024a). Globally, women make up only 35% of STEM graduates, a figure that has remained unchanged for over ten years (UNESCO, 2024a: 2). In 2022, women held less than 25% of STEM jobs (UNESCO, 2024b). Focus group interviews done for this study also found this pattern, with one participant in Nigeria pointing out that in her engineering classes, out of 75 students, there were only 6 girls (FGD Ethiopia, 2024; FGD India, 2024; FGD Kenya, 2024; FGD Nigeria, 2024; FGD Uganda, 2024).

This inequality is also reflected in access to information technology; for instance, in 2022, 130 million fewer women than men owned a mobile phone, and 244 million fewer women had Internet access (UNESCO, 2024b). The level of inequality is higher in developing countries with incomplete access to modern energy and communication technologies, including in India and the four sub-Saharan African countries studied in this report, even though digital tools can be a lifeline for girls and women in rural zones, poorer areas and crisis situations (UNESCO, 2024b).

Together, these inequalities explain why few women go into jobs in the DRE sector, which is heavily based on education in STEM and requires routine access to communication technologies.

The ramifications of these disparities are far-reaching, shaping the career trajectories of women from an early age and perpetuating gender imbalances in the workforce. Moreover, the phenomenon of reverse causality exacerbates these disparities, as women may forego pursuing technical education due to the perceived lack of employment opportunities in male-dominated industries like energy.

Additional barriers specific to the DRE sector include mobility issues. Focus group interviews in Ethiopia highlighted that most DRE training happens in rural areas, which constitutes a barrier for women willing to train but unable to travel safely to those training opportunities (FGD Ethiopia, 2024). In Uganda, universities teach DRE-related context, but without the necessary on-site training, which in turn exacerbates the belief that women are not able to carry out field activities (FGD Uganda, 2024).

In India, the situation is somewhat the other way around. India produces some of the world's highest numbers of women graduates in STEM disciplines. However, their representation in the workplace continues to be low, underscoring the numerous obstacles in the path to achieving gender parity (UN, 2024). Here, finding employment appears to be a far greater barrier than access to education. Some available data, however, suggest that women in India do marginally better in the DRE sector than in other parts of the renewable energy sector, because DRE technologies are usually installed within or closer to home and due to their local entrepreneurial potential for women (Kwatra, 2023). However, women in engineering often prefer core fields in multinational companies, viewing the DRE/renewable energy sector as lacking long-term career advancement opportunities. The physically demanding nature of fieldwork coupled with the perception that women may not meet the sector's physical requirement and the limited advancement for women, except in administrative and management roles, further exacerbate the issue and represent an important obstacle for the sector to attract talent (FGD India, 2024).

Women also tend to have fewer opportunities to access information about jobs in the DRE sector, owing to the disparity in social interactions between men and women, networking, and access to modern communication technology (Cullen and Perez-Truglia, 2019). Moreover, the fact that women predominantly interact within female-centric social circles further restricts their exposure to jobs in STEM subjects broadly, and the DRE sector particularly. Consequently, job opportunities tend to reach men more readily than women, perpetuating gender disparities in workforce representation. Dedicated initiatives focusing on women and providing them with the necessary skills in the sector can be a highly effective way to reach women in this context. For example, initiatives carried out by the organisation Solar Sister recruit, train and support women entrepreneurs to build businesses and bring renewable energy to their communities (Solar Sister, 2018).

Women have fewer opportunities to access information about DRE jobs, owing to gender disparities in networking and other factors.

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Gendered workplace barriers

Women face a myriad of workplace barriers that keep them from pursuing work. Some are specific to the DRE sector, but most reflect wider, gendered workplace barriers that hinder women from achieving their full potential across many sectors. The DRE sector, by virtue of its localised nature, could offer women many opportunities, with dedicated, gender-sensitive policies being able to reduce these barriers significantly.

Biases from employers and customers

Closely linked to social and cultural bias, employer-based bias can play an important role in dissuading women from pursuing careers in the DRE sector. This also includes employers' and customers' expectations about technical skill and expertise, physical capacity, and negotiation and sales power in client interactions (FGD Nigeria, 2024). In Kenya, it was highlighted that customers always direct questions to men, even in a situation where the woman is the engineer of the team (FGD Kenya, 2024). In Uganda, focus group participants pointed out women had a generally higher level of integrity, and thus would be less likely to bend the rules of "whatever it takes" to close a deal (FGD Uganda, 2024). At the same time, interviewees for this study from across different countries studied, including male interviewees, also said that men tend to feel uncomfortable with women asserting themselves (FGD Ethiopia, 2024; FGD Nigeria, 2024).

