

WOMEN'S PARTICIPATION IN RENEWABLE ENERGY ENTERPRISES

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Abstract

Women's engagement in renewable-energy enterprise is increasingly important for an inclusive energy transition. Women participate as founders, technicians, installers, distributors, service providers, cooperative members, managers, financiers, and community energy leaders. Their enterprise activity can widen access to clean electricity and productive energy services while also supporting income, skills, decision-making opportunities, and local employment. Yet women remain less visible in technical, asset-intensive, and leadership-intensive segments of many renewable-energy value chains. Common barriers include unequal access to finance, land and collateral, formal networks, technical training, procurement opportunities, mobility, safety, time, and market information.

This literature-based study examines the conditions that shape women's participation in enterprises associated with solar, wind, bioenergy, mini-grid, clean-cooking, energy-efficiency, storage, and energy-service markets. It reviews gender and energy scholarship, entrepreneurship research, workforce evidence, and policy guidance to identify the opportunities and constraints affecting entry, retention, enterprise growth, and leadership. The analysis follows an enterprise pathway: awareness and aspiration, skills and certification, access to capital and productive assets, market entry, customer and supplier relationships, operational support, and scale. Special attention is given to the difference between participation as a consumer, employee, entrepreneur, and decision-maker.

The study finds that enterprise inclusion is strongest when technical training is paired with financing, mentorship, safe and reliable work arrangements, market linkages, gender-responsive procurement, and institutional accountability. Stand-alone training is rarely sufficient when women face credit constraints, unpaid care responsibilities, discriminatory norms, or limited control over business assets. Women-led and women-inclusive enterprises can contribute to more accessible and locally trusted renewable-energy markets, but their potential depends on policies and business models that treat gender equality as a core design requirement rather than an optional social add-on. The paper concludes that participation should be measured not only by headcounts, but also by income, ownership, leadership, skills, asset control, safety, voice, and long-term business resilience.

Keywords: Women Entrepreneurs, Renewable Energy, Gender Inclusion, Green Enterprises, Energy Access, Clean Energy Finance, Skills Development, Women-Led Businesses, Just Energy Transition, Inclusive Markets

1. INTRODUCTION

Renewable-energy deployment is changing the way electricity, heat, mobility, and productive services are supplied. Solar systems, wind projects, bioenergy solutions, mini-grids, battery services, efficient appliances, and clean-cooking technologies create new forms of enterprise activity across manufacturing, installation, operations, maintenance, retail, finance, digital platforms, and after-sales service. These markets are not gender-neutral. The ability to enter and benefit from them is shaped by education, property rights, access to

capital, household responsibilities, occupational segregation, employment practices, safety, social norms, and participation in business networks. A transition that expands renewable capacity without widening access to ownership and decent work may reproduce existing inequalities rather than reduce them [1, 3, 4].

Women are present throughout renewable-energy value chains, but their participation is often concentrated in administrative, customer-facing, informal, or lower-paid roles. Technical installation, engineering,

construction, ownership, senior management, and investment decision-making remain comparatively less accessible. International assessments indicate that renewable-energy industries can provide a stronger basis for gender inclusion than some conventional energy industries, but women continue to be underrepresented in technical occupations and leadership positions [1, 2, 4]. This pattern matters because enterprise ownership and decision-making influence who captures economic value, what products are designed, how customers are served, and whether local benefits are distributed fairly.

Women's participation also has a wider development dimension. In many communities, women are central users and managers of household energy, small enterprises, agriculture, food processing, water-related activities, and care work. Their practical knowledge can improve the design, sale, maintenance, and financing of renewable-energy products. When women have a meaningful role in enterprise planning, technologies are more likely to reflect affordability, reliability, safety, mobility, and service needs that may otherwise be overlooked. However, it would be inaccurate to assume that women will automatically benefit from a renewable-energy project merely because it is located in their community. Benefits depend on rights, resources, influence, and the quality of enterprise opportunities available [5, 6, 8].

This paper examines women's participation in renewable-energy enterprises through an inclusive entrepreneurship perspective. It considers the structural barriers that limit entry and growth, the enabling conditions that strengthen enterprise capability, and the institutional arrangements required for durable inclusion. The purpose is not to treat women as a single homogeneous group. Experiences vary by income, geography, age, caste, ethnicity, disability, education, marital status, business type, and access to infrastructure. The study therefore focuses on the design principles that can be adapted to different sectors and local contexts.