In all focus countries, women are often viewed as more expensive to employ due to a variety of factors. This includes existing parental leave provisions in all five countries, with paid maternity leave for women only, ranging from 12 weeks in Nigeria to 26 weeks in India, with the employer bearing the financial burden of this leave (ILO, 2024). Men, by contrast, are awarded zero to a few days of parental leave, creating a substantial disincentive for employers economy-wide to employ women. Parental leave is critically important to improve the participation of women in labour markets. However, the shift of the financial burden for this leave onto employers coupled with highly divergent parental leave rights between men and women may actually act as a counter-incentive to employ women. Parental leave also imposes other costs on employers, including the need to re-recruit, and train, new staff more frequently (FGD Ethiopia, 2024; FGD India, 2024).

In addition to gender bias, the lack of gender-sensitive policies itself can be seen as a barrier to a larger female workforce in DRE. A study based on India highlights that gender inclusion is not an active business goal for many enterprises in the renewable energy sector. This is not always because of conscious bias, but also because of limited resources and other priorities (Singhal *et al.*, 2023). This also includes a lack of consistent support for gender inclusion in livelihood programmes that support DRE deployment, for instance for rural electrification (*ibid.*).

This lack of attention to gender is also relevant at the customer level. One of the most underappreciated role women in the DRE workforce could play is to promote more off-grid solutions to women as consumers, who can play active roles in energy provision and consumption at the household level and through community networks. In India, 80% of economically active women are in the agriculture sector (UNDP, 2021), where DRE solutions could offer significant benefits through improved and affordable electricity supply – a key factor helping reduce food waste and increase revenue across the food value chain, which is overwhelmingly staffed by women. Solar Sahelis in India's state of Rajasthan respond to exactly this problem, promoting quality solar products for self-generation through an organisation led by and employing exclusively women (Arya, 2018).

Many businesses do not yet fully consider the potential of DRE solutions specifically to women, by women employees, and the value of creating gender-inclusive marketing collaterals to the benefit of their own business. Part of the reason for this may also be existing representation of women in the management of many DRE businesses; in the case of the above study based on India, most programme enterprises have less than 30% women in their teams (Singhal *et al.*, 2023) and are facing difficulties attracting women employees, thus losing out on viable business opportunities as well as opportunities to attract a more diverse skill pool.

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Customers frequently direct their inquiries to men, despite the woman being the engineer on the team.

Pay gaps

in the DRE sector are closely linked to occupational segregation, workplace discrimination, and cultural or institutional factors.

Pay gaps

Pay gaps are important hurdles to the equal participation of women in the workforce because they discourage employment, especially where initial pay ranges are low and where socio-cultural factors discourage women from seeking paid, formal work anyway. In many cases, women seeking such employment then need to justify comparably low paid work in the face of personal safety risks, and the need to find alternative arrangements for childcare and work in the home. The DRE sector is not immune to gender pay gaps. In addition to all the above-mentioned hurdles, women in the sector also often earn less money than men for equal or similar work (Power for All, 2022).

Global research shows that the gender pay gap – irrespective of the sector – is more concentrated in low- and middle-income regions, such as sub-Saharan Africa, the Middle East and North Africa, and South Asia (World Economic Forum, 2023). The Global Gender Gap Index[10] shows India and Nigeria rank particularly low on equity between the genders for pay, placing them at 127th and 130th out of 146 evaluated countries, respectively. Meanwhile, Ethiopia, Kenya and Uganda rank comparatively better, at 75th, 77th and 78th, respectively (World Economic Forum, 2023). The Powering Jobs Census 2022, which estimates the gender pay gap in the DRE sector, reveals that in all focus countries, the gender pay gap increases with the skill level (Power for All, 2022).

Several reasons are behind the existing gender pay gaps, but the FGDs and expert interviews conducted in the five focus countries reveal that pay gaps in the DRE sector are closely linked to inequitable access to employment, especially at leadership levels, also known as occupational segregation (*i.e.* women are disproportionately concentrated in lower-paying roles, such as administrative positions). Workplace discrimination and cultural or institutional factors that reduce women's bargaining power also play a big role in affecting women in the sector.

Interviews in India for this study suggested the gender pay gap is also explained by women negotiating less well than men, due to a combination of cultural factors and socialisation, limited options and lack of inside information. Furthermore, women may be more likely to work in informal positions, such as commission-based roles, which may lack benefits like health insurance and maternity leave, contributing to a gender pay gap (FGD India, 2024).

10 The Global Gender Gap Index is a comprehensive benchmark developed by the World Economic Forum to assess gender disparities across 146 countries. It evaluates gender gaps in four key areas: economic participation and opportunity, educational attainment, health and survival, and political empowerment. The index provides a numerical score, and countries are ranked based on their performance, with a lower score indicating a narrower gender gap.

Safety and mobility

A gendered barrier to female participation that is more specific to the DRE sector than some other sectors is very clearly limited mobility due to concerns about safety. The DRE sector is often by definition (though not always) serving remote communities, and involves planning, installation and maintenance work locally, rather than at a centralised power plant.

Significant safety concerns exist for girls and women in many countries, including those discussed in this study. Personal safety is a critical concern for women wishing to work in the DRE sector. Public and private transport is often not available or not deemed safe for women. Safety at installation sites, with a lack of adequate equipment and infrastructure and the cost of additional housing, and significant concerns about women's safety during travel further exacerbate biases against hiring women in the DRE sector (FGD Ethiopia, 2024; FGD Uganda, 2024).

Focus group interviews with women in India in particular highlighted a high level of concern about women's safety in travel. This concern leads to a lack of mobility and lack of attractiveness of jobs in the DRE sector for women, in addition to family opposition to such jobs owing to concerns over women's safety (FGD India, 2024). This lack of mobility is also an issue in Kenya, where it is rare to find women who ride motorbikes, therefore limiting their ability to perform roles in sales or any role that requires travel (FGD Kenya, 2024). In Uganda, too, focus group members explained that for safety reasons, many companies do not send female sales agents on solo trips, necessitating the pairing of two women for travel assignments. This precaution addresses safety concerns, but it increases the financial burden on employers, who must allocate resources for the deployment of two agents instead of one (FGD Uganda, 2024).

Lack of workplace flexibility

Interviews conducted in Kenya as part of a focus group for this study highlighted that many women preferred informal to formal jobs owing to more flexible schedules that allowed them more freedom to reconcile family duties as well as, in some regions, seasonal work at the family farm. This is in spite of unequal pay and benefits. This, in turn, affects their ability to accept formal jobs in the DRE sector that involve more rigid schedules. This finding reflects economy-wide barriers across countries and industries for women that are linked to inflexible working schedules, lack of part-time opportunities, required office attendance even for jobs that can be done from home, as well as routinised overtime hours, all of which make reconciling caring for a family while working full-time more difficult.

Barriers particularly affecting women entrepreneurs in the decentralised solar PV sector

Women face many challenges as entrepreneurs in the DRE sector. This is despite their great potential to drive innovation and foster sustainable development, particularly as entrepreneurs, given the large number and proportion of women working in sectors that could benefit from DRE technologies, including agriculture and food production. As in the case of employment, many of the obstacles women entrepreneurs encounter in the sector link back to wider socio-economic challenges women face in their daily lives, and addressing them more widely would likely increase women's chances to make a positive impact as entrepreneurs in the DRE sector.

The Alliance for Rural Electrification summarises these challenges as arising from many women's disadvantageous position to access financial means, training, information, productive use equipment and land (Alliance for Rural Electrification, 2020). Cultural barriers influence all these factors, in addition to creating a barrier of their own right, including through persistent, pre-defined social roles, and an environment that restricts their movements. In Kenya, focus group interviews also showed women entrepreneurs encounter various bureaucratic obstacles in the formal sector (Kenya Land Alliance, 2019). And, as in everywhere else in the world, women in the DRE sector also face a perpetual challenge of combining childcare and family care, expectations about their role in the home, and their work in a dynamic, technology-driven sector.

Unequal access to finance and assets like land represents a significant barrier to women entrepreneurs.


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Access to finance, ownership and assets

Access to finance poses a significant barrier to female entrepreneurship both globally and in Africa and India. For example, research conducted by the IFC in 2017 indicated that women-owned SMEs globally face an estimated credit gap of USD 1.4 trillion to USD 1.7 trillion (IFC, 2022b). During the FGD for this study, participants highlighted the challenges women face in securing financing through traditional banks, where stringent requirements often exclude them, particularly those with lower incomes. For instance, in sub-Saharan Africa, only 37% of women have a bank account, compared to 48% of men (Morsy *et al.*, 2019).

Land plays a pivotal role in the socio-economic development and empowerment of women everywhere in the world, including in sub-Saharan Africa. Ownership and control of assets, notably land, significantly influence economic mobility, bargaining power within households, and access to finance. Banks and credit agencies, as well as microfinance institutions, typically require collateral. This collateral predominantly consists of assets owned by men, such as land or property ownership. The gender disparity in asset ownership, exemplified by the predominance of male-owned collateral such as land, exacerbates the financial exclusion faced by women entrepreneurs.

Land rights and ownership are influenced largely by national legislation, including land titling, public recognition of customary land use, as well as family and inheritance law (Kenya Land Alliance, 2019).

In Kenya, for instance, in most marriages, the title deed usually bears the man's name, leaving women vulnerable to dispossession (Kenya Land Alliance, 2024). The absence of women's interests in title deeds makes the land they depend on for livelihoods susceptible to disposal without their knowledge or consent (Morsy *et al.*, 2019). As a result, in Kenya in 2021, evidence shows that women possess only 1% of land titles in their names and only 6% jointly (Kenya Land Alliance, 2024). In sub-Saharan Africa, recent studies show that only 13% of women claim sole ownership (Behr *et al.*, 2023). This is striking, especially considering that women produce between 60% to 80% of the food in developing countries (Otieno Onyalo, 2019). In sub-Saharan Africa this is a rampant issue facing women specifically, as most often land, property, vehicles and livestock are under a man's name, creating an impenetrable obstacle for women attempting to further their economic development. This gender disparity in asset ownership, exemplified by the predominance of male-owned collateral such as land, exacerbates the financial exclusion faced by women entrepreneurs.