2. LITERATURE REVIEW

Research on gender and energy has shown that energy systems affect women and men differently because resources, responsibilities,

and decision-making power are not distributed equally. Early work on energy access emphasized household benefits such as reduced time spent collecting fuel and improved lighting. More recent scholarship has moved beyond household consumption to examine agency, productive use, labour markets, enterprise ownership, and participation in energy governance. This broader perspective recognizes that access to an energy device or connection does not by itself guarantee control over its use, the income it creates, or the opportunities generated by energy markets [8, 9, 10].

Studies of entrepreneurship identify finance, networks, skills, market access, regulatory conditions, and social recognition as core determinants of business formation and growth. For women, these determinants are frequently affected by unequal collateral ownership, lower access to formal credit, exclusion from technical networks, biased perceptions of competence, restricted mobility, and the unequal distribution of unpaid care work. In renewable-energy sectors, the same barriers interact with additional requirements such as equipment certification, supplier relationships, tender eligibility, project-based procurement, and working-capital needs. Enterprise support must therefore combine gender-responsive business services with sector-specific technical and commercial capability [5, 13, 14].

The literature further suggests that inclusion must be examined across the full value chain. A programme may increase the number of women trained in solar sales but fail to create pathways into installation, ownership, management, or procurement. Likewise, a company may recruit women but retain few of them if workplace safety, promotion criteria, field travel, parental support, and grievance mechanisms are weak. A gender-responsive enterprise ecosystem addresses entry, retention, advancement, ownership, and leadership together. It also measures whether women gain control over earnings, assets, customer relationships, and business decisions rather than merely taking part in short-term project activities [1, 2, 6, 11].

2.1 WOMEN'S PARTICIPATION IN ENTERPRISE VALUE CHAINS

- Women may participate as founders, co-founders, franchisees, technicians, installers, sales agents, product designers, maintenance providers, cooperative members, managers, investors, trainers, and community energy facilitators.
- Participation should be distinguished by role, quality of work, pay, ownership, asset control, authority, safety, and opportunities for progression; headcounts alone can conceal unequal outcomes.
- Decentralised energy markets can create entry points through local retail, service, repair, productive-use applications, and last-mile distribution, especially where enterprise support reaches rural and peri-urban areas.
- Large utility-scale projects can expand employment and procurement opportunities, but women may need targeted access to technical training, construction-site safety, supplier development, and leadership pathways.

2.2 RENEWABLE-ENERGY ENTERPRISE ECOSYSTEM

- The enterprise ecosystem includes training institutions, certification bodies, incubators, banks, microfinance providers, investors, manufacturers, distributors, regulators, utilities, public procurement agencies, and local business networks.
- Solar, wind, bioenergy, mini-grid, clean-cooking, storage, energy-efficiency, and e-mobility markets have different capital requirements, skills profiles, customer bases, and opportunities for women-led firms.
- Reliable after-sales service, spare-parts access, working capital, digital payment capability, and customer trust are essential for enterprise survival in distributed renewable-energy markets.
- Enterprise development is strengthened when policies link clean-energy targets with local manufacturing, skills development, supplier diversity, and inclusive access to finance.

2.3 CONSTRAINTS AND ENABLING CONDITIONS

- Finance constraints can arise from limited collateral, smaller loan sizes, high

3.1 ENTERPRISE CONTEXTS AND INCLUSION REQUIREMENTS

perceived risk, lack of credit history, and limited access to investment networks; blended finance and guarantee mechanisms can reduce these barriers.

- Technical and business training should include practical installation, safety, troubleshooting, bookkeeping, digital sales, procurement, negotiation, and leadership, not only introductory awareness sessions.
- Safe mobility, predictable work schedules, childcare support, anti-harassment measures, and accessible grievance systems are relevant to women's retention in field-based and technical roles.
- Mentorship, peer networks, visible role models, and supplier-development programmes can improve confidence, market access, and the legitimacy of women-led enterprises in male-dominated sectors.

3. OBJECT OF STUDY

The present study examines the participation of women in enterprises that develop, distribute, install, operate, maintain, finance, or support renewable-energy technologies and services. The object of study is not limited to one technology or country. Instead, it considers representative enterprise settings in which women may encounter different opportunities and constraints, including decentralised solar markets, utility-scale project supply chains, clean-cooking ventures, agricultural productive-use businesses, energy-service companies, and community or cooperative models.

The theoretical basis of the study is that inclusive participation requires more than access to a job or training course. It requires the capability to enter markets, use skills, secure finance, control assets, make decisions, earn a fair return, and progress into leadership. A renewable-energy enterprise ecosystem that addresses only one part of this pathway may increase visible participation without changing unequal control over value and opportunity. The study therefore treats enterprise inclusion, market viability, and gender equality as linked dimensions of a just energy transition.