Unequal access to modern energy

Disparities in electricity access further hinder women's participation in entrepreneurship. Women bear a disproportionate burden of energy poverty: it is estimated that 70% of the population living in energy poverty are women (European Economic and Social Committee, 2022). They face health risks from household air pollution, carry heavy fuel loads and lack lighting, affecting their well-being and economic rights. In both India and Kenya, electricity connections are overwhelmingly registered under men's names, surpassing 80% (Energia, 2019a). This discrepancy stems from utility regulations mandating that the connection's name align with the household owner, perpetuating gender imbalances in energy access. Limited access to reliable electricity undermines the viability of women-led businesses, hindering their growth and productivity.

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Childcare and family obligations

As is the case everywhere else in the world, women entrepreneurs in the focus countries studied for this brief need to reconcile work and family life. Globally women spend on average over four hours per day on unpaid care work, which limits their ability to study, work, network and access other economic opportunities (Shell Foundation, 2024). The demanding nature of entrepreneurship often requires long hours and sacrifices, posing challenges for women balancing family responsibilities and business pursuits. In Uganda's Mukono District, a peri-urban area located 20 kilometres away from Kampala, female restaurant owners highlighted that DRE cooking appliances significantly save cooking time, allowing them to devote more time to childcare (FGD Uganda, 2024).

Case studies of women-led enterprises

This chapter presents three examples of role models that shed light on the experiences of female entrepreneurs in the decentralised solar PV space, offering insights into their challenges, successes and contributions to sustainable development. By highlighting their stories, the case studies seek to inspire action and advocacy for gender-inclusive approaches to energy access and climate resilience. They are based on a mixed-methods approach, combining qualitative interviews, quantitative analysis and literature review to capture the nuanced experiences of female entrepreneurs in the DRE sector.

Alem Gebru Gebremeskel
Modify Electromechanical, Ethiopia

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Alem Gebru Gebremeskel is an electrical engineer and advocate for women. She is also the founder of Modify Electromechanical, which provides clean energy solutions to rural areas and champions female inclusion in this male-dominated field. Her journey mirrors the broader struggle and ambitions of women aiming to break into the sector.

From a young age, Alem excelled in mathematics and physics. Motivated to break the stereotype that women are unsuited for engineering, she was one of only five women in her sixty-student class, actively challenging socio-cultural norms. After graduating, Alem transitioned from construction consulting to product supply, where her electrical engineering background provided a unique advantage in determining the materials and products needed for large civil engineering projects. Capitalising on that advantage, in 2011, she founded Modify Electromechanical. However, she faced hurdles: "Access to capital was a challenge, and working with contractors often meant overcoming biases to prove my capability," Alem said.

While working on a stand-alone solar street light installation project she spotted a neglected opportunity: introducing stand-alone SHSs and solar irrigation pumps to rural Ethiopian households. Her initiative addressed a critical need while also setting the stage for women's active participation in renewable energy solutions. This approach not only aids in the development of sustainable communities but also puts women at the forefront of decision-making processes, particularly in purchasing decisions for SHSs – over 70% of Modify's customers are women (GOGLA, 2022).

However, the road to achieving greater female participation in the DRE sector is fraught with barriers. Alem notes the limited presence of women in technical roles, attributing this to prevalent security concerns in off-grid areas and the bias among women for stable, office-based careers over unpredictable fieldwork. This highlights the need to create a safer and more inclusive working environment for women in the energy sector.

Despite these hurdles, Alem remains optimistic, bolstered by the support from initiatives like the REACT sub-Saharan Africa (REACT SSA) programme run by AECF, which specialises in derisking small and unique business models that bring clean energy to off-grid, low-income households (AECF, n.d.). This programme has been instrumental in providing Alem's business, Modify Electromechanical, with essential technical assistance, business development support and valuable networking opportunities. She believes such initiatives are essential in building a sustainable business model and fostering a supportive community for female-led companies in the renewable energy sector.

To bridge the gender gap, Alem emphasises the importance of early education and mentorship programmes aimed at encouraging more women to pursue careers in renewable energy. She advocates for greater access to financial support for women's entrepreneurial endeavours, envisioning a future where the local sector thrives with capable, diverse talent and where women enjoy equal opportunities alongside men.

Catrine Shroff
Mwangaza Light, Kenya

Catrine Shroff is an anthropologist turned entrepreneur who aims to transform communities through her renewable energy initiative, Mwangaza Light. A women-led, faith-based social enterprise, Mwangaza Light partners with churches to improve the lives of people by enhancing clean energy access, women's empowerment, environmental protection and climate action in Kenya (Mwangaza Light, 2024). It does so by distributing high-quality solar solutions and energy-efficient cookstoves and by using clean energy solutions to offer women and youth new sources of entrepreneurship. The goal is to ultimately eliminate the use of kerosene for lighting and to reduce or eliminate the use of charcoal and wood for cooking (Clean Cooking Alliance, n.d.). Mwangaza Light has also initiated a Green Church/Green Mosque initiative that seeks to enable churches/mosques to lead the turn to clean energy and a cleaner environment (*ibid.*).

However, the adoption of renewable technologies in regions with entrenched cultural traditions poses significant challenges. Unlike the commercially driven solar sector, the clean cooking sector emphasises social and environmental benefits, especially for women. Traditional practices like three-stone fireplaces, deeply ingrained as cultural symbols, necessitate a shift in long-standing cultural norms – a challenge Catrine has been navigating thanks to her background in anthropology. Additional hurdles, particularly for women entrepreneurs and workers in the renewable energy sector, include overcoming gender biases and stereotypes that question their resilience and capability in technical and leadership roles. Despite these challenges, there is a slow but noticeable shift in narrative, with increasing recognition of diverse perspectives in local initiatives.

© Mwangaza Light

Financial constraints further complicate the landscape. High interest rates epitomise the significant financial barriers that enterprises like Mwangaza Light face, encapsulated in the local saying, "slow but sure." Despite growth in annual revenue, the cost of finance remains a formidable obstacle. Engaging effectively with women in rural areas is another persistent challenge. These women often juggle numerous responsibilities with limited time, making it difficult for them to fully participate in new initiatives. Catrine leverages her partnerships with churches to gain market recognition and build credibility, a crucial strategy given the competition and initial lack of respect for new endeavours like hers.

As renewable energy technologies evolve, the sector presents a promising platform for women to become leaders and innovators. Catrine's leadership in Mwangaza Light challenges traditional gender norms and showcases the pivotal role women can play in driving sustainable development and technological innovation.

Juliana Lanyero
cloud-Green, Uganda

Juliana Lanyero is a self-made entrepreneur in Uganda, and her journey showcases her breakthrough as a female entrepreneur against traditional and cultural barriers, highlighting distributed renewable energy's key role in reducing food waste and aiding community development in Uganda through her company, cloud-Green. She began her business career while still a student, launching various ventures, to understand the practicalities of entrepreneurship beyond the classroom. This hands-on, risk-averse approach, coupled with her leadership roles within the student community, laid the groundwork for her future endeavours with cloud-Green (Response Innovation Lab, 2021).

The turning point for cloud-Green came when Juliana recognised the potential of regenerative agriculture to help mitigate the alarming levels of food waste in Uganda. This propelled her to explore innovative solutions to recycle food waste through cloud-Green. Her initial idea of transforming market food waste into fertiliser evolved into a more integrated approach at cloud-Green to address food waste with distributed renewable energy technologies.

Juliana's vision led to the development of a business model for cloud-Green that works as two separate companies to help small-scale farmers create added value for their produce. One part of the business collaborates with a company supplying solar-powered drying systems for agricultural use, allowing users to increase the durability of their fruits and vegetables. The other arm of the business collaborates with eBikes Africa, an organisation that manufactures solar bikes – as well as another company that supplies solar-powered drying systems for agricultural use, to allow suppliers to transport and deliver their food. To make the project financially accessible to smallholder farmers, cloud-Green co-operates with Akaboxi, a microfinance company that operates a digital financial inclusion system aimed at enabling smallholder farmers – most of which are women – in communities manage and monitor their savings together (Akaboxi, 2023).

The project benefits particularly refugees in settlements and self-settled refugees in urban areas. Refugees in settlements are given land by the government to grow food, mostly for subsistence. They receive training on how to use solar-powered drying systems and bikes to produce value-added foodstuff and sell it with reduced waste to final consumers. Combined, this project directly tackles food waste across the supply chain while promoting the use of clean energy. This helps create markets and significantly reduces food waste. The project also supports producers to use eco-friendly packaging to further reduce waste. For those with smart phones, there is a mobile app to further help sell produce. cloud-Green has also opened a profitable fresh food delivery service in Kampala that will be scalable to other Ugandan cities in the future (Response Innovation Lab, 2021).

When developing cloud-Green, Juliana was confronted with challenges typical of a sector dominated by men and often sceptical of women's abilities in technical fields. Despite these obstacles, her determination and commitment to learning and improving propelled the business forward. These endeavours went beyond mere business; they began a process at cloud-Green to empower women and communities through the innovative use of renewable energy. By training women in the use of solar dehydrators and promoting the use of electric motorcycles for delivery, cloud-Green not only contributes to reducing food waste but also empowers individuals and communities to embrace sustainable practices.