TABLE 1. RENEWABLE-ENERGY ENTERPRISE CONTEXTS AND GENDER-INCLUSIVE PARTICIPATION REQUIREMENTS

S.No.	Enterprise Context	Participation Opportunity	Main Gender Constraint	Inclusion Requirement
1	Decentralised solar retail and service	Local sales, installation support, repair, customer education, and after-sales service	Limited technical certification, mobility constraints, weak working capital	Practical training, tool access, local service networks, safe field travel, and working-capital finance
2	Utility-scale renewable projects	Construction, operations, environmental services, catering, logistics, procurement, and management	Occupational segregation, site safety concerns, exclusion from tenders and technical roles	Inclusive hiring, safety standards, apprenticeships, supplier diversity targets, and promotion pathways
3	Clean-cooking and bioenergy enterprises	Production, distribution, user training, maintenance, fuel supply, and micro-franchising	Low margins, limited decision-making over household purchases, unpaid care responsibilities	Affordable finance, user-centred design, commission transparency, and local women-led sales channels
4	Agricultural productive-use energy	Solar irrigation services, cold storage, milling, processing, charging, and farm-service businesses	Weak land and asset rights, limited access to farmer networks and equipment finance	Asset ownership support, group enterprises, tailored credit, market linkages, and extension services
5	Community and cooperative energy models	Membership, governance, operation, local tariff collection, enterprise services, and benefit sharing	Limited representation in committees and unequal voice in community decisions	Reserved leadership spaces, transparent rules, capacity building, and gender-responsive benefit sharing

3.2 STUDY OBJECTIVES

- To examine the roles through which women participate in renewable-energy enterprises across different value chains and market settings.
- To identify the financial, technical, institutional, social, and workplace barriers affecting women's entry, retention, enterprise ownership, and leadership.
- To compare inclusion requirements across decentralised energy, utility-scale projects, clean-cooking ventures, agricultural productive-use enterprises, and community energy models.
- To evaluate the importance of finance, training, mentorship, procurement, safety, market linkages, and supportive policies in enabling women-led and women-inclusive enterprises.

- To develop a practical framework for strengthening women's economic participation and decision-making within the renewable-energy transition.

4. RESEARCH METHODOLOGY

The study adopts a qualitative, literature-based research methodology. It synthesises international reports, academic research, policy guidance, and enterprise-development evidence related to gender, entrepreneurship, energy access, labour markets, and renewable-energy deployment. This approach is appropriate because the central question concerns the relationship between enterprise ecosystems, gendered constraints, and participation outcomes rather than the measurement of a single intervention. The paper does not claim to present primary survey findings; its conclusions are interpretive and

intended to guide policy design, programme development, and future empirical research.

The analytical framework follows a participation pathway. It begins with awareness, aspiration, and access to information; continues through skills development, certification, finance, asset acquisition, and market entry; and then considers enterprise operations, supplier and customer relationships, workplace conditions, growth, ownership, and leadership. The framework also examines the institutional environment, including regulations, procurement practices, financial products, training systems, social norms, and local infrastructure. This pathway approach recognises that barriers can occur at several points and may reinforce one another.

4.1 RESEARCH DESIGN (QUALITATIVE ANALYTICAL APPROACH)

- The study follows a qualitative and comparative design based on established literature, sector reports, and evidence-informed policy guidance.
- The analysis compares renewable-energy enterprise settings according to technology type, capital intensity, skills demand, market structure, employment conditions, and opportunities for ownership.
- A gender and social-inclusion perspective is used to connect enterprise capability with asset control, safety, mobility, care responsibilities, voice, and institutional access.
- Findings are interpreted through practical enterprise and policy principles rather than through a controlled experiment or a statistically representative survey dataset.

4.2 WOMEN'S ENTERPRISE PARTICIPATION FRAMEWORK

- Entry conditions are assessed through awareness, access to education, technical training, certification, social networks, role models, and the perceived legitimacy of women in energy-related work.
- Enterprise formation is assessed through access to savings, credit, guarantees, equipment, land or premises, inventory, digital tools, registration support, and business-development services.
- Enterprise performance is assessed through customer access, revenue stability, maintenance capability, supply-chain

relationships, working capital, procurement opportunities, and business resilience.

- Empowerment outcomes are assessed through income, ownership, control over assets and earnings, decision-making, leadership, career advancement, safety, voice, and the ability to influence market and policy decisions.