Juliana's success with cloud-Green highlights the need for better policies and support systems to encourage female participation in the renewable energy sector. Her experience underscores the importance of dismantling stereotypes and providing women with the resources and opportunities to thrive in traditionally male-dominated fields. By integrating distributed renewable energy into cloud-Green's business model, Juliana not only addressed immediate community needs but also contributed to the broader goals of sustainable development and gender equality.

As Juliana continues her academic pursuits with a focus on energy economics and governance, her story serves as a testament to the transformative power of renewable energy not just in addressing environmental challenges but also in breaking down societal barriers. Her efforts with cloud-Green highlight the potential for distributed renewable energy to empower entrepreneurs, especially women, to create sustainable solutions that benefit their communities and the environment.

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3

Recommendations to increase women's role in DRE

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DRE solutions address energy poverty and enhance climate resilience, while **creating substantial socio-economic opportunities** for both men and women.

Building an inclusive, decentralised renewable sector presents a significant opportunity for the five focus countries studied for this report. This transition not only addresses energy poverty, but also enhances climate resilience, and it can create substantial socio-economic opportunities for both men and women. Only a truly diverse DRE sector that attracts the best talent and caters for all market segments will ultimately be successful, making a focus on the right kind of talent – including women – essential to the sector's long-term development. Realising the full potential of the DRE sector, including its potential to generate employment, requires a deliberate focus on gender-responsive policies and institutional frameworks that ensure jobs are created on the basis of talent, not gender.

Available gender-disaggregated data – however patchy – show the continued gender gap in access to jobs in the DRE sector. The barriers women face to working in the sector in the five focus countries examined in this study are significant, largely reflecting wider obstacles women face across countries and continents in fully participating in their countries' wider economies. These obstacles include early factors such as access to education, whole-society factors such as cultural and social biases, as well as workplace factors ranging from lacking training opportunities to safety on the job. Many of these barriers will require wider-reaching interventions beyond just the DRE sector, with benefits across the economy.

Listed below are some key priorities to improve job creation for women in the DRE sector. Implementing these priorities is key to improving livelihoods for women, their families and their overall communities. At the same time, realising these priorities will shape a better and fairer society.

Improving market data and knowledge about women's inclusion in the sector

A lack of gender-disaggregated data in the off-grid sector – across both the producer and the consumer segment – means knowledge about women's inclusion, and their challenges, remains limited. To improve women's access to jobs in DRE, much better data are needed at the country and community levels. This includes survey data on energy access to start with, but also on energy consumption patterns, social expectations and concrete barriers women themselves cite to accessing jobs in this sector. Much of this data could be collected as part of economy-wide efforts to increase women's participation in the labour force, especially in energy- and STEM-related areas.

For many decades, gender equity has been one of the SGDs and has been pursued by development policies, yet gendered survey data are still highly insufficient today. This deficiency highlights the need for policy makers and businesses to step up data collection much more than has been the case in the past.

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Mainstreaming gender in all energy policies and programmes

To achieve true gender equality in the energy sector, mainstreaming gender in all energy policies and programmes must be a priority. Gender-responsive policies need to ensure that women have equal access to training, employment and entrepreneurship opportunities across the entire energy spectrum, and decentralised solar PV cannot be an exception. Policy makers should incorporate gender analysis into the planning, design and implementation stages of energy programmes, ensuring that the unique needs, barriers and potential contributions of women are considered at every level.

Moreover, energy frameworks (*i.e.* policies, regulations, strategies and institutional structures that govern the production, distribution and consumption of energy) usually disregard gender considerations. For example, women face challenges in accessing energy resources, limiting their economic potential and their role in the informal economy – which, in reality, is often an important source of employment for women in developing countries. Therefore, it is essential to create policies – and allocate budgets at the level of goverments – that recognise and support women's involvement in informal energy-related activities, such as local solar system sales, maintenance and energy access advocacy. These efforts should include providing financial incentives and access to capital and capacity-building programmes that allow women to formalise and expand their economic participation in both decentralised and on-grid renewable energy sectors.

By creating a more inclusive and equitable energy ecosystem,[11] these policies can help accelerate the global transition to sustainable energy while empowering women as key drivers of this transformation.

11 An ecosystem is a complex network of interrelated actors, institutions, policies, technologies and markets that interact within the energy sector. An energy ecosystem includes all the elements that contribute to how energy is produced, distributed, consumed and regulated, as well as how people and businesses interact with these processes.

Providing specific skill-building opportunities for women in all required competencies

To effectively provide skill-building opportunities for women who will be the future decentralised solar PV sector workforce, a well-designed and developed curriculum is needed. The various roles require different kinds of expertise to be integrated. While the technical aspect should cover the installation, maintenance and troubleshooting of solar PV systems, entrepreneurial training should focus on business development, financial management and market access strategies specific to the solar energy sector. This curriculum must be accessible and tailored to the varying levels of experience and education that women may have – and many last-mile entrepreneurs, male or female, may not have any formal education at all.

In addition to curriculum development that considers these local realities, collaboration with industry partners, including solar companies, non-governmental organisations and government agencies, is crucial for ensuring the training is relevant and connected to real-world opportunities. These partnerships can provide access to equipment, internships and mentorships, offering hands-on experience and support to women trainees. Businesses can also proactively support women in the sector by setting internal targets to promote and/or train women specifically as part of their development strategies.

Training programmes delivered in formats that are accessible to women – including flexible schedules, localised training centers and online modules for those in remote areas – are likely to prove more successful than conventional training options. Financial support such as scholarships or stipends is also essential to help women overcome barriers to participation and to increase incentives for young women to move into the sector. Finally, ongoing mentorship and networking opportunities are needed to help women continue developing their skills, build professional relationships and navigate the challenges of entering and succeeding in the solar PV industry.

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Tailored training, industry collaboration, and financial support are essential to empower women with the skills needed to succeed in the decentralised solar PV sector.

Tackling social expectations and the skills shortages

The DRE sector offers many different roles with different requirements, including many that are not typically associated with the sector, from factory assembly to office jobs and highly-skilled engineers and site planners (see Table 1). With so many different professional roles, the sector could employ men and women across a large variety of skills, but continued skill shortages throughout the DRE workforce limit how many jobs the sector can help create – including for women.

Addressing this barrier requires targeted efforts to increase women's access to information about DRE employment opportunities through tailored outreach programmes, networking initiatives and partnerships with community organisations, in addition to far greater media representation and the promotion of women in STEM subjects in the education sector and popular media. By enhancing the awareness and visibility of job opportunities among women, the DRE sector can foster a more inclusive and equitable workforce, driving positive socio-economic outcomes for all stakeholders involved. At the education level, syllabus reform and outreach programmes could help increase the appeal of STEM subjects for girls and women more generally, as well as the level of social acceptance of women working in such fields.

Societal expectations about what women can or should be expected to do, and about what they can accomplish, are deeply ingrained in society. Restrictive views of gender roles remain a significant barrier to better education and training of women in relevant subjects and the DRE sector itself. Changing such views, along with the structures that reinforce them, is a slow process that requires proactive encouragement from policy makers, businesses, civil society and the media. In few sectors is this so important as in the energy sector, which along with other STEM-related job areas has experienced greater levels of gender inequity in access to jobs and employee retainment as well as entrepreneurship than many other sectors.

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STEM education reforms are essential to increase women's access to opportunities and challenge restrictive societal expectations.

Creating a positive enabling environment for gender-responsive work

Women face a large array of barriers that keep them from entering the DRE sector and other sectors. An opportunity exists now for employers, policy makers and communities to explore more means for supporting both men and women to contribute to the sector's growth. At the government and business level, this means creating a positive enabling environment for gender-responsive work, not only across the off-grid sector, but across the economy. Key areas that support this objective include the proactive promotion of women into STEM fields of work and, within that work, into leadership positions; the establishment of mentorship programmes for young people to help break through glass ceilings; the imlementation of policies to improve workplace flexibility, including part-time work and hybrid workplaces; the promotion of childcare facilities; and dedicated investment in public information, transport and safety so that no woman has to decline paid work over concerns for her mobility and safety.

Lowering barriers to women entrepreneurship

Addressing barriers to women entrepreneurship requires comprehensive support mechanisms, including ongoing mentorship and training programmes tailored to the specific needs of female entrepreneurs (Energia, 2019b). Initiatives aimed at providing financial literacy, access to non-traditional financing options and mentorship opportunities can empower women to overcome systemic obstacles and thrive as entrepreneurs (UN Women, 2021).

The disparity in asset ownership should be addressed as a crucial cornerstone with multiple gender impacts, where female entrepreneurs are a significant expression of it. In addition, women entrepreneurs across countries could be supported significantly through better access to finance, for instance, by introducing financing products targeted towards women who may lack land or capital. Microloans and the use of development finance specifically to support women entrepreneurship in the sector could be a highly fruitful activity that would likely require very limited financial resources compared with large-scale infrastructure projects.

Initiatives offering economic opportunities, skills development, and mentorship to **bridge gender gaps** in renewable energy are key.

Box 4. Initiatives to increase female participation

Across the African continent and India, numerous initiatives are actively working to enhance women's participation in the DRE sector. These initiatives play a crucial role in addressing gender disparities and promoting inclusivity in the renewable energy landscape. For example, **Solar Sister** is an impactful initiative that empowers women by providing them with economic opportunities to start a business in the clean energy sector. Through a women-centered, last-mile distribution network, Solar Sister has enabled over 10 000 women to become clean energy entrepreneurs (Solar Sister, 2024).