4.3 ENTERPRISE AND COMMUNITY CONTEXT

- The study considers rural, peri-urban, and urban markets, including households, microenterprises, farms, cooperatives, small and medium enterprises, public institutions, and energy-service companies.
- Renewable technologies include solar photovoltaic systems, solar-powered productive-use equipment, wind energy, mini-grids, battery systems, bioenergy, clean-cooking technologies, and energy-efficiency services.
- Women are considered in diverse roles, including employees, entrepreneurs, customers, producers, technicians, managers, cooperative members, investors, and community representatives.
- Institutions are considered through their roles in policy, licensing, training, finance, procurement, labour standards, social protection, local development, and gender-equality enforcement.

4.4 PARAMETERS OF ANALYSIS

- Availability and quality of technical, business, digital, and leadership training, including access to certification and practical field experience.
- Access to savings, credit, grants, guarantees, insurance, investment, equipment leasing, working capital, and gender-responsive financial products.
- Control over productive assets, land, business registration, technology, income, customer relationships, and enterprise decision-making.
- Workplace safety, predictable schedules, mobility, care responsibilities, field conditions, anti-harassment protections, and grievance mechanisms.
- Access to markets through supplier networks, product distribution, digital channels, incubators, public procurement,

utilities, cooperatives, and business associations.

- Participation in governance, including representation in company leadership, project committees, cooperative boards, regulatory consultation, and community decision-making.

4.5 PROCEDURE OF STUDY

- Review gender and energy literature, renewable-energy workforce reports, entrepreneurship research, and enterprise-development guidance.
- Identify recurring opportunities and constraints affecting women's participation across renewable-energy value chains.
- Compare enterprise contexts according to skills requirements, financial exposure, market access, social norms, and potential for ownership and leadership.
- Map each context to relevant measures in training, finance, procurement, safety, mentorship, enterprise support, and governance.
- Interpret the combined evidence to formulate an inclusive renewable-energy enterprise framework.
- Develop practical recommendations that can guide site-specific programmes, policies, investment decisions, monitoring, and future empirical investigation.

4.6 ANALYTICAL APPROACH

- Qualitative comparison of participation pathways and enterprise constraints across representative renewable-energy market contexts.
- Interpretation of how finance, skills, networks, safety, care infrastructure, and policy design interact to shape enterprise outcomes.
- Assessment of the relationship between women's ownership and leadership, enterprise viability, customer reach, and the broader inclusiveness of energy transitions.
- Identification of measures that can be adapted for public programmes, private companies, financial institutions, training providers, cooperatives, and local governments.

5. DATA ANALYSIS

The qualitative analysis indicates that women's participation in renewable-energy enterprise is shaped by a sequence of linked opportunities

rather than by a single factor. Access to training can increase awareness and technical confidence, but it does not necessarily create a viable enterprise when equipment, working capital, credit history, supplier relationships, and customers remain inaccessible. Similarly, a loan product may be available but ineffective if repayment terms do not match seasonal incomes, if collateral rules exclude women, or if business registration and procurement systems are difficult to navigate. Effective support therefore needs to be designed as an ecosystem rather than as an isolated intervention.

The analysis also shows that decentralised renewable-energy markets can provide relatively accessible entry points because services are often local, relationship-based, and compatible with microenterprise models. Women may build businesses around customer education, sales, maintenance coordination, digital payments, appliance finance, repair, solar-powered processing, or community service centres. However, these markets can also create risks of low margins, irregular cash flow, weak after-sales support, and unpaid or underpaid outreach work. Inclusion programmes should assess whether enterprise roles provide real income, asset accumulation, and progression rather than relying on women as temporary sales intermediaries.

In utility-scale renewable-energy projects, women can benefit from jobs and procurement opportunities across construction, operations, logistics, catering, environmental services, digital monitoring, administration, and community engagement. Yet technical and leadership roles may remain inaccessible when recruitment relies on male-dominated labour pools, project sites lack safe facilities, contractors do not use inclusive hiring practices, or training is offered too late. The analysis suggests that project developers and public authorities can improve outcomes through early workforce planning, apprenticeships, contractor requirements, supplier diversity, safety standards, data reporting, and clear pathways into skilled roles.

Finance emerges as a central constraint across enterprise types. Women entrepreneurs may have lower access to collateral, formal banking relationships, investment networks, and large-

ticket loans, while energy businesses often require upfront investment in tools, stock, transport, components, or productive-use equipment. Enterprise finance must therefore combine suitable repayment structures with guarantees, asset leasing, group lending where appropriate, invoice finance, catalytic grants, and technical assistance. Financial inclusion should be monitored not only by the number of loans disbursed but by loan size, asset ownership, business survival, profitability, and the degree of control women retain over borrowed resources.