In Kenya, **Mwangaza Light**, a faith-based social enterprise, leverages the existing networks of Catholic churches to enhance energy access, women's empowerment and climate action (Mwangaza Light, 2024). Additionally, the Women in Renewable Energy Association of Uganda provides specialised skilling for women, particularly in solar energy, helping to bridge the gender gap in the renewable energy workforce.

Moreover, the **Women for Green Jobs** initiative is dedicated to advancing women's participation in environmentally sustainable employment, including the green energy sector (Shortlist, 2024). By connecting women with opportunities in green jobs, this initiative contributes to diversifying the workforce and promoting women's active involvement in sectors crucial for addressing climate change. Through mentorship programmes, skill development and job placements, Women for Green Jobs is actively breaking down barriers and facilitating women's entry into the green workforce.

In India, the **Suryamitra programme** and initiatives by the Skills Council for Green Jobs are notable for their efforts in training women and promoting gender-inclusive policies, although compliance gaps exist (NISE, 2024). These programmes aim to equip women with the skills needed to participate in the renewable energy sector, thereby fostering greater gender inclusivity.

Recently, as part of COP28's **Gender Equality Day, the COP28 Presidency** launched the Gender-Responsive Just Transitions & Climate Action Partnership, which was endorsed by 68 Parties (UNFCCC, 2023). The partnership includes a package of commitments on finance, data and equal opportunities. Of the five focus countries, Nigeria was the only country that endorsed the partnership.

These initiatives serve as inspiring models for how targeted efforts can create pathways for women to contribute meaningfully to the DRE sector. By providing training, fostering entrepreneurship and creating supportive networks, organisations like Solar Sister, Mwangaza Light, the Women in Renewable Energy Association of Uganda and Suryamitra in India are instrumental in unlocking the full potential of women in sustainable energy. It is crucial for policy makers to actively engage with and build upon these successful models. By incorporating the principles and strategies employed by these initiatives, policy makers can amplify the impact of their interventions, catalysing broader societal transformations.

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4 Conclusion

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04

As the world pivots towards sustainable energy solutions, the importance of the role of women in the deployment of DRE systems, particularly in rural areas, cannot be overstated. Women's unique position within their communities means that in rural areas they often serve as primary energy managers within their households, giving them a deep understanding of local needs and dynamics. This intrinsic connection positions women as pivotal agents in accelerating the adoption and implementation of off-grid energy solutions, driving socio-economic transformation at the grassroots level. Their involvement in off-grid energy initiatives can significantly enhance the effectiveness and reach of these projects. Women can facilitate trust and communication between project developers and local communities, ensuring that the solutions provided are tailored to the specific needs and preferences of the users. Their participation can lead to higher acceptance rates and more sustainable outcomes, as women are adept at mobilising community resources and fostering collective action.

The engagement of women in the DRE sector also holds the potential to challenge and reshape societal norms. Traditionally, gender biases have limited women's roles to domestic spheres, constraining their contributions to broader economic activities. By actively participating in the energy sector, women can demonstrate the full range of their capabilities, thereby shifting perceptions and breaking down barriers. These experiences empower women to advocate for greater gender equality, not just within their communities, but across broader societal structures.

The impact of women's involvement in off-grid applications extends beyond direct employment in the energy sector. As mini-grids and other decentralised energy solutions become operational, they open new avenues for productive uses of energy. Women can leverage these opportunities to start small businesses, engage in agro-processing activities or provide essential services that were previously unavailable due to energy constraints. These economic activities contribute to the well-being of their families and the community at large, fostering a vibrant local economy and enhancing overall living standards.

The presence of women in the off-grid energy landscape ensures a more inclusive approach to community development. By integrating women into the energy value chain, from planning and implementation to operation and maintenance, communities can harness a diverse set of skills and perspectives. This inclusivity is critical for building resilient communities that can adapt and thrive amid changing environmental and socio-economic conditions.

In conclusion, women are key to tapping the full potential of DRE in remote areas. Their involvement accelerates deployment, facilitates community acceptance and drives socio-economic transformation. By overcoming societal biases and embracing productive uses of energy, women can contribute significantly to enhancing the fabric of local economies, including industries and services, and thus help ensure decent living standards. Empowering women in the energy sector is not just an ethical imperative; it is a strategic necessity for achieving sustainable and inclusive growth.

Over a decade ago, IRENA emerged as the leading authority in gathering and analysing data on the socio-economic impacts of the renewable energy sector. The agency remains in the lead on that effort, tirelessly advocating for an accelerated energy transition and emphasising that this shift must be inclusive and equitable. IRENA's commitment to ensuring that truly no one is left behind is unwavering, with a special focus on remote communities where women are at the forefront of change. Empowering these communities and highlighting the pivotal role of women is not just promoting energy access but also driving socio-economic transformation on a global scale. This report, and previous work, embodies the belief that sustainable development and gender equality are not isolated goals but imperatives for a just and inclusive future.

04


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