A further finding is that representation alone is not enough. A woman may be counted as an employee, trainee, committee member, or business partner without having influence over investment, technology choice, prices, schedules, or enterprise income. Meaningful participation requires voice and decision-making power. Monitoring systems should therefore combine quantitative indicators, such as recruitment and ownership rates, with qualitative indicators, such as perceived safety, respect, confidence, control over earnings, access to promotion, and ability to influence business decisions. This approach makes it possible to distinguish symbolic inclusion from substantive economic participation.

6. DISCUSSION

The analysis confirms that women's enterprise participation should be treated as an economic and sector-development priority rather than as a marginal social objective. Renewable-energy markets need a wider pool of technical talent, trusted local service providers, entrepreneurs, and decision-makers. Gender-inclusive enterprise development can broaden this pool while improving the responsiveness of products and services to diverse customer needs. The business case, however, should not replace a rights-based approach. Women have a claim to equitable opportunities, safe work, ownership, and leadership regardless of whether their participation is framed as commercially useful.

The strongest strategies are layered. At the policy level, governments can integrate gender objectives into energy planning, skills initiatives, public procurement, labour standards, enterprise support, and data systems. At the financial level, banks, development-finance institutions, and

investors can offer products that match renewable-energy business cycles and reduce collateral barriers. At the company level, employers and project developers can establish inclusive recruitment, safe workplaces, mentorship, advancement pathways, and supplier-development programmes. At the community level, cooperatives and local institutions can create spaces for women's leadership, peer support, and enterprise collaboration.

Care responsibilities and safety are particularly important in field-based renewable-energy work. Training schedules, travel requirements, installation sites, customer visits, and project camps can exclude capable women when transport is unreliable, childcare is unavailable, facilities are unsafe, or harassment is tolerated. These constraints should not be described as individual limitations. They are organisational and social design issues that can be addressed through scheduling, safe transport, appropriate facilities, anti-harassment policies, supervisory accountability, and family-responsive workplace practices.

Procurement can be a powerful but underused instrument. Public agencies, utilities, developers, and large companies purchase equipment, construction services, logistics, maintenance, consulting, and community services. Gender-responsive procurement can create demand for women-owned and women-led firms when tender requirements are accessible, contract sizes are realistic, payment cycles are fair, and supplier-development support is available. Care is needed to avoid token targets that are not matched by practical assistance; otherwise women-owned firms may be registered but excluded from higher-value contracts.

Finally, enterprise inclusion should be adaptive. Renewable-energy markets, technologies, financing models, and labour needs are changing quickly. Programmes should monitor who is entering, who is leaving, who is advancing, and why. They should examine intersectional differences and avoid assuming that all women face the same obstacles. Regular feedback from women entrepreneurs, workers, customers, and community leaders can reveal barriers that administrative data misses. This evidence can

support more effective policies and prevent the energy transition from reproducing old patterns of exclusion in new industries.

7. CONCLUSION

This study examined women's participation in renewable-energy enterprises as a central component of an inclusive and just energy transition. It showed that women can contribute across renewable-energy value chains as entrepreneurs, technicians, distributors, service providers, managers, cooperative members, and leaders. Yet participation is often limited by unequal access to finance, technical training, asset ownership, networks, safe mobility, workplace protection, procurement opportunities, and decision-making power. Enterprise inclusion must therefore be understood as a capability pathway, not merely as a recruitment statistic. The analysis found that decentralised solar markets, utility-scale projects, clean-cooking ventures, agricultural productive-use enterprises, and community energy models require different combinations of support. Practical training, certification, working-

capital finance, asset access, mentorship, gender-responsive procurement, safe workplaces, childcare-sensitive schedules, market linkages, and leadership opportunities can improve outcomes when they are coordinated. No single measure is sufficient on its own. The quality of participation should be assessed through ownership, earnings, safety, voice, advancement, and long-term enterprise resilience.

Women-led and women-inclusive renewable-energy enterprises can strengthen local economies, improve energy access, increase innovation, and distribute the benefits of clean-energy investment more fairly. Their long-term success depends on policy frameworks, financial systems, companies, and community institutions that recognise women as skilled economic actors and decision-makers. When gender equality is integrated into the design of energy markets from the beginning, renewable-energy enterprise can become a practical pathway toward both economic empowerment and sustainable development.

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